COLMAC COIL
Manufacturing Inc.

A+ Series™
Refrigeration E-Catalog

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A+ Series™

Refrigeration Air Coolers

"The Heat Transfer Experts"

COLMAC COIL Manufacturing Inc.

A+ Series™

Colmac Coil is pleased to introduce A+ Series™ air coolers for industrial refrigeration applications. Compared to previously available designs, this all new product line offers unsurpassed levels of:

Food Safety	Worker Safety
Energy Efficiency	Reliability

A wide range of cabinet construction materials are available with cleanability features built-in as standard. A+ Series™ coil construction materials are available to suit any working fluid or environment:

- Copper tubes/aluminum fins
- Aluminum tubes/aluminum fins
- Stainless steel tubes/aluminum fins
- Stainless steel tubes/stainless steel fins
- Stainless steel tubes/anti-microbial alloy fins
- Galvanized steel tubes and fins

Three unique tube and fin patterns are used to optimize the cooling performance of Colmac Coil A+ Series™ air coolers depending on the capacity, working fluid, and operating temperature specific to your application. Other manufacturers use a single tube and fin pattern for their air cooler product lines, forcing you to accept "one-size-fits-all" and a less than optimum selection. Not with Colmac Coil!

A number of Colmac innovations have been incorporated into the A+ Series™ line as optional features, including:

► *Anti-microbial Coil Construction*
- Aggressive anti-microbial fin alloy kills pathogens
- Corrosion resistance equivalent to all stainless construction
- Thermal performance equivalent to aluminum fins

► *Low Temp Low Charge DX Ammonia*
- Reduces system ammonia charge by 10 lbs/TR
- Operates down to -40°F suction temperature

► *Smart Hanger System*
- Reduces suspended load time by as much as 75%
- Improved safety during installation

► *High Performance Glycol Technology*
- Proprietary heat transfer technology boosts performance
- Reduces pumping power by 30%
- Reduces fan power by 30%
- Reduces defrost energy by 30%

► *Smart Hot Gas Defrost*
- Reduces defrost time to as short as 10 minutes
- Saves energy and reduces operating costs

Online software accurately selects, rates, prices, and specifies A+ Series™ air coolers. No more downloading and installing software onto your computer. A+ Series™ software runs on your internet browser. Another first from Colmac Coil!

Read on to learn more about the new A+ Series™ air coolers from Colmac Coil!

REFRIGERATION AIR COOLERS

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A+L High Profile Unit

- High profile for medium to large industrial applications
- "Plug-in" fan section for horizontal, 45° down, or penthouse air discharge
- High efficiency fans and premium efficiency motors standard
- Hinged fan panels standard
- Capacity range: 5 – 100 TR

A+M Medium Profile Unit

- Medium profile for small to medium industrial applications
- High efficiency fans and ***foot mounted motors*** up to 3 Hp
- Hinged fan panels standard
- Optional full coverage drain pan
- Capacity range: 2 – 50 TR

A+S Low Profile Unit

- Low profile for small to medium industrial applications
- High efficiency fans and motors up to 1 Hp
- Hinged fan panels standard
- Optional full coverage drain pan
- Capacity range: 2 – 35 TR

A+R Process Rooms

- "Above Rail" style air cooler for use in food processing rooms where cleanability is critical
- Optional CIP piping available
- Hinged access panels standard
- Full coverage insulated drain pan standard
- Capacity range: 3 – 25 TR

COLMAC COIL Manufacturing Inc.

FEATURES

UNCRATING AND RIGGING MADE SAFE AND EASY

The new Colmac Coil A+ Series™ air coolers are crated and designed for fast and safe installation.

Cradle Crating System: The unique cradle crating system from Colmac Coil supports the full weight of the air cooler while withstanding the rigors of shipment. The cradle crate also safely supports the weight of the air cooler while it is lifted into position from below. Then after the air cooler is secured to the ceiling, the crate easily comes away from the unit by gravity allowing it to be safely lowered to the ground. See Figure 1.

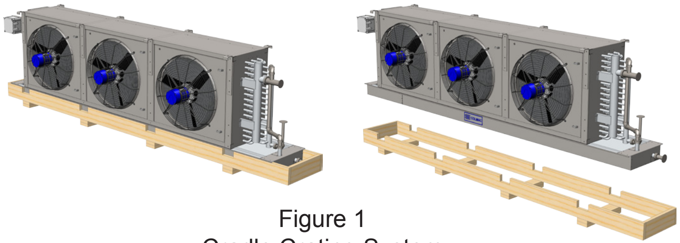


Figure 1
Cradle Crating System

Smart Hanger System: This optional patented design was developed to make the process of mounting ceiling-hung air coolers faster and safer. Smart hanger brackets and rails allow air cooler units to be hung from the ceiling without any personnel leaving the floor level. The time consuming process of aligning threaded rods into mounting holes while the unit is being lifted into position is eliminated, reducing suspended load time by as much as 75%. Side to side placement of the air cooler on the Smart Hanger rails is non-critical and therefore faster. See Figure 2.

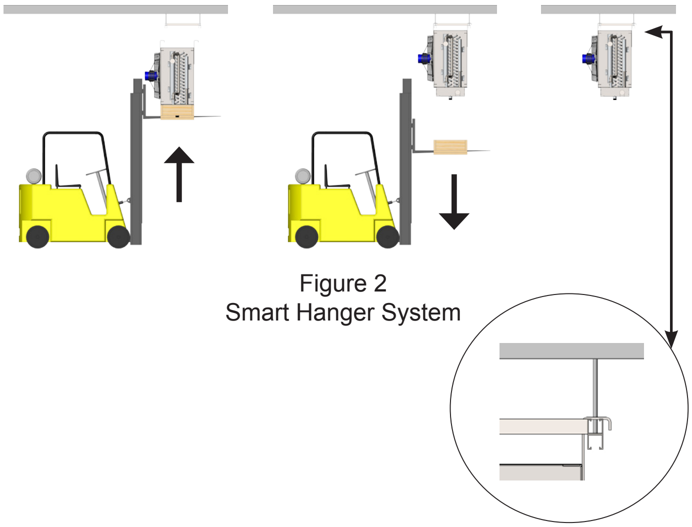


Figure 2
Smart Hanger System

QUIET AND EFFICIENT

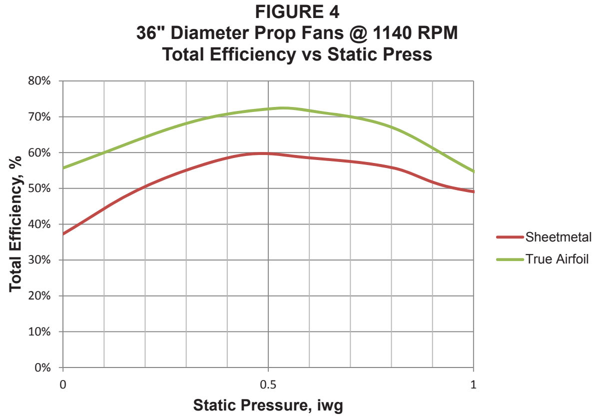
Fans

Other manufacturers use stamped steel or aluminum sheetmetal fan blades. While this type of fan is low cost, it is inefficient and costly to operate. All Colmac Coil A+ Series™ air coolers use only high efficiency fan blades having a true airfoil shape profile as standard equipment. See Figure 3.

Figure 3
True Airfoil Blade Profile

This type of fan offers several advantages over stamped steel or aluminum blades:

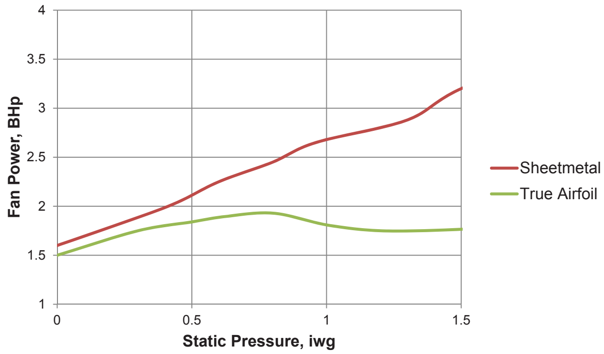
High Efficiency: The true airfoil blade shape can achieve mechanical efficiencies of 70%+. The best a stamped steel or aluminum sheetmetal blade can achieve is approximately 60%. This means Colmac Coil A+ Series™ air coolers will operate with 10% less fan power for the same cooling load, which not only translates to lower operating costs, but also lower first cost for power cabling and transforming. See Figure 4.



Low Noise: The higher efficiency of the A+ Series™ fans also results in lower sound levels during operation. A wide range of fan diameters and speeds are available to allow the selection of the appropriate sound level for the application and customer requirements.

Non-overloading: Another benefit of standard A+ Series™ fans with airfoil shape profile is the non-overloading power vs. pressure characteristic curve. The power vs pressure curve is very flat which means that as frost accumulates on the air cooler and static pressure through the coil block increases, the brake power load imposed on the fan motor remains constant. Stamped steel and aluminum sheetmetal fan blades used by other manufacturers have a steep power vs. pressure curve which results in brake power (and amperage) continuing to rise as frost accumulates and static pressure increases. See Figure 5.

FIGURE 5
36" Diameter Prop Fans @ 1140 RPM
Power vs Static Press



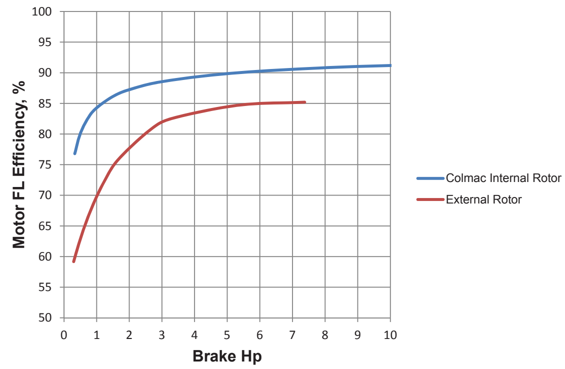
Motors

All standard fan and motor combinations on A+ Series™ air coolers are optimized for maximum total efficiency. This is different from the integral external rotor fan motor units supplied by other manufacturers. While certain airflow and pressure conditions may result in total efficiencies approaching the A+ Series™ efficiency, in many cases the total efficiency for integral external rotor fan motor units is inferior. See Figure 6.

All standard fan motors supplied with A+ Series™ air coolers are high efficiency, internal rotor, totally enclosed, and *VFD compatible*. Integral horsepower motors (greater than 1 Hp) are supplied standard as NEMA Premium Efficiency. See the NEMA definition of Premium Efficiency for actual motor efficiencies. Fractional horsepower motors (1 Hp and less) are supplied standard as 80% minimum efficiency.

The A+ Series™ offer both 1140 rpm (6 pole) motors for high capacity applications and 850 rpm (8 pole) for low noise applications. Motors are suitable for either 50 or 60 Hz supply voltage.

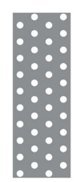
FIGURE 6
Motor Efficiency vs Brake Power
Internal vs External Rotor



OPTIMIZED HEAT TRANSFER

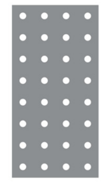
Unlike other manufacturers who offer a single "one-size-fits-all" tube pattern in their air coolers, Colmac Coil A+ Series™ air coolers feature optimized tube patterns to precisely match the operating conditions:

5/8" diameter x 1.5" staggered



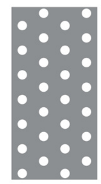
- Enhanced plate fins
- Compact pattern for highest heat transfer efficiency in high heat flux applications
- Best for high temperature wet fin applications with large TD

5/8" diameter x 2" inline



- Enhanced plate fins
- Lowest fan power
- Large secondary (fin) surface area for maximum frost carrying capacity and extended runtime between defrosts
- Best for low temperature frosted fin applications

7/8" diameter x 2.25" staggered



- Enhanced plate fins
- Low fan power
- Large secondary (fin) surface area for maximum frost carrying capacity and extended runtime between defrosts
- Best for:
  - Gravity flooded ammonia
  - Large capacity pumped ammonia
  - Low temperature DX ammonia

FEATURES

Available For Any Working Fluid

Colmac Coil A+ Series™ air coolers can be supplied to utilize any working fluid (refrigerant), either volatile or non-volatile, primary or secondary. This includes (but is not limited to):

Volatile

- Ammonia
- CO_2
- Propene (Propylene)
- Halocarbons
- Liquid Nitrogen

Non-Volatile

- Glycols
- Calcium or Potassium Chloride
- Dynalene
- d-Limonene
- Potassium Formate

Circuiting is matched to each application and optimized for highest heat transfer with lowest tubeside pressure drop.

- Pumped bottom feed
- Pumped top feed
- Gravity flooded
- Direct expansion
- CPR feed

DX AMMONIA TO -40°F, NO PROBLEM

The industrial refrigeration industry has always used the old rule of thumb: "Don't use DX Ammonia below 0 degrees F, it won't work!". Now with patented Colmac Coil technology, DX with ammonia is finally possible down to blast freezing temperatures (-40°F). The benefits of Colmac Coil Low Temp DX ammonia compared to pumped ammonia include:

- Dry suction – no wet suction risers to worry about
- Reduces system ammonia charge by 10lbs/TR
- Lower first cost – no recirculator pumps, smaller line sizes, simpler controls
- Lower operating costs – liquid pumping power is eliminiated

Colmac Coil low temp DX ammonia is available on all A+ Series™ air coolers.

FINALLY, HIGH PERFORMANCE GLYCOL COOLERS!

Secondary refrigerants (glycols and brines) are being widely used in industrial refrigeration systems as a means of (a) reducing the total ammonia charge on site, and (b) removing ammonia from occupied spaces (i.e. process rooms) and other areas highly sensitive to the risk of ammonia leaks. Unfortunately, these benefits are accompanied by a number of disadvantages including:

- Added complexity
- Increased first cost
- Increased power consumption

To minimize air cooler power consumption (added pumping power and fan power) with secondary refrigerants, Colmac Coil A+ Series™ air coolers have been redesigned with a unique revolutionary new heat transfer technology which significantly boosts performance. Compared to traditional cooler designs offered by other manufacturers, A+ Series™ air coolers have:

- 30% less pumping power
- 30% less fan power
- 30% less defrost energy
- 30% less piping and insulation costs

MATERIALS OF CONSTRUCTION

Colmac Coil A+ Series™ air coolers are offered in a variety of construction materials to match the operating environment and provide the most cost effective solution to the customer.

Aluminum tube and fins: Colmac Coil has specialized in all aluminum construction for ammonia air coolers for over 30 years. All aluminum construction offers:

- Lightest weight
- Best performance
- Fastest defrost
- Good corrosion resistance
- Lowest cost
- Patented bi-metallic couplers

Stainless steel tube and aluminum fins: The stainless steel tubes used in this popular type of construction offers some added corrosion resistance and resistance to mechanical damage compared to all aluminum construction. However, the poor conductivity and higher cost of stainless steel tubes means relatively lower performance and higher cost compared to all aluminum.

A variety of fin materials are available with stainless steel tube A+ Series™ air coolers.

- Aluminum fins
- Stainless steel fins
- AM (anti-microbial) fins
- 304 or 316 SST

Galvanized steel tube and fins: In certain limited cases where highly alkaline cleaners are used directly on coil surfaces, galvanized steel construction may be desirable. This type of construction is significantly heavier (2 to 3 times), has significantly lower performance (12 to 15% less), and is costlier when compared to all aluminum construction.

More detailed information on the subject of coil construction can be found in the online Colmac Coil Technical Bulletin "Comparing Ammonia Evaporator Construction: "Which one is best?"

BREAKTHROUGH IN HYGIENIC DESIGN

Colmac Coil specializes in hygienic coil designs for the food processing industry. A+ Series™ air coolers can be supplied with the following types of coil construction to match more demanding cleaning and sanitizing requirements:

All Stainless: Both tubes and fins can be made of type 304 or type 316 stainless steel.

Anti-Microbial: Stainless steel tubes with proprietary anti-microbial fin alloy provides:

- Equivalent corrosion resistance to stainless steel tubes and fins
- Equivalent performance to stainless steel tube and aluminum fins
- Active anti-microbial action. Pathogen colony counts approach zero after just 2-3 hours exposure to this fin alloy
- Not a coating which can chip or peel off and contaminate food products

3-A Sanitary Design: The only design USDA approved for direct contact with food. Only available from Colmac Coil.

CLEANABILITY IS STANDARD

Cabinet Materials: Cabinet sheet metal is offered in galvanized steel, aluminum, or stainless steel.

Hinged Fan Panels: All fan panels on all A+ Series™ air coolers are hinged as standard for ease of inspection, cleaning, and service. See Figure 7.

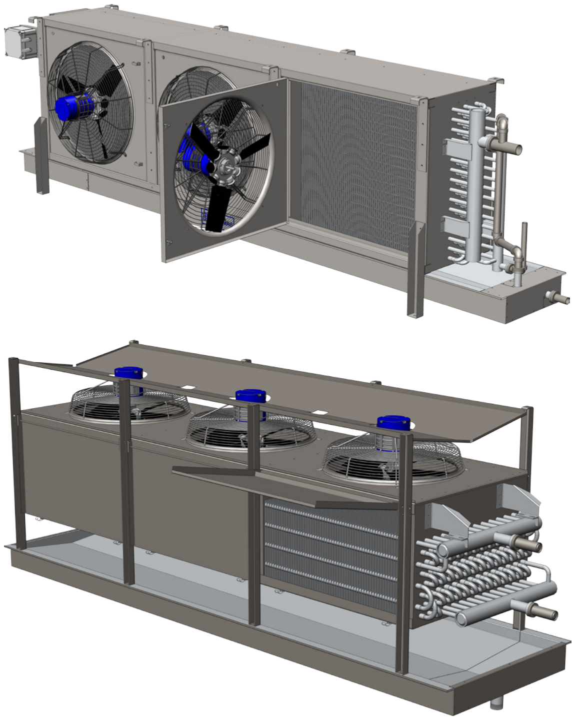


Figure 7
Hinged Access Panels

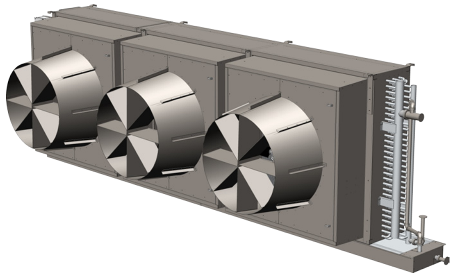
Cleaning Clearance: Care has been taken to eliminate difficult to inspect and clean areas on top of the fins and between the bottom of the fins and the drain pan. The "Triple Pitch" drain pan is designed to be easily cleaned, drain quickly, and leave no standing water after a defrost or cleaning cycle.

FEATURES

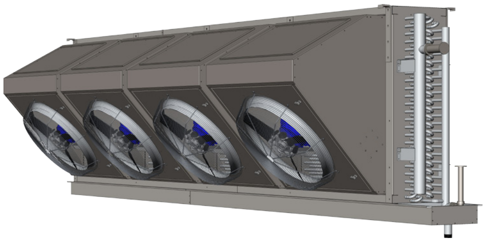
AIR DISCHARGE ARRANGEMENTS:

On applicable models, air discharge alternatives include:

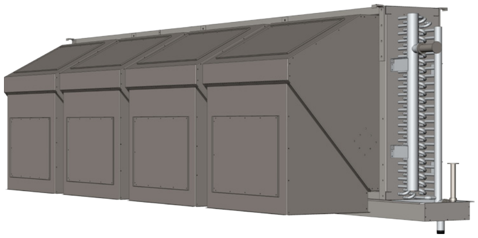
- Long throw adapters



- 45° down discharge

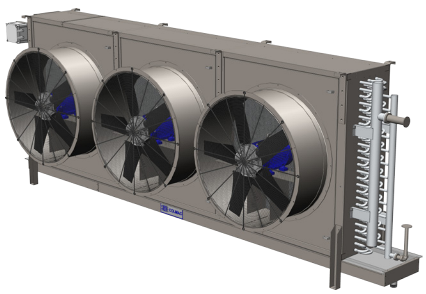


- 90° down discharge (penthouse adapters)



45° and 90° penthouse options feature heavy-duty discharge housings that tilt the fans 45° down from the vertical plane. These housings ship installed for ease of installation. Access panels are provided on penthouse adapters to permit service access.

- Fans selected for external static pressure (ESP)



FACTORY ELECTRICAL WIRING OPTIONS:

- All motors wired to a common fused or non-fused disconnect switch located in a NEMA 4X box
- Each motor wired to an individual fused or non-fused disconnect switch located in a NEMA 4X box
- All motors wired to a control panel with a common fused disconnect switch and individual IEC motor starters. All located in a NEMA 4X box.
- Customized UL508 listed control panels available for all units

OTHER OPTIONS

Re-heat coil

- Installed to re-heat air leaving the air cooler coil

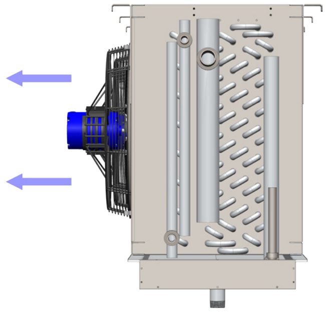


Figure 8
A+S Air Cooler With Re-Heat Coil

Variable fin spacing

- For severe frost applications, fins on the air inlet face of the coil have wider fin spacing than the remainder of the coil. The wider spacing allows for more frost build-up before defrosting becomes necessary, resulting in fewer defrosts compared to a coil without variable fin spacing.

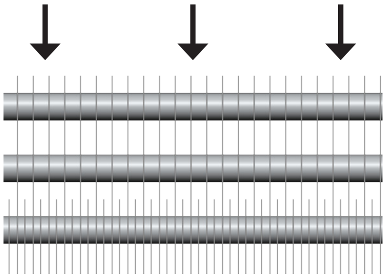


Figure 9
Variable Fin Spacing

Electric heat trace in the drain pan cover

- Use this option for conditions where the room temperature is above freezing and the drain pan cover temperature may drop below the dew point temperature of the room air, resulting in condensate forming on the cover and dripping. The heat trace keeps the drain pan cover above the room dew point temperature, and eliminates the possibility of condensation.

Extended legs

- For applications where a floor mounted coil must be elevated

Alternate voltages and 50 Hz fan motors

- Units can be designed and manufactured to be compatible with power supplies anywhere in the world.

NEW DEFROST TECHNOLOGY FROM COLMAC COIL

Colmac Coil A+ Series™ air coolers are designed to:

1. Defrost faster
2. Use less energy during defrost
3. Eliminate drain pan icing problems

SMART HOT GAS DEFROST™

Colmac Coil A+ Series™ air coolers equipped with Smart Hot Gas Defrost™ save you money!

“Triple Pitch” Drain Pan

Colmac Coil’s innovative “Triple Pitch” V-bottom drain pan design provides for rapid and complete drainage of melted frost and ice. The drain pan is conveniently pitched to a single drain connection on one end of the unit, simplifying drain piping. The “V” shape acts to quickly move melted frost to the center of the pan where it flows to the end of the pan and the drain. Low spots and “pooling” of melted frost in the pan are completely eliminated. Pitching the drain pan in three directions (front to center, rear to center, and end-to-end) combined with continuous hot gas loop contact has resulted in “the perfect pan”! See Figure 10.

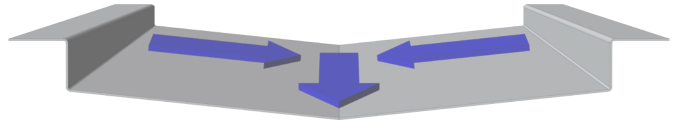


Figure 10
Triple Pitch Drain Pan

Drain connections found in other manufacturers’ drain pans are typically made of pipe nipples cut at 90 degrees and welded onto a flat hole in the drain pan sheet metal. This type of construction distorts the drain pan and can cause incomplete drainage because of high spots around the drain outlet. Colmac Coil has solved this problem with a full radius drain outlet formed into the drain pan to eliminate the possibility of water pooling around the drain after a defrost. The Colmac Coil A+ Series™ drain pan drains *completely.* No more time and money wasted de-icing drain pans! See Figure 11.

Figure 11
Full Radius Drain Outlet

Continuous Contact Pan Loop

Other manufacturers attach the hot gas pan loop (tubes and headers) underneath the drain pan in such a way that complete contact over the length of the pan is not possible. The tubes in the drain pan loop on Colmac Coil A+ Series™ air coolers are held tightly in contact along the entire length of the underside of the drain pan by means of special spring tension clips. No thermal mastic paste is used or needed with the Colmac Coil A+ design. Pan loop headers are held outside the ends of the drain pan to allow full contact of the tubes with the pan. Defrost heat is transferred to the pan surface not only by the tubes themselves, but also through the metal of the full length clips. See Figure 12.

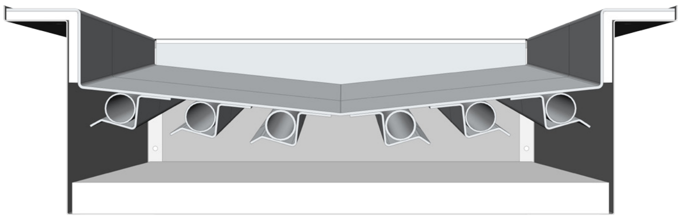


Figure 12
Continuous Contact Pan Loop

Simplified Control Valve Group with Shorter Defrost Duration

Colmac Coil Smart Hot Gas Defrost™:

- Costs less to install
- Costs less to operate

Conventional hot gas defrost controls use an expensive defrost pressure regulating valve on each air cooler to maintain hot gas pressure during defrost. Also, the pan loop is typically routed in series with the coil block. This piping arrangement forces the defrost duration to be longer (much longer in some cases) than needed to melt and remove frost from the coil fins and tubes. i.e. Defrost duration is extended purely to prevent ice from forming in the drain pan. While the extended defrost may clean the pan of ice, it is unnecessarily sending heated air into the refrigerated space, reducing defrost efficiency and wasting money.

The Colmac Coil Smart Hot Gas Defrost™ controls eliminate the defrost pressure regulating valve and instead uses a simple, inexpensive liquid drainer to maintain defrost pressure in the coil during defrost. The drain pan is piped and heated independently of the coil block, allowing the hot gas to flow to the coil for only 6-8 minutes. It has been shown that reducing the defrost duration from 30 minutes to 10 minutes in a zero degree room can reduce operating costs by as much as $25,000 per year per 100 TR (Nelson 2011)! The amount of hot gas required to keep the drain pan sufficiently heated pre, during, and post defrost is relatively small such that pan loop piping can typically be done with a very simple 3/4” branch hot gas line, solenoid, and needle valve.

Colmac Coil Smart Hot Gas Defrost™ can be applied to bottom feed pumped, top feed pumped, or DX ammonia systems. More detailed information on how to design and specify Colmac Coil Smart Hot Gas Defrost™ can be found online in the Colmac Coil Engineering Design Guide on this subject.

“It’s All In The Piping”

Liquid Seal Hot Gas Drain Pan Loop: In conventional hot gas drain pan designs, liquid refrigerant can flood the lower tubes in the drain pan hot gas loop, rendering them much less effective in heating the pan, and resulting in slow and uneven drain pan defrosting. Colmac Coil’s trapped outlet design ensures that condensed, liquid refrigerant is carried out of the pan ensuring fast, complete, and uniform heating of the pan during defrost. See Figure 13.

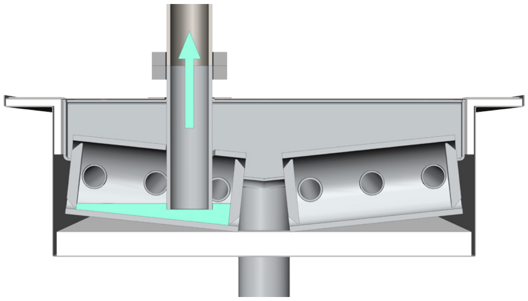


Figure 13
Liquid Seal Loop Outlet

Free Draining Liquid Connections: With conventional coil designs, the liquid connection enters the liquid header in such a way that the bottom tubes in the coil stay flooded during defrost with condensed, liquid refrigerant. The result is slow, uneven (or incomplete) defrosting of the coil. Colmac Coil has solved this problem by extending the liquid header downward and placing the liquid connection below the level of the lowest tube in the coil. This design effectively traps all of the condensed liquid refrigerant and forces it out of the coil during defrost, resulting in a fast, complete and effective defrost of the entire coil. See Figure 14.

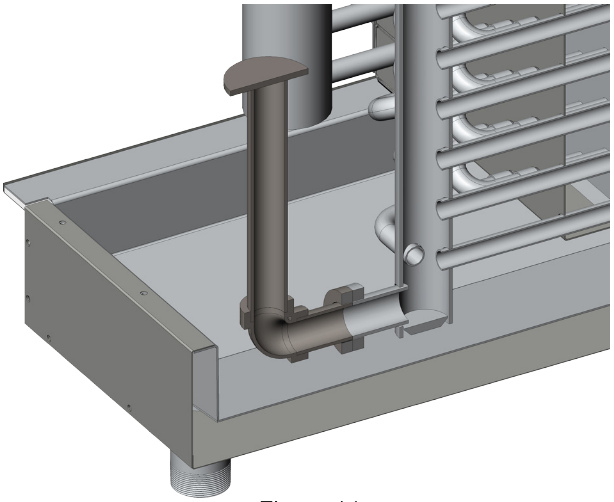


Figure 14
Trapped Liquid Connection

Vertical Liquid and Hot Gas Connections: Since nearly all piping in a refrigerated warehouse runs along the ceiling, and then vertically down to the air cooler coil connections, Colmac Coil’s vertical liquid and hot gas connections eliminates the need for field installed elbows and piping required to connect to horizontal connections. The result is time and money saved on the jobsite during installation.

THERMODYNAMIC WATER DEFROST™

Water defrost has many advantages:

- Fast – defrost duration is short
- Washes/cleans fin surfaces
- Energy efficient
- Simple

In spite of the benefits listed above water defrost has seen limited use, particularly at freezer temperatures, due to the perceived disadvantages of:

- Large water flowrate required
- Messy – frost and ice buildup from overspray
- Tendency of spray nozzles to foul and plug

Now Colmac Coil has introduced a new approach to water defrost addressing each of these challenges.

Thermodynamically correct water flow rate: Traditionally, the amount of defrost water shown by air cooler manufacturers has been based on rules of thumb such as “1-1/2 to 2 gpm per sq foot of face area”, or “3 gpm per sq foot of top area”. These rules of thumb are overly conservative and result in higher-than-needed defrost water flow rates and pumping power. Colmac Coil Thermodynamic Water Defrost™ limits the defrost water flow rate to only the amount needed to heat the mass of the coil metal and melt the frost, no more.

No more overspray: Colmac Coil engineers have solved the problem of splashing and overspray with a patented system combining a special fin design to limit water leaving the edges of fins, with a drain pan designed to fully contain defrost water.

Removable, cleanable water distribution pans: Fouling and plugging of spray nozzles is eliminated by the use of removable, cleanable water distribution pans. The distribution pans are designed to be easily removable for inspection and cleaning while the air cooler remains in place and undisturbed. See Figure 15.

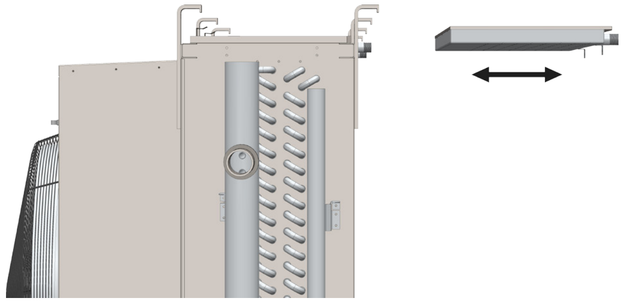


Figure 15
Removable Water Defrost Pan

FAIL-SAFE ELECTRIC DEFROST™

This patented electric defrost heater element design eliminates elements “creeping” or “walking” out of the heat exchanger, which can cause damage to elements and wiring. The new proprietary design extends heater element life and reduces the risk of damage and electrical failures. See Figure 16.

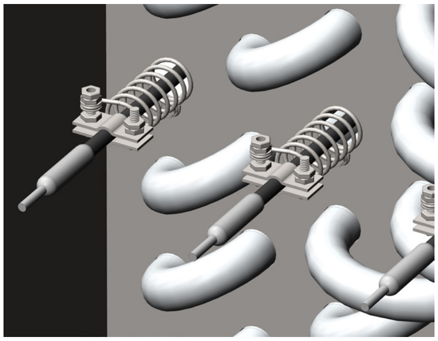
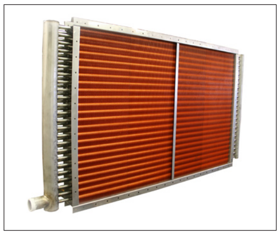


Figure 16
Heater Element
With Self Centering Spring

ONLINE SELECTION SOFTWARE

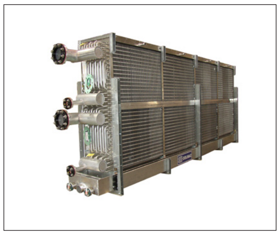
Colmac Coil has made selection, specification, and pricing of A+ Series™ air coolers fast and accurate with new online software. Access to this new state-of-the-art software tool is available to Colmac Coil representatives, and qualified engineers and end-users.

Other Quality Products From Colmac Coil


Heating and Cooling Coils


Heat Pipes for Heat Recovery


Dry Coolers for Glycol or Gas Cooling


Custom Evaporators & Baudelot Coolers


Air Cooled Condensers

CE(PED) Certification, ASME Sec. VIII, Canadian Registration Number, UL508, Canadian Standards Association

CE U CRN UL CSA

Visit www.colmaccoil.com for more information and resources:

Product Information
Product Literature
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Sales Rep e-Library
Product Videos

North American Headquarters
Colmac Coil Manufacturing, Inc.
370 N. Lincoln St. | P.O. Box 571
Colville, WA 99114 | USA
+1.509.684.2595 | +1.800.845.6778

Midwest US Manufacturing
Colmac Coil Midwest
350 Baltimore Dr. | Paxton, IL 60957 | USA

"The Heat Transfer Experts"

ENG00019355

Engineering Catalog

COLMAC COIL
Manufacturing Inc.

A+ Series™
Engineering Catalog
IP Units

Covers:

Refrigeration Air Coolers

- A+L - High Profile Unit
- A+M - Medium Profile Unit
- A+S - Low Profile Unit
- A+R - Process Room Unit

Refrigerants

- Ammonia
- R22, R134a, R404a, R507

ENG00019635 RevA

Table Of Contents

A+ Series™ Air Cooler Features

A+L High Profile Unit

- High profile for medium to large industrial applications
- "Plug-in" fan section for horizontal, 45° down, or penthouse air discharge
- High efficiency fans and premium efficiency motors standard
- Hinged fan panels standard
- Capacity range: 5 – 100 TR

A+M Medium Profile Unit

- Medium profile for small to medium industrial applications
- High efficiency fans and foot mounted motors with up to 3 Hp
- Hinged fan panels standard
- Optional full coverage drainpan
- Capacity range: 2 – 50 TR

A+S Low Profile Unit

- Low profile for small to medium industrial applications
- High efficiency fans and motors up to 1 Hp
- Hinged fan panels standard
- Optional full coverage drainpan
- Capacity range: 2 – 35 TR

A+R Process Room Unit

- "Above Rail" style air cooler for use in food processing rooms where cleanability is critical
- Optional "clean-in-place" piping available
- Hinged access panels standard
- Full coverage insulated drainpan standard
- Capacity range: 3 – 25 TR

MODEL NOMENCLATURE

A+M 3 3 I - 16 - 144 - 6 1R 4 V C - 0100 L - A RB - GG - S D - L

MODEL SERIES
- A+S
- A+M
- A+L
- A+R

NUMBER OF FANS

COIL MATERIALS
- 3 - SST/AL
- A - AL/AL
- C - CU/AL
- S - GALV
- 3CN - SST/AM
- 33 - SST/SST
- CC - CU/CU

TUBE PATTERN
- I - 5/8" STAGGERED
- M - 7/8" STAGGERED
- T - 5/8" INLINE

TUBES HIGH

FINNED LENGTH

ROWS DEEP

REHEAT ROWS
- 1R - 1 ROW
- 2R - 2 ROWS

FIN SPACING (FPI)

VARIABLE FINS

FIN TYPE
- F - FLAT
- C - CONFIGURED

MOTOR HP
- 0033 - 0.33
- 0050 - 0.5
- 0075 - 0.75
- 0100 - 1
- 0150 - 1.5
- 0200 - 2
- 0300 - 3
- 0500 - 5
- 0750 - 7.5
- 1000 - 10
- 1500 - 15

MOTOR SPEED
- S - 900
- L - 1200
- H - 1800
- R - 750
- K - 1000
- G - 1500

FLUID
- A - AMMONIA
- C - CO2
- F - R22, R507A, R404A, R404C
- B - BRINE, WATER, GLYCOL

FEED
- FL - FLOODED
- RB - RECIRC. BOTTOM
- RT - RECIRC. TOP
- DX - DIRECT EXPANSION
- BR - BRINE
- PT - CPR TOP
- PB - CPR BOTTOM

DEFROST
- AD - AIR COIL, AIR PAN
- AG - AIR COIL, HOT GAS PAN
- AE - AIR COIL, ELECTRIC PAN
- GA - HOT GAS COIL, AIR PAN
- GG - HOT GAS COIL, HOT GAS PAN
- GE - HOT GAS COIL, ELECTRIC PAN
- EA - ELECTRIC COIL, AIR PAN
- EG - ELECTRIC COIL, ELECTRIC PAN
- EE - ELECTRIC COIL, ELECTRIC PAN
- WW - WATER COIL, WATER PAN

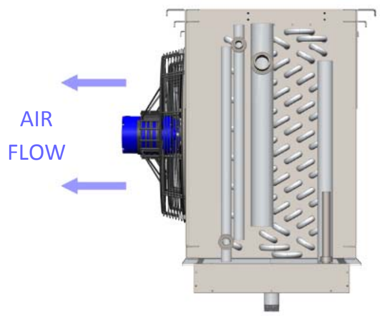
DISCHARGE
- S - STANDARD
- L - LONG THROW
- F - 45° DOWN
- P - PENTHOUSE
- 1 - 1/4" STATIC
- 2 - 1/2" STATIC
- 3 - 3/4" STATIC

FAN ORIENTATION
- D - DRAW THROUGH
- B - BLOW THROUGH

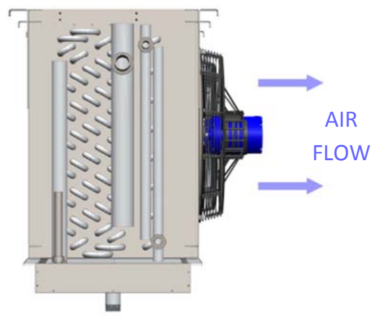
COIL HAND
- R- RIGHT
- L - LEFT

UNIT HAND DESIGNATION

Left Hand



Right Hand



COLMAC COIL
Manufacturing Inc.

CONSTRUCTION

Colmac Coil A+ Series™ air coolers offer a wide range of materials and configurations, providing the optimal solution for every application.

COIL MATERIALS

Coil construction materials are available to suit any working fluid and environment:

- Stainless steel tubes/aluminum fins (standard)
- Galvanized steel
- Stainless steel tubes and fins
- Copper tubes and fins
- Aluminum tubes/aluminum fins
- Copper tubes/aluminum fins
- Stainless steel tubes/anti-microbial fins

All coils are designed and manufactured according to ASME B31.5 (2001) and pressure tested to a minimum of 350 psig with air under water and shipped with a holding charge.

REFRIGERANTS

A+ Series™ air coolers can be designed to utilize any refrigerant, either volatile or non-volatile. This includes:

- Ammonia
- Water
- CO2
- Glycols
- R-22
- Calcium chloride
- R-507
- Potassium formate
- R-404a

Catalog ratings are given for Ammonia with correction factors provided for select refrigerants. Ratings for all other fluids can be obtained using the online A+Pro software or by contacting your local Colmac representative.

REFRIGERANT FEED METHODS

A+ Series™ air coolers are available in all feed methods. Coil circuiting is customized to match each application for optimal heat transfer with the lowest tube side pressure drop.

- Pump recirculated (top and bottom)
- Gravity flooded
- Standard DX
- Low temp DX ammonia
- CPR
- Single phase fluids

TUBES

All catalog selections feature 7/8" diameter tubes in a staggered arrangement. This pattern ensures air turbulence to maximize heat transfer efficiency at a low air pressure drop. It also offers a large amount of secondary (fin) surface area for maximum frost carrying capacity and extended runtime between defrosts. Additional 5/8" tube patterns are available using the online A+Pro software or by contacting your local Colmac representative.

A+ Series™ Air Cooler Features

FINS

All fins are a continuous design with a clean, full collar to optimize performance and cleanability while minimizing airflow resistance. Multiple fin spacing options are available to match every application.

- 3 or 4 FPI: Standard applications with light to moderate frost loads
- 6 FPI: Above freezing/wet fin applications
- Variable Spacing: High frost load applications

Fin Configurations

- Enhanced fins (standard): Highest heat transfer
- Flat fins: Reduced fan power, improved cleanability

CASING

All A+ Series™ air coolers feature hinged fan panels for ease of inspection, cleaning, and service. Care has also been taken to eliminate areas near the evaporator fins that are difficult to inspect and clean. Fan sections are sloped to allow for water drainage. Casings are constructed of durable, corrosion resistant G-90 galvanized steel as standard with stainless steel available as an option.

DRAINPAN

Colmac Coil's innovative "Triple Pitch" V-bottom drainpan design provides for rapid and complete drainage of melted frost and ice. Low spots and pooling of melted frost are completely eliminated. The pan drains to a single drain connection on one end, simplifying drain piping.

Materials

Inner:

- Aluminum (standard)
- Stainless steel (optional)

Outer cover (insulated pans):

- Matches casing as standard
- Available in any casing material
- Fully seal welded seams available as an option

FANS

All Colmac Coil A+ Series™ air coolers use high efficiency fan blades with a true airfoil shape. The airfoil shape can achieve mechanical efficiencies above 70% and lower sound levels during operation. These blades are also non-overloading to accommodate variations in static pressure due to frost buildup or condensing water. A wide range of fan diameters and speeds are available to match performance and sound requirements.

Materials

- PPG Composite (above 0°F operating temperature)
- PAG Composite (above -20°F operating temperature)
- Cast aluminum available on request (low temperature freezers)
- Optional stamped stainless steel for food processing applications

MOTORS/ELECTRICAL

All standard fan motors supplied with A+ Series™ air coolers are premium efficiency, internal rotor, totally enclosed and VFD compatible. Motors are supplied with low temperature grease when appropriate.

Motor Speed Options

- 900 rpm (low noise)
- 1200 rpm (standard)
- 1800 rpm

Power Options

- 460/60/3
- 575/60/3
- 380/60/3
- 230/60/3
- 400/50/3
- 200/50/3

Wiring Options

- Common disconnect, fused or non-fused (standard)
- Individual disconnects, fused or non-fused
- Common fused disconnect with motor starters
- Custom UL508 listed control panels available

All wiring options use NEMA 4X boxes as standard. All panels are UL listed.

DEFROST

Colmac Coil A+ Series™ air coolers are designed to defrost faster, using less energy, and eliminate drainpan icing problems. The coil and drainpan are available in combinations of:

- Hot gas
- Water
- Air
- Electric (5/8" inline tube pattern only)

STANDARD FEATURES

All A+ Series™ air coolers come with the following features as standard:

CRADLE CRATING SYSTEM

The unique cradle crating system from Colmac Coil supports the full weight of the air cooler while withstanding the rigors of shipment. The cradle crate also safely supports the weight of the air cooler while it is lifted into position from below. Then after the air cooler is secured to the ceiling, the crate is easily removed from the unit by gravity allowing it to be safely lowered to the ground.

VERTICAL CONNECTIONS

Colmac Coil's vertical liquid and hot gas connections eliminate the need for field installed elbows and piping required to connect to horizontal connections. The result is time and money saved on the jobsite during installation.

FREE DRAINING LIQUID CONNECTIONS

With conventional coil designs, the liquid connection enters the liquid header in such a way that the bottom tubes in the coil stay flooded with condensed refrigerant during defrost. The result is slow, uneven (or incomplete) defrosting of the coil. Colmac Coil has solved this problem by extending the liquid header downward and placing the liquid connection below the level of the lowest tube in the coil. This design effectively traps all condensed liquid refrigerant and forces it out of the coil during defrost, resulting in a fast, complete and effective defrost of the entire coil.

REMOVABLE WATER DISTRIBUTION PANS (Water Defrost Units)

Fouling and plugging of spray nozzles is eliminated by the use of removable, cleanable water distribution pans. The distribution pans are designed to be easily removable for inspection and cleaning while the air cooler remains in place and undisturbed.

BIMETALLIC COUPLERS

Aluminum tube coils come standard with Bimetallic Couplers. These couplers make the transition from aluminum to the steel (or stainless steel) piping connections via a proprietary metallurgical bonding process. Bolts, gaskets and flanges that can leak over time are eliminated.

AVAILABLE OPTIONS

AIR DISCHARGE ARRANGEMENTS (A+L only)

Long Throw Adapters

Fan guards are replaced with conical ducts which increase air throw distance approximately 30 - 40%. Consult your local Colmac representative.

45° Down Discharge

Fans are located in an optional, 45° down discharge duct. Fan capacities are calculated with an additional 1/4 iwg (62 Pa) of external static pressure.

Penthouse (90° down)

Fans are located in an optional, 90° down discharge duct (Penthouse). Access doors for inspection and motor removal are included. Fan capacities are calculated with an additional 1/2 iwg (124 Pa) of external static pressure.

Tube Axial Fans (external static pressure)

Fans are located in extended tubes that enhance the fan's ability to handle very large external static pressures. Consult your local Colmac representative.

WASHDOWN DUTY MOTORS

For applications where units are regularly washed down, these motors feature an epoxy coated finish and double sealed bearings.

REHEAT COIL SECTION

A condenser or hot fluid section can be added to the coil core to produce continuous dehumidification and reduce sweating by heating the air after it leaves the cooling coil section.

SEAL WELDED DRAINPAN

Fully welded seams on the drainpan cover improve hygiene and cleanability.

HINGED DRAINPAN

Drainpan hinges allow access for cleaning and maintenance.

FULL COVERAGE DRAINPAN (Standard on A+R)

Drainpan is extended to ensure that all water dripping off of the fans or casing is caught in the drainpan. This is not available on units with support legs.

ELECTRIC HEAT TRACE DRAINPAN COVER

Heat trace is added to the drainpan cover to keep it above the room dew point temperature, preventing condensate from forming on the cover and dripping. It is good for use in above freezing applications when the drainpan cover temperature may drop below the dew point temperature of the room air.

END COVERS

End covers enclose the header and/or return end of the unit to add protection from mechanical damage and hold in defrost heat. Covers are hinged to allow easy access for cleaning and maintenance. This is recommended for electric and water defrost units.

SUPPORT LEGS

Standard: Heights from 3 to 15 inches
Extended: Heights from 16 to 30 inches. Includes additional cross bracing for added stability.

SMART HANGER™ SYSTEM

This patented design was developed to make the process of mounting ceiling-hung air coolers faster and safer. Smart Hanger™ brackets and rails allow air cooler units to be hung from the ceiling without any personnel leaving the floor level. The time consuming process of aligning threaded rods into mounting holes while the unit is being lifted into position is eliminated, reducing suspended load time by as much as 75%. Side to side placement of the air cooler on the Smart Hanger™ rails is non-critical and therefore faster.

COIL INLET FILTER RACKS

Filters are added to inlet side of unit for applications with large amounts of airborne particulates.

COATED COIL CORE

Evaporator coils may be Heresite or Electrofin coated for added corrosion protection.

AIR DEFLECTORS (A+R only)

Air deflectors are added above fans to efficiently redirect air to the sides.

HIGH PERFORMANCE GLYCOL

This is optional when designing A+ Series™ air coolers for use with secondary refrigerants (glycols and brines). This significantly boosts performance while minimizing the pumping and fan power associated with secondary refrigerants. Ratings with this option may be obtained using our online A+Pro software or by contacting your local Colmac representative.

COLMAC COIL
Manufacturing Inc.

UNIT SELECTION

CAPACITY RATINGS

Evaporator ratings listed in the tables are given as gross capacity in Tons Refrigeration (TR). Ratings are based on the DT1 rating method for the following construction and conditions:

- 304L stainless steel tube/aluminum fin evaporator
- 7/8" tubes, staggered pattern (not available with electric defrost)
- Configured (waffle) fins
- Pump recirculated ammonia, 3:1 overfeed
- 1200 rpm fan speed

Frosted Conditions	Wet Conditions
-10°F air on temperature	35°F air on temperature
-20°F saturated suction temperature	25°F saturated suction temperature
85% RH Air	85% RH Air
3 FPI fin spacing	4 FPI fin spacing

SELECTION PROCEDURE

1. Calculate the total Net cooling load required in TR per unit.
2. Add the estimated motor heat of the cooler to the Net cooling load, which can be calculated as 0.35 TR/HP. Examining the motor power of units in the tables will help to improve this estimate.
3. Select the A+ Series™ cooler type that best fits the application and capacity range.
4. Choose the desired construction materials based on the refrigerant and operating environment.
5. If using alternate materials or conditions, find the appropriate correction factors given in Tables 1, 2 and 3.
6. Determine the temperature difference (TD) by taking the difference between the room and evaporator temperatures.
7. If using a TD other than 10°F, determine the TD correction factor by dividing the actual TD by 10°F. Example: For a 12°F TD, this factor would be 12°F / 10°F = 1.20.
8. Divide the required capacity by all of the applicable correction factors to apply them.
9. Determine if the tables for Frosted or Wet Conditions should be used. If the room temperature is below 35°F, Frosted Conditions should be used. For 35°F and above, the Wet Conditions tables should be used.
10. Select a unit that meets or exceeds the required capacity from the tables.
11. Verify that the fan motor heat of the selected unit match the estimate made in Step 2. If not, recalculate the required cooling load with the actual motor heat to see if the selected unit will still meet capacity. If it does not, a new unit must be selected based on the recalculated cooling load.

Example Selection #1:

Three units are needed to refrigerate a 0°F room with a total cooling load of 60 tons (net). The evaporator temperature is -12°F, and it is a pump recirculated ammonia (R-717) system. A+L coolers with two fans each will be used. The evaporator construction will be aluminum tube, aluminum fins. Ratings are required for sea level.

1. Determine the required load per unit: 60 TR / 3 units = 20 TR per unit

2. Add the estimated *fan motor heat* to the net capacity to get the *gross capacity*. In this example, it will be estimated as two 3 hp motors.
   Estimated *fan motor heat* = (number of fans) x (est. hp per motor) x (0.35 TR/hp)
   = 2 fans x 3 hp x 0.35 TR/hp = 2.1 TR

   The estimated *gross capacity* = 20 TR + 2.1 TR = 22.1 TR

3. Select the appropriate material correction factor from Table 1.
   Correction factor for aluminum tube, aluminum fin = 1.02

4. The feed method and elevation match those used in the tables, so those correction factors are not required.

5. Determine the temperature difference (TD) for the evaporator.
   TD = (air on temp) - (evaporator temp) = 0°F – (-12)°F = 12°F
   Because the catalog ratings are based on a 10°F TD, a TD correction factor must be calculated.

   TD correction factor = (actual TD) / (10°F) = 12°F / 10°F = 1.2

6. Divide the *gross capacity* in Step 2 by all of the correction factors found in Steps 3-5.
   Adjusted gross capacity = 22.1 TR / 1.02 / 1.2 = 18.0 TR

7. Determine if the Frosted Condition or Wet Condition tables should be used.
   0°F Room Temp < 35°F, so use Frosted Condition tables

8. Select a unit that meets or exceeds the *adjusted gross capacity* (18 TR) from the "A+L Two Fan Models" section. This results in selecting model A+L23M-24-132-63.0C-0500L, rated at 18 TR.

9. The selected unit has more motor horsepower than was estimated in Step 2. To verify that the selected unit will still meet capacity, we must recalculate Steps 2 and 6 with the actual motor horsepower.

   New *fan motor heat* = 2 fans x 5 hp ea x 0.35 TR/hp = 3.5 TR (Step 2)
   New *gross capacity* = 20 TR + 3.5 TR = 23.5 TR (Step 2)
   New *adjusted gross capacity* = 19.2 TR (Step 6)

   The selected unit's capacity does not meet the new *adjusted gross capacity*, so a different unit must be chosen.

10. Repeat Step 8 using the new *adjusted gross capacity* of 19.2 TR. The resulting unit selection is A+L23M-24-132-83.0C-0500L, which is rated at 20 TR.

11. Repeat Step 9. Both unit and calculations now have the same total motor horsepower, so no recalculations are required. This confirms the final selection is A+L23M-24-132-83.0C-0500L.

Example Selection #2:

Two units are required to refrigerate a 40°F room with a total cooling load of 18 tons (net). The evaporator temperature is 30°F, and it is a DX R-22 system. A+S coolers will be used with copper tube, aluminum fin construction. The lowest first cost unit ($/TR) is desired and the number of fans per unit is flexible. The elevation is 3,000 feet.

1. Determine the required load per unit: 20 TR / 2 units = 9 TR per unit

2. Add the estimated *fan motor heat* to the *net capacity* to get the *gross capacity*. In this example, it will be estimated as two 3/4 hp motors.
   Estimated *fan motor heat* = (number of fans) x (est. hp per motor) x (0.35 TR/hp)
   = 2 fans x 0.75 hp x 0.35 TR/hp = 0.53 TR

   The estimated *gross capacity* = 9 TR + 0.53 TR = 9.53 TR

3. Select the appropriate material correction factor from Table 1.
   Correction factor for copper tube, aluminum fin = 1.11

4. Select the appropriate refrigerant/feed method correction factor from Table 2.
   Correction factor for R-22, DX = 0.83

5. Select the appropriate elevation correction factor from Table 3. Correction factor for 3,000 feet = 0.94.

6. Determine the temperature difference (TD) for the evaporator.
   TD = (air on temp) - (evaporator temp) = 40°F – 30°F = 10°F
   This matches the catalog TD, so no TD correction factor is required.

7. Divide the *gross capacity* in Step 2 by all of the correction factors found in Steps 3-5.
   Adjusted gross capacity = 9.53 TR / 1.11 / 0.83 / 0.94 = 11 TR

8. Determine if the Frosted Condition or Wet Condition tables should be used.
   40°F Room Temp > 35°F, so use Wet Condition tables

9. Select a unit that meets or exceeds the *adjusted gross capacity* (11 TR) from the “A+S Lowest First Cost $/TR Models” section. This results in selecting model A+S33M-16-162-44.0C-0075L, rated at 12 TR.

10. The selected unit has more total motor horsepower than was estimated in Step 2. To verify that the selected unit will still meet capacity, we must recalculate Steps 2 and 6 with the actual motor horsepower.

    New *fan motor heat* = 3 fans x 0.75 hp ea x 0.35 TR/hp = 0.79 TR (Step 2)
    New *gross capacity* = 9.53 TR + 0.79 TR = 10.32 TR (Step 2)
    New *adjusted gross capacity* = 11.9 TR (Step 6)

    The selected unit’s capacity still exceeds the new *adjusted gross capacity*, confirming that it will still meet the required capacity with the higher fan heat. The final selection is A+S33M-16-162-44.0C-0075L.

CORRECTION FACTORS

To select a cooler of alternate construction materials, divide the required capacity by the appropriate correction factor in the table below.

Table 1: Material Correction Factors

Coil Material	Correction Factor
Stainless steel tube/aluminum fin (standard)	-
Aluminum tube and fin	1.02
Galvanized steel	0.85
Copper tube/aluminum fin	1.05
Stainless steel tube and fin	0.54
Stainless steel tube/anti-microbial fin	0.81
Copper tube and fin	1.11

For alternate refrigerants and feed methods, divide the required capacity by the appropriate factor in the table below.

Table 2: Refrigerant and Feed Method Correction Factors

Refrigerant	Feed Method	Correction Factors By Suction Temperature				
		+40F	+20F	0F	-20F	-40F
R-717	Pump recirc. - Bottom	1.0	1.0	1.0	1.0	1.0
	Pump recirc. - Top	1.0	1.0	1.0	1.0	1.0
	Flooded	1.0	1.0	1.0	1.0	1.0
	DX	0.83*	0.83*	*	*	*
	CPR	1.0	1.0	1.0	1.0	1.0
R-22 R-134a R-507 R-404a	Pump recirc. - Bottom	1.0	1.0	0.95	0.90	0.80
	Pump recirc. - Top	1.0	1.0	*	*	*
	Flooded	*				
	DX	0.83*	0.83*	0.83*	*	*

*Consult your local CCM representative for selections.

For ratings at an elevation other than sea level, divide the required capacity by the appropriate factor in the table below.

Table 3: Elevation Correction Factors

Elevation, ft Above Mean Sea Level	Correction Factor
0	1.00
1,000	0.98
2,000	0.96
3,000	0.94
4,000	0.91
5,000	0.89
6,000	0.87

SELECTION TABLES

The Selection Tables are divided according to cooler type. The first set of tables in each section show the lowest first cost unit for each capacity increment over the standard range. The remaining tables provide alternative options, arranged by the number of fans.

Additional custom selections are available using Colmac's A+Pro online software.

ELECTRICAL INFORMATION

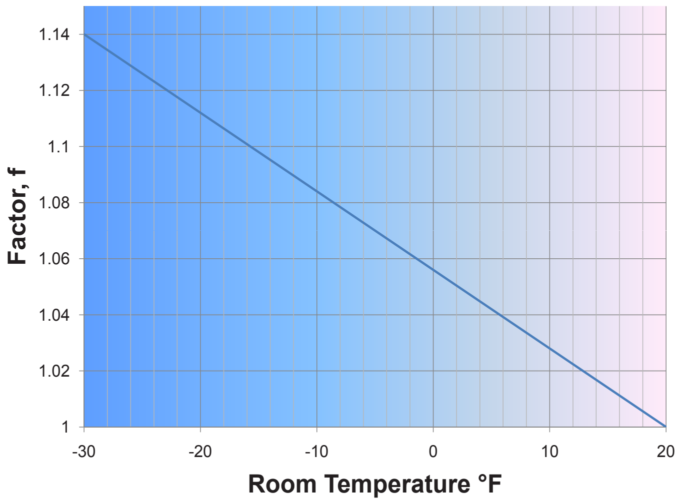
Table 4: Estimated Motor Full-Load Amps*

Motor Horsepower	208V (Amps)	230V (Amps)	460V (Amps)
0.33	1.7	1.5	0.8
0.5	2.4	2.2	1.1
0.75	3.5	3.2	1.6
1	4.6	4.2	2.1
1.5	6.6	6.0	3.0
2	7.5	6.8	3.4
3	10.7	9.6	4.8
5	16.7	15.2	7.6
7.5	24.2	22.0	11.0
10	30.8	28.0	14.0

*Based on 3 phase, 1200 rpm motors

When designing overload protection systems for temperatures below 20° F, apply the appropriate correction factor from the chart below to estimate the actual current draw.

Motor Amperage Correction vs. Temperature



SOUND PRESSURE ADJUSTMENT FOR DISTANCE

Sound data shown in the rating tables are in Sound Pressure Level (SPL) in dB(A). Sound Pressure is calculated based on 1/8 spherical field environment at a distance of 10 feet from the cooler. Sound Pressure at distances other than 10 ft can be determined by subtracting the reduction (dB) shown in the table below from the Sound Pressure Level shown in the rating tables.

Distance (ft)	10	15	20	25	30	40	50	60	70	80	90	100
Reduction (dB)	0	-3.5	-6	-8	-9.5	-12	-14	-15.5	-17	-18	-19	-20

A+ Series™ Air Cooler Features

A+L HIGH PROFILE UNITS

Capacity Range: 5 - 100 TR

Featuring:

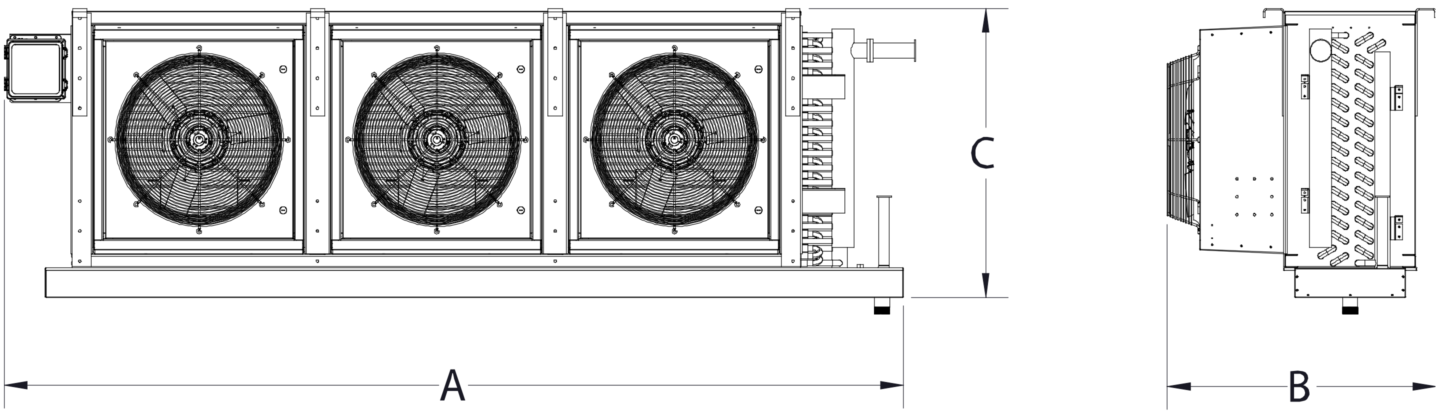
- 3/4 – 10 hp premium efficiency motors
- 26” – 48” diameter airfoil shaped fans
- 36” – 72” coil height
- 4 – 10 row deep coil
- Hinged fan panels
- Sloped fan boxes for water drainage

Options:

- Long air throw adapters
- 45° down air section
- Penthouse air section
- Tube Axial Fans (External Static Pressure)
- Reheat coil
- Seal welded drainpan
- Extended unit legs

A+L Unit Dimensions

Dimensions and weights provided in the tables may change based on the options and features selected. Do not use these for construction, refer to the factory submittal provided at time of order.



(3 fan unit shown)

A+L Lowest Cost ($/TR) Models

Table 4: Frosted Conditions*

Model Number	Capacity (TR)	Number of Fans	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Air Throw (FT)	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+L13M-20-48-63.0C-0150L	5	1	10042	669	6	2	30	0.3	159	74	1005	2.16	70	43	54	728
A+L13M-24-66-43.0C-0300L	6	1	18203	736	4	3	36	0.446	240	81	1106	2.34	88	43	63	938
A+L13M-24-66-63.0C-0300L	8	1	17018	688	6	3	36	0.327	224	82	1657	3.42	88	47	63	1088
A+L13M-24-66-83.0C-0500L	10	1	19796	800	8	5	36	0.381	261	81	2209	4.67	89	51	63	1331
A+L23M-20-120-63.0C-0200L	12	2	24415	651	6	2	30	0.295	193	78	2511	5.07	143	43	55	1636
A+L13M-32-66-83.0C-0750L	15	1	27800	842	8	7.5	48	0.389	275	88	2946	6.22	89	55	81	1652
A+L23M-24-132-63.0C-0500L	18	2	41931	847	6	5	36	0.473	276	85	3315	6.63	155	47	64	2203
A+L23M-24-132-83.0C-0500L	20	2	40110	810	8	5	36	0.401	264	85	4419	8.73	155	51	64	2527
A+L23M-28-144-63.0C-0750L	22	2	53487	849	6	7.5	42	0.478	302	89	4219	8.38	167	51	73	2733
A+L23M-28-144-83.0C-0500L	25	2	47403	752	8	5	42	0.315	268	86	5624	11.28	168	51	73	2973
A+L23M-32-132-83.0C-0750L	28	2	55600	842	8	7.5	48	0.389	275	91	5892	11.89	156	55	82	3166
A+L23M-32-132-83.0C-0750L	30	2	55600	842	8	7.5	48	0.389	275	91	5892	11.89	156	55	82	3166
A+L23M-32-144-83.0C-1000L	32	2	61087	848	8	10	48	0.416	302	91	6427	12.87	168	55	82	3414
A+L33M-28-180-83.0C-0500L	35	3	65566	833	8	5	42	0.343	247	87	7030	13.85	204	51	73	3859
A+L23M-32-144-103.0C-1000L	38	2	61130	849	10	10	48	0.393	302	97	8033	15.92	168	59	82	3879
A+L43M-28-288-63.0C-0500L	40	4	95434	757	6	5	42	0.383	269	90	8438	16.47	312	47	74	5017
A+L43M-24-264-83.0C-0500L	42	4	79185	800	8	5	36	0.379	261	87	8838	17.15	288	51	65	4917
A+L33M-32-216-83.0C-0750L	45	3	88607	820	8	7.5	48	0.388	292	98	9641	18.93	240	55	83	5033
A+L33M-32-198-103.0C-1000L	48	3	83163	840	10	10	48	0.41	274	94	11045	21.49	222	59	83	5285
A+L33M-32-216-103.0C-0750L	50	3	85263	789	10	7.5	48	0.351	281	99	12049	23.48	240	59	83	5640
A+L33M-32-216-103.0C-0750L	52	3	85264	790	10	7.5	48	0.351	281	99	12049	23.48	240	59	83	5640
A+L43M-28-288-83.0C-0500L	55	4	94803	752	8	5	42	0.314	268	89	11248	21.71	312	51	74	5766
A+L43M-32-264-83.0C-0750L	58	4	111200	842	8	7.5	48	0.389	275	94	11783	23.63	290	55	83	6172
A+L43M-32-264-83.0C-0750L	60	4	111200	842	8	7.5	48	0.389	275	94	11783	23.63	290	55	83	6172
A+L43M-32-288-83.0C-1000L	62	4	122173	848	8	10	48	0.416	302	94	12855	25.6	314	55	83	6689
A+L43M-32-288-83.0C-1000L	65	4	122173	848	8	10	48	0.416	302	94	12855	25.6	314	55	83	6689
A+L43M-32-264-103.0C-0750L	68	4	106984	811	10	7.5	48	0.351	264	95	14727	29.15	290	59	83	6905
A+L43M-32-288-103.0C-0750L	70	4	113685	789	10	7.5	48	0.336	281	100	16066	31.61	314	59	84	7462
A+L43M-32-288-103.0C-0750L	72	4	113684	790	10	7.5	48	0.336	281	100	16066	31.61	314	59	84	7462
A+L43M-32-288-103.0C-1000L	75	4	122259	849	10	10	48	0.386	302	100	16066	31.61	314	59	84	7597

*Ratings based on -10°F/85% rh air on temp, -20°F evaporating temp, 3 FPI fin spacing, 3:1 pumped ammonia (bottom feed).

Table 5: Wet Conditions**

Model Number	Capacity (TR)	Number of Fans	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Air Throw (FT)	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+L13M-16-52-64.0C-0100L	5	1	7247	558	6	1	26	0.187	132	71	1127	1.82	73	42	45	667
A+L13M-24-54-44.0C-0150L	6	1	12105	560	4	1.5	36	0.236	159	81	1171	1.92	75	39	63	772
A+L13M-28-60-44.0C-0200L	8	1	15522	591	4	2	42	0.178	175	81	1518	2.46	81	39	72	929
A+L13M-28-72-44.0C-0300L	10	1	18688	593	4	3	42	0.201	211	82	1822	2.89	93	43	72	1112
A+L13M-28-72-64.0C-0300L	12	1	18833	598	6	3	42	0.2	213	84	2731	4.26	93	47	72	1309
A+L23M-24-132-44.0C-0150L	15	2	28262	571	4	1.5	36	0.201	186	81	2863	4.37	154	39	64	1637
A+L23M-28-144-44.0C-0200L	18	2	35615	565	4	2	42	0.189	201	84	3644	5.53	166	39	73	1968
A+L23M-28-144-44.0C-0500L	20	2	37795	600	4	5	42	0.265	213	89	3644	5.53	166	43	73	2230
A+L23M-32-144-44.0C-0500L	22	2	41723	580	4	5	48	0.233	206	86	4164	6.32	166	43	82	2420
A+L23M-28-144-64.0C-0300L	25	2	37667	598	6	3	42	0.183	213	87	5463	8.19	166	47	73	2521
A+L23M-32-144-64.0C-0500L	28	2	41289	574	6	5	48	0.2	195	88	6243	9.36	166	47	82	2911
A+L33M-28-216-44.0C-0200L	30	3	53423	565	4	2	42	0.184	201	86	5466	8.36	239	39	73	2988
A+L43M-24-264-44.0C-0200L	32	4	59130	597	4	2	36	0.193	191	85	5726	8.64	287	39	65	3331
A+L23M-32-144-84.0C-0500L	35	2	42732	594	8	5	48	0.203	211	88	8322	12.62	167	51	82	3396
A+L43M-28-288-44.0C-0200L	38	4	67838	538	4	2	42	0.174	154	87	7288	10.94	311	39	74	3929
A+L43M-28-288-44.0C-0500L	40	4	75590	600	4	5	42	0.265	213	92	7288	10.97	311	43	74	4452
A+L53M-24-270-64.0C-0150L	42	5	58661	579	6	1.5	36	0.171	181	85	8780	13.09	293	43	65	4168
A+L43M-28-288-64.0C-0200L	45	4	64332	511	6	2	42	0.149	182	88	10926	16.24	311	43	74	4673
A+L43M-28-288-64.0C-0200L	48	4	63995	508	6	2	42	0.144	213	88	10926	16.24	311	43	74	4721
A+L43M-28-288-64.0C-0300L	50	4	75333	598	6	3	42	0.185	213	90	10926	16.24	311	47	74	4957
A+L43M-28-288-64.0C-0300L	52	4	75333	598	6	3	42	0.185	204	90	10926	16.24	311	47	74	4957
A+L43M-32-288-64.0C-0500L	55	4	82577	574	6	5	48	0.2	204	91	12487	18.55	311	47	83	5727
A+L43M-32-288-64.0C-0500L	58	4	82578	574	6	5	48	0.2	213	91	12487	18.55	311	47	83	5727
A+L43M-28-288-84.0C-0300L	60	4	72373	574	8	3	42	0.17	204	90	14564	21.5	311	51	74	5795
A+L43M-28-288-84.0C-0500L	62	4	75399	598	8	5	42	0.212	213	93	14564	21.5	311	51	74	6082
A+L43M-32-264-84.0C-0500L	65	4	79036	599	8	5	48	0.199	195	92	15257	22.6	287	51	83	6214
A+L43M-32-288-84.0C-0500L	68	4	85464	594	8	5	48	0.203	211	91	16644	24.84	312	51	83	6646
A+L43M-32-288-84.0C-0500L	70	4	85464	594	8	5	48	0.203	211	91	16644	24.84	312	51	83	6646
A+L43M-32-264-104.0C-0500L	72	4	77621	588	10	5	48	0.203	192	92	19068	28.4	288	54	83	7063
A+L43M-32-288-104.0C-0500L	75	4	84037	584	10	5	48	0.207	207	91	20802	30.86	312	54	84	7541
A+L43M-32-288-104.0C-0750L	78	4	85201	592	10	7.5	48	0.226	210	94	20802	30.86	312	59	84	7908

**Ratings based on +35°F/85% rh air on temp, +25°F evaporating temp, 4 FPI fin spacing, 3:1 pumped ammonia (bottom feed).

Additional models and custom selections available - contact your local Colmac Coil representative.

A+ Series™ Air Cooler Features

A+L One Fan Models

Table 6: Frosted Conditions*

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Air Throw (FT)	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+L13M-20-48-63.0C-0150L	5	10042	669	6	2	30	0.3	74	159	1005	2.16	70	43	54	728
A+L13M-24-66-43.0C-0300L	6	18203	736	4	3	36	0.446	81	240	1106	2.34	88	43	63	938
A+L13M-24-66-63.0C-0300L	8	17018	688	6	3	36	0.327	82	224	1657	3.42	88	47	63	1088
A+L13M-24-66-83.0C-0500L	10	19796	800	8	5	36	0.381	81	261	2209	4.67	89	51	63	1331
A+L13M-32-72-63.0C-0750L	12	28741	798	6	7.5	48	0.469	94	284	2411	5.15	95	51	81	1570
A+L13M-32-66-83.0C-0750L	15	27800	842	8	7.5	48	0.389	88	275	2946	6.22	89	55	81	1652

*Ratings based on -10°F/85% rh air on temp, -20°F evaporating temp, 3 FPI fin spacing, 3:1 pumped ammonia (bottom feed).

Table 7: Wet Conditions**

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Air Throw (FT)	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+L13M-16-52-64.0C-0100L	5	7247	558	6	1	26	0.187	71	132	1127	1.82	73	42	45	667
A+L13M-24-54-44.0C-0150L	6	12105	560	4	1.5	36	0.236	81	159	1171	1.92	75	63	75	772
A+L13M-28-60-44.0C-0200L	8	15522	591	4	2	42	0.178	81	175	1518	2.46	81	39	72	929
A+L13M-28-72-44.0C-0300L	10	18688	593	4	3	42	0.201	82	211	1822	2.89	93	43	72	1112
A+L13M-28-72-64.0C-0300L	12	18833	598	6	3	42	0.2	84	213	2731	4.26	93	47	72	1309
A+L13M-28-72-84.0C-0300L	15	18093	574	8	3	42	0.17	84	204	3641	5.68	94	51	72	1535
A+L13M-32-66-104.0C-0500L	18	19405	588	10	5	48	0.204	86	192	4767	7.44	88	54	82	1908
A+L23M-28-144-44.0C-0500L	20	37795	600	4	5	42	0.265	89	213	3644	5.53	166	43	73	2230

**Ratings based on +35°F/85% rh air on temp, +25°F evaporating temp, 4 FPI fin spacing, 3:1 pumped ammonia (bottom feed).

Additional models and custom selections available - contact your local Colmac Coil representative.

A+L Two Fan Models

Table 8: Frosted Conditions*

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Air Throw (FT)	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+L23M-20-96-63.0C-0075L	8	15899	530	6	0.75	30	0.179	125.61	77	2009	4.01	118	42	54	1250
A+L23M-20-96-63.0C-0200L	10	23170	772	6	2	30	0.336	183	79	2009	4.14	119	43	54	1410
A+L23M-20-120-63.0C-0200L	12	24415	651	6	2	30	0.295	193	78	2511	5.07	143	43	55	1636
A+L23M-28-144-43.0C-0300L	15	42667	677	4	3	42	0.333	241	86	2814	5.72	167	43	73	2032
A+L23M-24-132-63.0C-0500L	18	41931	847	6	5	36	0.473	276	85	3315	6.63	155	47	64	2203
A+L23M-24-132-83.0C-0500L	20	40110	810	8	5	36	0.401	264	85	4419	8.73	155	51	64	2527
A+L23M-28-144-63.0C-0750L	22	53487	849	6	7.5	42	0.478	302	89	4219	8.38	167	51	73	2733
A+L23M-28-144-83.0C-0500L	25	47403	752	8	5	42	0.315	268	86	5624	11.28	168	51	73	2973
A+L23M-32-132-83.0C-0750L	28	55600	842	8	7.5	48	0.389	275	91	5892	11.89	156	55	82	3166
A+L23M-32-132-83.0C-0750L	30	55600	842	8	7.5	48	0.389	275	91	5892	11.89	156	55	82	3166
A+L23M-32-144-83.0C-1000L	32	61087	848	8	10	48	0.416	302	91	6427	12.87	168	55	82	3414
A+L23M-32-144-103.0C-0750L	35	56842	789	10	7.5	48	0.342	281	97	8033	15.92	168	59	82	3812
A+L23M-32-144-103.0C-1000L	38	61130	849	10	10	48	0.393	302	97	8033	15.92	168	59	82	3879

*Ratings based on -10°F/85% rh air on temp, -20°F evaporating temp, 3 FPI fin spacing, 3:1 pumped ammonia (bottom feed).

Table 9: Wet Conditions**

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Air Throw (FT)	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+L23M-16-76-44.0C-0075L	5	9908	522	4	0.75	26	0.193	90	79	1099	1.74	97	38	45	866
A+L23M-16-104-44.0C-0075L	8	13996	538	4	0.75	26	0.184	127	73	1504	2.31	125	38	45	1043
A+L23M-16-104-64.0C-0100L	10	14495	558	6	1	26	0.186	132	74	2255	3.42	125	42	45	1242
A+L23M-20-96-64.0C-0150L	12	17989	600	6	1.5	30	0.215	142	76	2601	3.96	117	43	54	1401
A+L23M-24-132-44.0C-0150L	15	28262	571	4	1.5	36	0.201	186	81	2863	4.37	154	39	64	1637
A+L23M-28-144-44.0C-0200L	18	35615	565	4	2	42	0.189	201	84	3644	5.53	166	39	73	1968
A+L23M-28-120-64.0C-0200L	20	30504	581	6	2	42	0.171	172	87	4552	6.9	142	43	73	2119
A+L23M-32-144-44.0C-0500L	22	41723	580	4	5	48	0.233	206	86	4164	6.32	166	43	82	2420
A+L23M-28-144-64.0C-0300L	25	37667	598	6	3	42	0.183	213	87	5463	8.19	166	47	73	2521
A+L23M-32-144-64.0C-0500L	28	41289	574	6	5	48	0.2	204	88	6243	9.36	166	47	82	2911
A+L23M-28-144-84.0C-0300L	30	36187	574	8	3	42	0.17	204	87	7282	11.05	167	51	73	2975
A+L23M-32-132-84.0C-0500L	32	39518	599	8	5	48	0.199	195	89	7629	11.64	155	51	82	3201
A+L23M-32-144-84.0C-0500L	35	42732	594	8	5	48	0.203	211	88	8322	12.62	167	51	82	3396
A+L23M-32-144-104.0C-0500L	38	42018	584	10	5	48	0.208	207	88	10401	15.66	167	54	82	3852

**Ratings based on +35°F/85% rh air on temp, +25°F evaporating temp, 4 FPI fin spacing, 3:1 pumped ammonia (bottom feed).

Additional models and custom selections available - contact your local Colmac Coil representative.

A+L Three Fan Models

Table 10: Frosted Conditions*

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Air Throw (FT)	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+L33M-20-144-43.0C-0075L	10	25346	563	4	0.75	30	0.216	134	78	2010	4.09	167	38	55	1579
A+L33M-24-162-43.0C-0100L	12	30843	508	4	1	36	0.214	135	84	2714	5.46	185	38	64	1902
A+L33M-24-162-43.0C-0150L	15	40521	667	4	1.5	36	0.306	178	82	2714	5.46	185	39	64	2044
A+L33M-20-144-83.0C-0200L	18	32885	731	8	2	30	0.291	173	81	4017	7.89	167	47	55	2362
A+L33M-24-162-63.0C-0200L	20	41870	689	6	2	36	0.256	184	83	4068	8.02	185	43	64	2496
A+L33M-24-198-63.0C-0200L	22	43882	591	6	2	36	0.225	193	84	4972	9.67	221	43	64	2854
A+L33M-28-180-63.0C-0300L	25	57291	728	6	3	42	0.298	216	89	5274	10.55	204	47	73	3169
A+L33M-28-180-63.0C-0500L	28	66241	841	6	5	42	0.387	249	90	5274	10.55	204	47	73	3422
A+L33M-24-198-83.0C-0500L	30	60164	810	8	5	36	0.401	264	87	6628	12.99	222	51	65	3719
A+L33M-24-198-83.0C-0500L	32	59389	800	8	5	36	0.38	261	86	6628	12.99	222	51	65	3719
A+L33M-28-180-83.0C-0500L	35	65566	833	8	5	42	0.343	247	87	7030	13.85	204	51	73	3859
A+L33M-28-180-103.0C-0500L	38	61979	787	10	5	42	0.321	233	87	8786	17.16	204	54	74	4307
A+L33M-28-216-83.0C-0750L	40	80323	850	8	7.5	42	0.469	302	90	8436	16.57	240	55	74	4635
A+L33M-32-198-83.0C-0750L	42	83400	842	8	7.5	48	0.404	275	93	8838	17.34	222	55	83	4631
A+L33M-32-216-83.0C-0750L	45	88607	820	8	7.5	48	0.388	292	98	9641	18.93	240	55	83	5033
A+L33M-32-198-103.0C-1000L	48	83163	840	10	10	48	0.41	274	94	11045	21.49	222	59	83	5285
A+L33M-32-216-103.0C-0750L	50	85263	789	10	7.5	48	0.351	281	99	12049	23.48	240	59	83	5640
A+L33M-32-216-103.0C-0750L	52	85264	790	10	7.5	48	0.351	281	99	12049	23.48	240	59	83	5640
A+L33M-32-216-103.0C-1000L	55	91694	849	10	10	48	0.406	302	98	12049	23.47	240	59	83	5740

*Ratings based on -10°F/85% rh air on temp, -20°F evaporating temp, 3 FPI fin spacing, 3:1 pumped ammonia (bottom feed).

Table 11: Wet Conditions**

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Air Throw (FT)	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+L33M-16-114-64.0C-0075L	10	15388	540	6	0.75	26	0.161	94	79	2471	3.73	135	42	46	1452
A+L33M-16-156-44.0C-0100L	12	23308	598	4	1	26	0.246	142	77	2256	3.37	177	38	46	1562
A+L33M-16-156-64.0C-0100L	15	21742	558	6	1	26	0.186	132	75	3382	5.05	178	42	46	1822
A+L33M-24-162-44.0C-0150L	18	36337	598	4	1.5	36	0.243	159	88	3514	5.3	184	39	64	2104
A+L33M-20-180-64.0C-0100L	20	26851	477.3	6	1	30	0.136	141.43	79	4878	7.24	202	42	55	2323
A+L33M-24-198-44.0C-0150L	22	41000	552	4	1.5	36	0.193	180	83	4295	6.4	220	39	64	2404
A+L33M-20-180-84.0C-0150L	25	29939	532	8	1.5	30	0.184	158	82	6502	9.6	202	47	55	2823
A+L33M-24-198-64.0C-0200L	28	42524	573	6	2	36	0.183	187	83	6438	9.52	220	43	64	2976
A+L33M-28-216-44.0C-0300L	30	56064	593	4	3	42	0.198	211	87	5466	8.36	239	43	73	3202
A+L33M-28-180-64.0C-0300L	32	45755	581	6	3	42	0.165	172	88	6829	10.33	203	47	73	3336
A+L33M-28-216-64.0C-0300L	35	55767	590	6	3	42	0.194	210	89	8194	12.34	239	47	73	3766
A+L33M-24-198-104.0C-0300L	38	43523	586	10	3	36	0.197	191	87	10726	15.9	221	54	65	4161
A+L33M-32-216-64.0C-0500L	40	61933	574	6	5	48	0.204	204	89	9365	14.13	239	47	82	4352
A+L33M-32-216-64.0C-0500L	42	61934	574	6	5	48	0.204	204	89	9365	14.13	239	47	82	4352
A+L33M-32-198-84.0C-0500L	45	59277	599	8	5	48	0.216	195	90	11443	17.09	221	51	83	4696
A+L33M-32-216-84.0C-0500L	48	64098	594	8	5	48	0.199	211	90	12483	18.66	239	51	83	5029
A+L33M-32-216-84.0C-0500L	50	64098	594	8	5	48	0.199	211	90	12483	18.66	239	51	83	5029
A+L33M-32-216-84.0C-0500L	52	64098	594	8	5	48	0.199	211	90	12483	18.66	239	51	83	5029
A+L33M-32-216-104.0C-0750L	55	63901	592	10	7.5	48	0.239	210	93	15601	23.22	239	59	83	5987

**Ratings based on +35°F/85% rh air on temp, +25°F evaporating temp, 4 FPI fin spacing, 3:1 pumped ammonia (bottom feed).

Additional models and custom selections available - contact your local Colmac Coil representative.

A+L Four Fan Models

Table 12: Frosted Conditions*

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Air Throw (FT)	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+L43M-20-192-43.0C-0075L	12	33791	563	4	0.75	30	0.232	133	80	2680	5.32	215	38	55	2109
A+L43M-20-192-43.0C-0150L	15	44092	735	4	1.5	30	0.411	174	82	2680	5.32	215	39	55	2313
A+L43M-20-240-43.0C-0150L	18	45791	611	4	1.5	30	0.348	181	81	3350	6.58	263	39	55	2669
A+L43M-20-192-63.0C-0200L	20	46339	772	6	2	30	0.347	183	82	4018	7.84	215	43	55	2747
A+L43M-20-192-63.0C-0300L	22	50791	847	6	3	30	0.435	201	83	4018	7.83	215	47	55	3007
A+L43M-20-240-63.0C-0300L	25	55650	742	6	3	30	0.403	220	84	5023	9.9	264	47	56	3486
A+L43M-28-240-43.0C-0300L	28	81270	774	4	3	42	0.366	229	89	4690	9.44	264	43	74	3582
A+L43M-28-288-43.0C-0300L	30	85334	677	4	3	42	0.333	241	89	5628	11.16	312	43	74	4025
A+L43M-24-264-63.0C-0300L	32	67114	678	6	3	36	0.323	221	85	6630	12.98	288	47	65	4065
A+L43M-24-264-63.0C-0500L	35	83862	847	6	5	36	0.472	276	88	6630	12.98	288	47	65	4350
A+L43M-28-240-63.0C-0500L	38	88321	841	6	5	42	0.387	249	91	7032	13.85	264	47	74	4516
A+L43M-28-240-83.0C-0300L	40	71333	679	8	3	42	0.27	201	90	9373	18.29	264	51	74	4777
A+L43M-24-264-83.0C-0500L	42	79185	800	8	5	36	0.379	261	87	8838	17.15	288	51	65	4917
A+L43M-28-288-63.0C-0750L	45	106973	849	6	7.5	42	0.477	302	92	8438	16.47	312	51	74	5348
A+L43M-32-288-63.0C-0750L	48	117921	819	6	7.5	48	0.46	291	93	9644	18.81	312	51	83	5706
A+L43M-28-288-83.0C-0500L	50	94806	752	8	5	42	0.314	268	89	11248	21.71	312	51	74	5766
A+L43M-28-288-83.0C-0500L	52	92717	736	8	5	42	0.298	262	88	11248	21.71	312	51	74	5766
A+L43M-28-288-83.0C-0500L	55	94803	752	8	5	42	0.314	268	89	11248	21.71	312	51	74	5766
A+L43M-32-264-83.0C-0750L	58	111200	842	8	7.5	48	0.389	275	94	11783	23.63	290	55	83	6172
A+L43M-32-264-83.0C-0750L	60	111200	842	8	7.5	48	0.389	275	94	11783	23.63	290	55	83	6172
A+L43M-32-288-83.0C-1000L	62	122173	848	8	10	48	0.416	302	94	12855	25.6	314	55	83	6689
A+L43M-32-288-83.0C-1000L	65	122173	848	8	10	48	0.416	302	94	12855	25.6	314	55	83	6689
A+L43M-32-264-103.0C-0750L	68	106984	811	10	7.5	48	0.351	264	95	14727	29.15	290	59	83	6905
A+L43M-32-288-103.0C-0750L	70	113685	789	10	7.5	48	0.336	281	100	16066	31.61	314	59	84	7462
A+L43M-32-288-103.0C-0750L	72	113684	790	10	7.5	48	0.336	281	100	16066	31.61	314	59	84	7462
A+L43M-32-288-103.0C-1000L	75	122259	849	10	10	48	0.386	302	100	16066	31.61	314	59	84	7597

*Ratings based on -10°F/85% rh air on temp, -20°F evaporating temp, 3 FPI fin spacing, 3:1 pumped ammonia (bottom feed).

Table 13: Wet Conditions**

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Air Throw (FT)	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+L43M-16-208-44.0C-0075L	15	27992	538	4	0.75	26	0.184	128	76	3008	4.47	230	38	46	2015
A+L43M-20-192-44.0C-0075L	18	33127	552	4	0.75	30	0.153	131	79	3470	5.18	214	38	55	2164
A+L43M-16-208-64.0C-0100L	20	28990	558	6	1	26	0.186	132	77	4509	6.65	230	42	46	2440
A+L43M-20-192-64.0C-0075L	22	30274	505	6	0.75	30	0.126	120	79	5203	7.7	214	42	55	2560
A+L43M-20-192-64.0C-0150L	25	35977	600	6	1.5	30	0.203	142	79	5203	7.7	214	43	55	2753
A+L43M-20-192-84.0C-0150L	28	35996	600	8	1.5	30	0.201	142	82	6935	10.21	214	47	55	3152
A+L43M-24-264-44.0C-0150L	30	56524	571	4	1.5	36	0.201	186	84	5726	8.64	287	39	65	3251
A+L43M-24-264-44.0C-0200L	32	59130	597	4	2	36	0.193	195	85	5726	8.64	287	39	65	3331
A+L43M-28-288-44.0C-0200L	35	67838	538	4	2	42	0.174	191	87	7288	10.94	311	39	74	3929
A+L43M-28-288-44.0C-0200L	38	67838	538	4	2	42	0.174	191	87	7288	10.94	311	39	74	3929
A+L43M-28-288-44.0C-0500L	40	75590	600	4	5	42	0.265	213	92	7288	10.97	311	43	74	4452
A+L43M-32-288-44.0C-0500L	42	83447	580	4	5	48	0.232	206	89	8329	12.54	311	43	83	4834
A+L43M-28-288-64.0C-0200L	45	64332	511	6	2	42	0.149	182	88	10926	16.24	311	43	74	4673
A+L43M-28-288-64.0C-0200L	48	63995	508	6	2	42	0.144	181	88	10926	16.24	311	43	74	4721
A+L43M-28-288-64.0C-0300L	50	75333	598	6	3	42	0.185	213	90	10926	16.24	311	47	74	4957
A+L43M-28-288-64.0C-0300L	52	75333	598	6	3	42	0.185	213	90	10926	16.24	311	47	74	4957
A+L43M-32-288-64.0C-0500L	55	82577	574	6	5	48	0.2	204	91	12487	18.55	311	47	83	5727
A+L43M-32-288-64.0C-0500L	58	82578	574	6	5	48	0.2	204	91	12487	18.55	311	47	83	5727
A+L43M-28-288-84.0C-0300L	60	72373	574	8	3	42	0.17	204	90	14564	21.5	311	51	74	5795
A+L43M-28-288-84.0C-0500L	62	75399	598	8	5	42	0.212	213	93	14564	21.5	311	51	74	6082
A+L43M-32-264-84.0C-0500L	65	79036	599	8	5	48	0.199	195	92	15257	22.6	287	51	83	6214
A+L43M-32-288-84.0C-0500L	68	85464	594	8	5	48	0.203	211	91	16644	24.84	312	51	83	6646
A+L43M-32-288-84.0C-0500L	70	85464	594	8	5	48	0.203	211	91	16644	24.84	312	51	83	6646
A+L43M-32-264-104.0C-0500L	72	77621	588	10	5	48	0.203	192	92	19068	28.4	288	54	83	7063
A+L43M-32-288-104.0C-0500L	75	84037	584	10	5	48	0.207	207	91	20802	30.86	312	54	84	7541
A+L43M-32-288-104.0C-0750L	78	85201	592	10	7.5	48	0.226	210	94	20802	30.86	312	59	84	7908

**Ratings based on +35°F/85% rh air on temp, +25°F evaporating temp, 4 FPI fin spacing, 3:1 pumped ammonia (bottom feed).

Additional models and custom selections available - contact your local Colmac Coil representative.

A+L Five Fan Models

Table 14: Frosted Conditions*

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Air Throw (FT)	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+L53M-20-240-43.0C-0075L	15	42239	563	4	0.75	30	0.232	133	81	3350	6.59	263	38	55	2619
A+L53M-20-240-43.0C-0100L	18	46550	621	4	1	30	0.259	147	81	3350	6.58	263	38	55	2667
A+L53M-20-240-43.0C-0200L	20	61750	823	4	2	30	0.431	195	82	3350	6.58	263	39	55	2971
A+L53M-20-300-43.0C-0150L	22	56086	598	4	1.5	30	0.333	177	81	4188	8.12	323	39	56	3307
A+L53M-20-240-63.0C-0200L	25	57924	772	6	2	30	0.343	183	83	5023	9.9	264	43	56	3432
A+L53M-20-240-63.0C-0300L	28	63488	847	6	3	30	0.429	201	84	5023	9.9	264	47	56	3757
A+L53M-20-300-63.0C-0300L	30	69562	742	6	3	30	0.424	220	85	6278	12.21	324	47	56	4317
A+L53M-24-270-63.0C-0200L	32	69273	684	6	2	36	0.258	182	86	6781	13.26	294	43	65	4090
A+L53M-28-300-43.0C-0300L	35	103061	785	4	3	42	0.378	233	90	5863	11.6	324	43	74	4434
A+L53M-24-270-83.0C-0200L	38	64884	641	8	2	36	0.223	171	86	9038	17.5	294	47	65	4672
A+L53M-28-300-63.0C-0300L	40	94249	718	6	3	42	0.306	213	91	8790	17.11	324	47	74	5175
A+L53M-28-300-63.0C-0300L	42	94252	718	6	3	42	0.306	213	91	8790	17.11	324	47	74	5175
A+L53M-28-300-63.0C-0500L	45	110401	841	6	5	42	0.41	249	92	8790	17.11	324	47	74	5598
A+L53M-20-300-103.0C-0500L	48	73187	781	10	5	30	0.407	231	86	10459	20.04	324	54	57	5761
A+L53M-24-270-103.0C-0500L	50	85916	849	10	5	36	0.386	226	92	11296	21.75	294	54	65	5961
A+L53M-24-270-103.0C-0500L	52	85916	849	10	5	36	0.386	226	92	11296	21.75	294	54	65	5961
A+L53M-28-300-83.0C-0500L	55	109277	833	8	5	42	0.337	247	89	11716	23.27	326	51	74	6361
A+L53M-28-300-83.0C-0500L	58	109277	833	8	5	42	0.337	247	89	11716	23.27	326	51	74	6361
A+L53M-28-300-83.0C-0500L	60	109277	833	8	5	42	0.337	247	89	11716	23.27	326	51	74	6361
A+L53M-28-300-103.0C-0500L	62	103298	787	10	5	42	0.305	233	89	14643	28.74	326	54	75	7096
A+L53M-28-300-103.0C-0500L	65	105345	803	10	5	42	0.32	238	90	14643	28.74	326	54	75	7096
A+L53M-28-300-103.0C-0750L	68	111456	849	10	7.5	42	0.368	252	92	14643	28.74	326	59	75	7486
A+L53M-28-300-103.0C-0750L	70	111456	849	10	7.5	42	0.368	252	92	14643	28.74	326	59	75	7486

*Ratings based on -10°F/85% rh air on temp, -20°F evaporating temp, 3 FPI fin spacing, 3:1 pumped ammonia (bottom feed).

Table 15: Wet Conditions**

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Air Throw (FT)	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+L53M-16-190-44.0C-0075L	15	28483	600	4	0.75	26	0.172	104	74	2747	4.1	212	38	46	2069
A+L53M-16-260-44.0C-0075L	18	34990	538	4	0.75	26	0.186	128	77	3760	5.57	282	38	47	2549
A+L53M-16-260-44.0C-0100L	20	38847	598	4	1	26	0.238	142	79	3760	5.57	282	38	47	2607
A+L53M-20-240-44.0C-0075L	22	41410	552	4	0.75	30	0.157	131	80	4338	6.45	262	38	55	2693
A+L53M-20-300-44.0C-0100L	25	48409	516	4	1	30	0.194	153	80	5423	7.99	322	38	56	3205
A+L53M-20-300-44.0C-0150L	28	56056	598	4	1.5	30	0.252	177	83	5423	7.99	322	39	56	3408
A+L53M-24-270-44.0C-0100L	30	52839	522	4	1	36	0.154	139	86	5856	8.83	293	38	65	3315
A+L53M-24-270-44.0C-0150L	32	60523	598	4	1.5	36	0.225	159	88	5856	8.83	293	39	65	3527
A+L53M-20-300-64.0C-0150L	35	53715	573	6	1.5	30	0.215	170	83	8129	12.04	323	43	56	4042
A+L53M-28-300-44.0C-0150L	38	67868	517	4	1.5	42	0.184	153	92	7592	11.37	323	39	74	4132
A+L53M-28-300-44.0C-0200L	40	77611	591	4	2	42	0.184	175	88	7592	11.4	323	39	74	4297
A+L53M-24-270-64.0C-0150L	42	58661	579	6	1.5	36	0.171	154	85	8780	13.09	293	43	65	4168
A+L53M-28-300-64.0C-0150L	45	62803	479	6	1.5	42	0.149	142	92	11381	16.88	323	43	74	4961
A+L53M-28-300-64.0C-0150L	48	62803	479	6	1.5	42	0.149	142	92	11381	16.88	323	43	74	4961
A+L53M-28-300-64.0C-0200L	50	76259	581	6	2	42	0.163	172	91	11381	16.88	323	43	74	5122
A+L53M-28-300-64.0C-0200L	52	74187	565	6	2	42	0.163	167	90	11381	16.88	323	43	74	5061
A+L53M-28-300-84.0C-0200L	55	68598	523	8	2	42	0.146	155	90	15170	22.36	323	47	74	5885
A+L53M-28-300-84.0C-0200L	58	68598	523	8	2	42	0.146	155	90	15170	22.36	323	47	74	5885
A+L53M-28-300-84.0C-0200L	60	71512	545	8	2	42	0.147	161	92	15170	22.36	323	47	74	5947
A+L53M-28-300-84.0C-0300L	62	78250	596	8	3	42	0.17	177	92	15170	22.36	323	51	74	6292
A+L53M-28-300-84.0C-0300L	65	78250	596	8	3	42	0.17	177	92	15170	22.36	323	51	74	6292
A+L53M-28-300-104.0C-0300L	68	76442	582	10	3	42	0.176	173	92	18960	27.85	323	54	75	7118
A+L53M-28-300-104.0C-0300L	70	77363	589	10	3	42	0.189	175	94	18960	28.09	324	54	75	7153

**Ratings based on +35°F/85% rh air on temp, +25°F evaporating temp, 4 FPI fin spacing, 3:1 pumped ammonia (bottom feed).

Additional models and custom selections available - contact your local Colmac Coil representative.

A+L PENTHOUSE AND 45° DOWN UNITS

Capacity Range: 5 - 100 TR

Featuring:

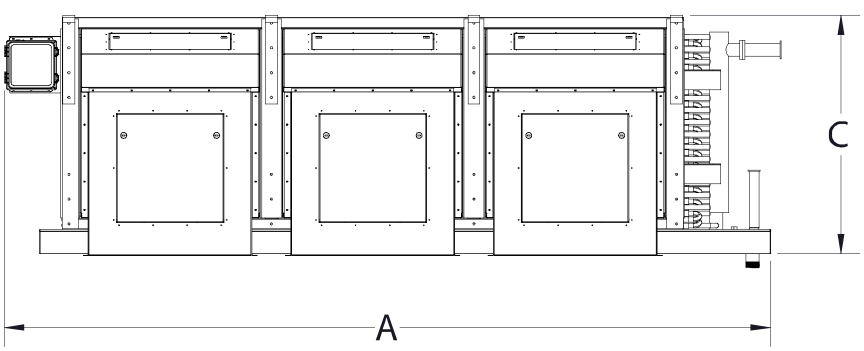
- 3/4 – 10 hp premium efficiency motors
- 26” – 48” diameter airfoil shaped fans
- 36” – 72” coil height
- 4 – 10 row deep coil
- Sloped fan boxes for water drainage
- 45 degree down versions include ¼” external static pressure

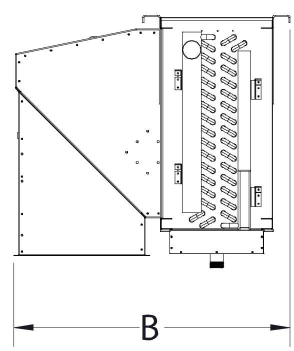
Options:

- Reheat coil
- Seal welded drainpan

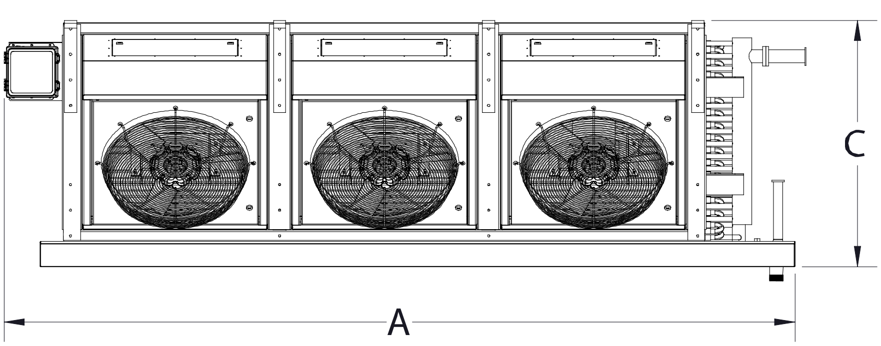
A+L Penthouse and 45° Down Unit Dimensions

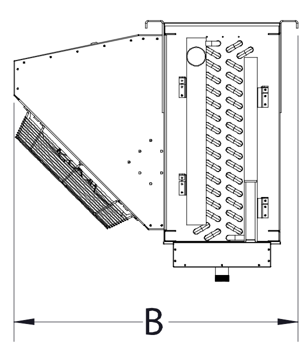
Dimensions and weights provided in the tables may change based on the options and features selected. Do not use these for construction, refer to the factory submittal provided at time of order.





(3 fan penhouse unit shown)





(3 fan 45° down unit shown)

A+L Penthouse and 45° Down Lowest Cost ($/TR) Models

Table 16: Frosted Conditions*

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Surface Area (FT^2)	Internal Volume (FT^3)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+L13M-20-48-63.0C-0200L	5	11130	742	6	2	30	0.335	76	1005	2.16	70	59	54	943
A+L13M-24-66-43.0C-0300L	6	17567	710	4	3	36	0.432	79	1106	2.34	88	61	63	1240
A+L13M-20-60-83.0C-0500L	8	15063	803	8	5	30	0.484	79	1674	3.45	82	62	54	1342
A+L13M-24-66-83.0C-0500L	10	19512	788	8	5	36	0.385	81	2209	4.67	89	69	63	1637
A+L13M-32-72-63.0C-0750L	12	30332	843	6	7.5	48	0.465	92	2411	5.15	95	78	81	2019
A+L13M-32-66-83.0C-1000L	15	28039	850	8	10	48	0.436	94	2946	6.22	89	82	81	2153
A+L23M-24-132-63.0C-0500L	18	40802	824	6	5	36	0.456	84	3315	6.63	155	65	64	2805
A+L23M-24-132-83.0C-0500L	20	39025	788	8	5	36	0.384	84	4419	8.73	155	69	64	3128
A+L23M-28-120-83.0C-0500L	22	42894	817	8	5	42	0.374	85	4687	9.32	143	75	73	3324
A+L23M-32-144-63.0C-0750L	25	60664	843	6	7.5	48	0.463	95	4822	9.85	168	78	82	3901
A+L33M-24-162-83.0C-0500L	28	51596	849	8	5	36	0.395	90	5423	10.78	186	69	64	4058
A+L23M-32-132-83.0C-1000L	30	56079	850	8	10	48	0.435	97	5892	11.89	156	82	82	4154
A+L23M-32-144-83.0C-0750L	32	58321	810	8	7.5	48	0.374	96	6427	12.87	168	82	82	4307
A+L33M-28-180-83.0C-0500L	35	64340	817	8	5	42	0.347	87	7030	13.85	204	75	73	4897
A+L43M-28-240-63.0C-0500L	38	88368	842	6	5	42	0.413	91	7032	13.85	264	71	74	5833
A+L33M-28-180-103.0C-0750L	40	66706	847	10	7.5	42	0.412	90	8786	17.19	204	79	74	5499
A+L43M-24-264-83.0C-0500L	42	78047	788	8	5	36	0.383	87	8838	17.15	288	69	65	6109
A+L33M-32-216-83.0C-0750L	45	87482	810	8	7.5	48	0.394	98	9641	18.93	240	82	83	6387
A+L43M-24-264-103.0C-0500L	48	74655	754	10	5	36	0.344	87	11045	21.3	288	73	65	6675
A+L43M-32-288-63.0C-0750L	50	121328	843	6	7.5	48	0.462	98	9644	18.81	312	78	83	7616
A+L33M-32-216-103.0C-0750L	52	81304	753	10	7.5	48	0.35	93	12049	23.48	240	85	83	7042
A+L33M-32-216-103.0C-1000L	55	90478	838	10	10	48	0.411	99	12049	23.47	240	85	83	7094
A+L43M-28-288-83.0C-0750L	58	105433	837	8	7.5	42	0.424	90	11248	21.71	312	75	74	7588
A+L53M-28-300-83.0C-0500L	60	107233	817	8	5	42	0.341	89	11716	23.27	326	75	74	8083
A+L43M-32-288-83.0C-0750L	62	116643	810	8	7.5	48	0.373	99	12855	25.6	314	82	83	8464
A+L43M-32-288-83.0C-0750L	65	116642	810	8	7.5	48	0.373	99	12855	25.6	314	82	83	8464
A+L43M-32-264-103.0C-0750L	68	105705	801	10	7.5	48	0.355	95	14727	29.15	290	85	83	8754
A+L43M-32-288-103.0C-1000L	70	120638	838	10	10	48	0.392	100	16066	31.61	314	85	84	9395
A+L43M-32-288-103.0C-1000L	72	120638	838	10	10	48	0.392	100	16066	31.61	314	85	84	9395
A+L43M-32-288-103.0C-1000L	75	120638	838	10	10	48	0.392	100	16066	31.61	314	85	84	9395

*Ratings based on -10°F/85% rh air on temp, -20°F evaporating temp, 3 FPI fin spacing, 3:1 pumped ammonia (bottom feed).

Additional models and custom selections available - contact your local Colmac Coil representative.

A+L Penthouse and 45° Down Lowest Cost ($/TR) Models

Table 17: Wet Conditions**

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+L13M-16-52-64.0C-0100L	5	7170	552	6	1	26	0.194	72	1127	1.82	73	52	45	825
A+L13M-24-54-44.0C-0150L	6	12126	599	4	1.5	36	0.218	77	1171	1.92	75	61	63	1062
A+L13M-24-66-44.0C-0300L	8	14836	599	4	3	36	0.225	82	1432	2.29	87	61	63	1267
A+L13M-28-72-44.0C-0300L	10	18658	592	4	3	42	0.209	82	1822	2.89	93	67	72	1508
A+L13M-28-72-64.0C-0300L	12	18552	589	6	3	42	0.202	84	2731	4.26	93	71	72	1717
A+L13M-32-72-64.0C-0500L	15	21445	596	6	5	48	0.217	85	3122	4.93	94	78	81	2006
A+L23M-20-120-84.0C-0200L	18	21784	581	8	2	30	0.191	78	4334	6.52	142	62	55	2397
A+L23M-28-144-44.0C-0300L	20	37315	592	4	3	42	0.213	86	3644	5.53	166	67	73	2890
A+L23M-32-144-44.0C-0500L	22	41166	572	4	5	48	0.235	87	4164	6.32	166	74	82	3388
A+L23M-28-144-64.0C-0300L	25	37104	589	6	3	42	0.184	87	5463	8.19	166	71	73	3324
A+L23M-32-144-64.0C-0500L	28	42889	596	6	5	48	0.217	88	6243	9.58	167	78	82	3909
A+L23M-32-144-64.0C-0500L	30	42889	596	6	5	48	0.217	88	6243	9.58	167	78	82	3909
A+L33M-28-180-64.0C-0300L	32	46576	591	6	3	42	0.182	87	6829	10.33	203	71	73	4338
A+L23M-32-144-84.0C-0500L	35	42211	586	8	5	48	0.205	88	8322	12.62	167	82	82	4365
A+L23M-32-144-104.0C-0500L	38	41536	577	10	5	48	0.209	88	10401	15.66	167	85	82	4821
A+L43M-28-240-64.0C-0200L	40	58429	557	6	2	42	0.171	89	9105	13.66	263	71	74	5543
A+L33M-32-216-64.0C-0500L	42	64334	596	6	5	48	0.221	90	9365	14.13	239	78	82	5805
A+L33M-32-198-84.0C-0500L	45	58513	591	8	5	48	0.218	90	11443	17.09	221	82	83	6049
A+L43M-28-288-64.0C-0300L	48	74209	589	6	3	42	0.187	90	10926	16.24	311	71	74	6555
A+L43M-28-288-64.0C-0300L	50	74208	589	6	3	42	0.187	90	10926	16.24	311	71	74	6555
A+L43M-28-288-64.0C-0300L	52	74208	589	6	3	42	0.187	90	10926	16.24	311	71	74	6555
A+L43M-32-288-64.0C-0500L	55	85779	596	6	5	48	0.216	91	12487	18.55	311	78	83	7656
A+L43M-32-288-64.0C-0500L	58	85779	596	6	5	48	0.216	91	12487	18.55	311	78	83	7656
A+L43M-32-288-64.0C-0500L	60	85779	596	6	5	48	0.216	91	12487	18.55	311	78	83	7656
A+L43M-28-288-84.0C-0500L	62	75176	597	8	5	42	0.185	90	14564	21.5	311	75	74	7624
A+L53M-28-300-84.0C-0300L	65	78420	598	8	3	42	0.181	92	15170	22.36	323	75	74	7953
A+L43M-32-288-84.0C-0500L	68	84423	586	8	5	48	0.205	91	16644	24.84	312	82	83	8574
A+L43M-32-288-84.0C-0500L	70	84423	586	8	5	48	0.205	91	16644	24.84	312	82	83	8574
A+L43M-32-288-104.0C-0500L	72	83073	577	10	5	48	0.209	91	20802	30.86	312	85	84	9470
A+L43M-32-288-104.0C-0500L	75	83072	577	10	5	48	0.209	91	20802	30.86	312	85	84	9470
A+L43M-32-288-104.0C-0750L	78	86072	598	10	7.5	48	0.243	95	20802	30.86	312	85	84	9705

**Ratings based on +35°F/85% rh air on temp, +25°F evaporating temp, 4 FPI fin spacing, 3:1 pumped ammonia (bottom feed).

Additional models and custom selections available - contact your local Colmac Coil representative.

A+L Penthouse and 45° Down One Fan Models

Table 18: Frosted Conditions*

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+L13M-20-48-63.0C-0200L	5	11130	742	6	2	30	0.335	76	1005	2.16	70	59	54	943
A+L13M-24-66-43.0C-0300L	6	17567	710	4	3	36	0.432	79	1106	2.34	88	61	63	1240
A+L13M-20-60-83.0C-0500L	8	15063	803	8	5	30	0.484	79	1674	3.45	82	62	54	1342
A+L13M-24-66-83.0C-0500L	10	19512	788	8	5	36	0.385	81	2209	4.67	89	69	63	1637
A+L13M-32-72-63.0C-0750L	12	30332	843	6	7.5	48	0.465	92	2411	5.15	95	78	81	2019
A+L13M-32-66-83.0C-1000L	15	28039	850	8	10	48	0.436	94	2946	6.22	89	82	81	2153
A+L13M-32-72-103.0C-1000L	18	30160	838	10	10	48	0.399	94	4016	8.27	95	85	82	2513

*Ratings based on -10°F/85% rh air on temp, -20°F evaporating temp, 3 FPI fin spacing, 3:1 pumped ammonia (bottom feed).

Table 19: Wet Conditions**

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+L13M-16-52-64.0C-0100L	5	7170	552	6	1	26	0.194	72	1127	1.82	73	52	45	825
A+L13M-24-54-44.0C-0150L	6	12126	599	4	1.5	36	0.218	77	1171	1.92	75	61	63	1062
A+L13M-24-66-44.0C-0300L	8	14836	599	4	3	36	0.225	82	1432	2.29	87	61	63	1267
A+L13M-28-72-44.0C-0300L	10	18658	592	4	3	42	0.209	82	1822	2.89	93	67	72	1508
A+L13M-28-72-64.0C-0300L	12	18552	589	6	3	42	0.202	84	2731	4.26	93	71	72	1717
A+L13M-32-72-64.0C-0500L	15	21445	596	6	5	48	0.217	85	3122	4.93	94	78	81	2006
A+L13M-32-72-104.0C-0500L	18	20768	577	10	5	48	0.21	85	5200	8.06	94	85	82	2516

**Ratings based on +35°F/85% rh air on temp, +25°F evaporating temp, 4 FPI fin spacing, 3:1 pumped ammonia (bottom feed).

Additional models and custom selections available - contact your local Colmac Coil representative.

A+L Penthouse and 45° Down Two Fan Models

Table 20: Frosted Conditions*

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Surface Area (FT^2)	Internal Volume (FT^3)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+L23M-20-96-43.0C-0075L	6	16590	553	4	0.75	30	0.236	77	1340	2.72	118	55	54	1467
A+L23M-20-96-43.0C-0300L	8	25460	849	4	3	30	0.584	80	1340	2.72	118	55	54	1695
A+L23M-20-96-63.0C-0200L	10	22261	742	6	2	30	0.327	79	2009	4.14	119	59	54	1792
A+L23M-20-120-63.0C-0200L	12	23729	633	6	2	30	0.291	79	2511	5.07	143	59	55	2098
A+L23M-28-144-43.0C-0300L	15	41309	656	4	3	42	0.331	86	2814	5.72	167	67	73	2834
A+L23M-24-132-63.0C-0500L	18	40802	824	6	5	36	0.456	84	3315	6.63	155	65	64	2805
A+L23M-24-132-83.0C-0500L	20	39025	788	8	5	36	0.384	84	4419	8.73	155	69	64	3128
A+L23M-28-120-83.0C-0500L	22	42894	817	8	5	42	0.374	85	4687	9.32	143	75	73	3324
A+L23M-32-144-63.0C-0750L	25	60664	843	6	7.5	48	0.463	95	4822	9.85	168	78	82	3901
A+L23M-28-144-83.0C-0750L	28	52717	837	8	7.5	42	0.424	87	5624	11.27	168	75	73	3886
A+L23M-32-132-83.0C-1000L	30	56079	850	8	10	48	0.435	97	5892	11.89	156	82	82	4154
A+L23M-32-144-83.0C-0750L	32	58321	810	8	7.5	48	0.374	96	6427	12.87	168	82	82	4307
A+L23M-32-144-103.0C-1000L	35	60319	838	10	10	48	0.398	97	8033	15.92	168	85	82	4782

*Ratings based on -10°F/85% rh air on temp, -20°F evaporating temp, 3 FPI fin spacing, 3:1 pumped ammonia (bottom feed).

Table 21: Wet Conditions**

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Surface Area (FT^2)	Internal Volume (FT^3)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+L23M-16-76-44.0C-0075L	5	9989	526	4	0.75	26	0.235	78	1099	1.74	97	48	45	1111
A+L23M-16-104-44.0C-0075L	8	13772	530	4	0.75	26	0.185	73	1504	2.31	125	48	45	1355
A+L23M-16-104-64.0C-0100L	10	14340	552	6	1	26	0.193	75	2255	3.42	125	52	45	1555
A+L23M-20-96-64.0C-0150L	12	17967	599	6	1.5	30	0.237	78	2601	3.96	117	59	54	1786
A+L23M-20-120-64.0C-0200L	15	22466	599	6	2	30	0.219	80	3252	4.93	142	59	55	2148
A+L23M-20-120-84.0C-0200L	18	21784	581	8	2	30	0.191	78	4334	6.52	142	62	55	2397
A+L23M-28-144-44.0C-0300L	20	37315	592	4	3	42	0.213	86	3644	5.53	166	67	73	2890
A+L23M-32-144-44.0C-0500L	22	41166	572	4	5	48	0.235	87	4164	6.32	166	74	82	3388
A+L23M-28-144-64.0C-0300L	25	37104	589	6	3	42	0.184	87	5463	8.19	166	71	73	3324
A+L23M-32-144-64.0C-0500L	28	42889	596	6	5	48	0.217	88	6243	9.58	167	78	82	3909
A+L23M-32-144-64.0C-0500L	30	42889	596	6	5	48	0.217	88	6243	9.58	167	78	82	3909
A+L23M-32-132-84.0C-0500L	32	39009	591	8	5	48	0.201	89	7629	11.64	155	82	82	4109
A+L23M-32-144-84.0C-0500L	35	42211	586	8	5	48	0.205	88	8322	12.62	167	82	82	4365
A+L23M-32-144-104.0C-0500L	38	41536	577	10	5	48	0.209	88	10401	15.66	167	85	82	4821

**Ratings based on +35°F/85% rh air on temp, +25°F evaporating temp, 4 FPI fin spacing, 3:1 pumped ammonia (bottom feed).

Additional models and custom selections available - contact your local Colmac Coil representative.

A+L Penthouse and 45° Down Three Fan Models

Table 22: Frosted Conditions*

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+L33M-20-144-43.0C-0075L	10	24887	553	4	0.75	30	0.219	78	2010	4.09	167	55	55	2173
A+L33M-20-144-43.0C-0200L	12	35712	794	4	2	30	0.442	81	2010	4.09	167	55	55	2362
A+L33M-20-144-63.0C-0200L	15	33392	742	6	2	30	0.347	81	3014	5.99	167	59	55	2662
A+L33M-20-144-83.0C-0200L	18	31462	699	8	2	30	0.273	82	4017	7.89	167	62	55	2932
A+L33M-20-144-83.0C-0300L	20	35980	800	8	3	30	0.395	83	4017	7.89	167	62	55	3083
A+L33M-24-162-63.0C-0500L	22	51616	850	6	5	36	0.449	83	4068	8.01	185	65	64	3664
A+L33M-24-198-63.0C-0500L	25	61204	824	6	5	36	0.455	86	4972	9.88	222	65	64	4191
A+L33M-24-162-83.0C-0500L	28	51596	849	8	5	36	0.395	90	5423	10.78	186	69	64	4058
A+L33M-24-198-83.0C-0500L	30	58537	788	8	5	36	0.383	86	6628	12.99	222	69	65	4615
A+L33M-24-198-83.0C-0500L	32	58535	788	8	5	36	0.383	86	6628	12.99	222	69	65	4615
A+L33M-28-180-83.0C-0500L	35	64340	817	8	5	42	0.347	87	7030	13.85	204	75	73	4897
A+L33M-32-216-63.0C-0750L	38	90996	843	6	7.5	48	0.462	97	7233	14.36	240	78	82	5777
A+L33M-28-180-103.0C-0750L	40	66706	847	10	7.5	42	0.412	90	8786	17.19	204	79	74	5499
A+L33M-32-198-83.0C-1000L	42	84118	850	8	10	48	0.452	99	8838	17.34	222	82	83	6106
A+L33M-32-216-83.0C-0750L	45	87482	810	8	7.5	48	0.394	98	9641	18.93	240	82	83	6387
A+L33M-28-216-103.0C-1000L	48	80238	849	10	10	42	0.451	90	10543	20.54	240	79	74	6399
A+L33M-32-216-103.0C-0750L	50	81304	753	10	7.5	48	0.35	93	12049	23.48	240	85	83	7042
A+L33M-32-216-103.0C-0750L	52	81304	753	10	7.5	48	0.35	93	12049	23.48	240	85	83	7042
A+L33M-32-216-103.0C-1000L	55	90478	838	10	10	48	0.411	99	12049	23.47	240	85	83	7094

*Ratings based on -10°F/85% rh air on temp, -20°F evaporating temp, 3 FPI fin spacing, 3:1 pumped ammonia (bottom feed).

Table 23: Wet Conditions**

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+L33M-16-114-64.0C-0075L	10	15413	541	6	0.75	26	0.156	76	2471	3.73	135	52	46	1809
A+L33M-16-156-44.0C-0100L	12	22840	586	4	1	26	0.236	75	2256	3.37	177	48	46	2026
A+L33M-16-156-64.0C-0100L	15	21509	552	6	1	26	0.193	77	3382	5.05	178	52	46	2290
A+L33M-20-144-64.0C-0150L	18	26951	599	6	1.5	30	0.236	80	3902	5.85	166	59	55	2667
A+L33M-20-180-64.0C-0100L	20	26510	471	6	1	30	0.137	79	4878	7.24	202	59	55	3038
A+L33M-20-180-64.0C-0150L	22	31095	553	6	1.5	30	0.193	81	4878	7.24	202	59	55	3139
A+L33M-20-180-84.0C-0200L	25	32676	581	8	2	30	0.198	80	6502	9.6	202	62	55	3570
A+L33M-24-162-84.0C-0200L	28	35756	589	8	2	36	0.173	85	7022	10.41	184	69	64	3800
A+L33M-28-216-44.0C-0300L	30	55973	592	4	3	42	0.207	87	5466	8.36	239	67	73	4368
A+L33M-28-180-64.0C-0300L	32	46576	591	6	3	42	0.182	87	6829	10.33	203	71	73	4338
A+L33M-28-216-64.0C-0300L	35	55656	589	6	3	42	0.2	89	8194	12.34	239	71	73	4969
A+L33M-24-198-104.0C-0300L	38	43114	581	10	3	36	0.199	87	10726	15.9	221	73	65	5058
A+L33M-32-216-64.0C-0500L	40	61162	566	6	5	48	0.206	89	9365	14.13	239	78	82	5805
A+L33M-32-216-64.0C-0500L	42	64334	596	6	5	48	0.221	90	9365	14.13	239	78	82	5805
A+L33M-32-198-84.0C-0500L	45	58513	591	8	5	48	0.218	90	11443	17.09	221	82	83	6049
A+L33M-28-216-104.0C-0500L	48	56589	599	10	5	42	0.189	88	13651	20.31	239	79	74	6412
A+L33M-32-216-84.0C-0500L	50	63318	586	8	5	48	0.201	90	12483	18.66	239	82	83	6482
A+L33M-32-216-84.0C-0500L	52	63317	586	8	5	48	0.201	90	12483	18.66	239	82	83	6482
A+L33M-32-216-104.0C-0750L	55	64554	598	10	7.5	48	0.258	94	15601	23.22	239	85	83	7341

**Ratings based on +35°F/85% rh air on temp, +25°F evaporating temp, 4 FPI fin spacing, 3:1 pumped ammonia (bottom feed).

Additional models and custom selections available - contact your local Colmac Coil representative.

A+L Penthouse and 45° Down Four Fan Models

Table 24: Frosted Conditions*

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+L43M-20-192-43.0C-0075L	12	33180	553	4	0.75	30	0.235	80	2680	5.32	215	55	55	2900
A+L43M-20-192-43.0C-0150L	15	42175	703	4	1.5	30	0.399	80	2680	5.32	215	55	55	3062
A+L43M-20-240-43.0C-0200L	18	49323	658	4	2	30	0.368	82	3350	6.58	263	55	55	3674
A+L43M-20-192-63.0C-0200L	20	44523	742	6	2	30	0.337	82	4018	7.84	215	59	55	3505
A+L43M-20-192-63.0C-0300L	22	50991	850	6	3	30	0.476	85	4018	7.83	215	59	55	3713
A+L43M-20-240-63.0C-0300L	25	53874	718	6	3	30	0.399	85	5023	9.9	264	59	56	4340
A+L43M-20-240-63.0C-0500L	28	63009	840	6	5	30	0.588	85	5023	9.9	264	59	56	4609
A+L43M-24-264-63.0C-0200L	30	57663	583	6	2	36	0.227	85	6630	12.99	288	65	65	5058
A+L43M-24-264-63.0C-0300L	32	66055	667	6	3	36	0.324	87	6630	12.98	288	65	65	5276
A+L43M-24-264-63.0C-0500L	35	81605	824	6	5	36	0.455	87	6630	12.98	288	65	65	5542
A+L43M-28-240-63.0C-0500L	38	88368	842	6	5	42	0.413	91	7032	13.85	264	71	74	5833
A+L43M-24-264-83.0C-0500L	40	78047	788	8	5	36	0.383	87	8838	17.15	288	69	65	6109
A+L43M-24-264-83.0C-0500L	42	78047	788	8	5	36	0.383	87	8838	17.15	288	69	65	6109
A+L43M-28-288-63.0C-1000L	45	106895	848	6	10	42	0.569	93	8438	16.47	312	71	74	6974
A+L43M-24-264-103.0C-0500L	48	74655	754	10	5	36	0.344	87	11045	21.3	288	73	65	6675
A+L43M-32-288-63.0C-0750L	50	121328	843	6	7.5	48	0.462	98	9644	18.81	312	78	83	7616
A+L43M-28-288-83.0C-0500L	52	91384	725	8	5	42	0.301	88	11248	21.71	312	75	74	7363
A+L43M-28-288-83.0C-0750L	55	105433	837	8	7.5	42	0.424	90	11248	21.71	312	75	74	7588
A+L43M-28-288-83.0C-0750L	58	105433	837	8	7.5	42	0.424	90	11248	21.71	312	75	74	7588
A+L43M-32-288-83.0C-0750L	60	116643	810	8	7.5	48	0.373	99	12855	25.6	314	82	83	8464
A+L43M-32-288-83.0C-0750L	62	116643	810	8	7.5	48	0.373	99	12855	25.6	314	82	83	8464
A+L43M-32-288-83.0C-0750L	65	116642	810	8	7.5	48	0.373	99	12855	25.6	314	82	83	8464
A+L43M-32-264-103.0C-0750L	68	105705	801	10	7.5	48	0.355	95	14727	29.15	290	85	83	8754
A+L43M-32-288-103.0C-1000L	70	120638	838	10	10	48	0.392	100	16066	31.61	314	85	84	9395
A+L43M-32-288-103.0C-1000L	72	120638	838	10	10	48	0.392	100	16066	31.61	314	85	84	9395
A+L43M-32-288-103.0C-1000L	75	120638	838	10	10	48	0.392	100	16066	31.61	314	85	84	9395

*Ratings based on -10°F/85% rh air on temp, -20°F evaporating temp, 3 FPI fin spacing, 3:1 pumped ammonia (bottom feed).

Table 25: Wet Conditions**

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+L43M-16-208-44.0C-0075L	15	27545	530	4	0.75	26	0.185	76	3008	4.47	230	48	46	2636
A+L43M-20-192-44.0C-0075L	18	32549	543	4	0.75	30	0.155	79	3470	5.18	214	55	55	2955
A+L43M-16-208-64.0C-0100L	20	28679	552	6	1	26	0.193	78	4509	6.65	230	52	46	3063
A+L43M-20-192-64.0C-0075L	22	29809	497	6	0.75	30	0.127	79	5203	7.7	214	59	55	3350
A+L43M-20-192-64.0C-0150L	25	35934	599	6	1.5	30	0.224	81	5203	7.7	214	59	55	3518
A+L43M-20-192-84.0C-0150L	28	35656	594	8	1.5	30	0.212	83	6935	10.21	214	62	55	3904
A+L43M-20-240-64.0C-0200L	30	44931	599	6	2	30	0.218	83	6503	9.74	263	59	56	4255
A+L43M-24-264-44.0C-0300L	32	59342	599	4	3	36	0.224	88	5726	8.64	287	61	65	4801
A+L43M-20-240-84.0C-0200L	35	43568	581	8	2	30	0.191	81	8669	12.88	263	62	56	4748
A+L43M-28-288-44.0C-0300L	38	74631	592	4	3	42	0.213	89	7288	10.97	311	67	74	5765
A+L43M-28-240-64.0C-0200L	40	58429	557	6	2	42	0.171	89	9105	13.66	263	71	74	5543
A+L43M-20-240-104.0C-0300L	42	44901	599	10	3	30	0.218	83	10834	16.05	263	66	56	5436
A+L43M-28-288-64.0C-0200L	45	63351	503	6	2	42	0.145	89	10926	16.24	311	71	74	6404
A+L43M-28-288-64.0C-0300L	48	74209	589	6	3	42	0.187	90	10926	16.24	311	71	74	6555
A+L43M-28-288-64.0C-0300L	50	74208	589	6	3	42	0.187	90	10926	16.24	311	71	74	6555
A+L43M-28-288-64.0C-0300L	52	74208	589	6	3	42	0.187	90	10926	16.24	311	71	74	6555
A+L43M-32-288-64.0C-0500L	55	85779	596	6	5	48	0.216	91	12487	18.55	311	78	83	7656
A+L43M-32-288-64.0C-0500L	58	85779	596	6	5	48	0.216	91	12487	18.55	311	78	83	7656
A+L43M-32-288-64.0C-0500L	60	85779	596	6	5	48	0.216	91	12487	18.55	311	78	83	7656
A+L43M-28-288-84.0C-0500L	62	75176	597	8	5	42	0.185	90	14564	21.5	311	75	74	7624
A+L43M-32-264-84.0C-0500L	65	78017	591	8	5	48	0.201	92	15257	22.6	287	82	83	8012
A+L43M-32-288-84.0C-0500L	68	84423	586	8	5	48	0.205	91	16644	24.84	312	82	83	8574
A+L43M-32-288-84.0C-0500L	70	84423	586	8	5	48	0.205	91	16644	24.84	312	82	83	8574
A+L43M-32-288-104.0C-0500L	72	83073	577	10	5	48	0.209	91	20802	30.86	312	85	84	9470
A+L43M-32-288-104.0C-0500L	75	83072	577	10	5	48	0.209	91	20802	30.86	312	85	84	9470
A+L43M-32-288-104.0C-0750L	78	86072	598	10	7.5	48	0.243	95	20802	30.86	312	85	84	9705

**Ratings based on +35°F/85% rh air on temp, +25°F evaporating temp, 4 FPI fin spacing, 3:1 pumped ammonia (bottom feed).

Additional models and custom selections available - contact your local Colmac Coil representative.

A+ Series™ Air Cooler Features

A+L Penthouse and 45° Down Five Fan Models

Table 26: Frosted Conditions*

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Surface Area (FT^2)	Internal Volume (FT^3)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+L53M-20-240-43.0C-0075L	15	41475	553	4	0.75	30	0.235	81	3350	6.59	263	55	55	3605
A+L53M-20-240-43.0C-0100L	18	45597	608	4	1	30	0.273	80	3350	6.58	263	55	55	3653
A+L53M-20-240-43.0C-0200L	20	59521	794	4	2	30	0.426	83	3350	6.58	263	55	55	3919
A+L53M-20-300-43.0C-0150L	22	55221	589	4	1.5	30	0.336	81	4188	8.12	323	55	56	4452
A+L53M-20-240-63.0C-0200L	25	55654	742	6	2	30	0.333	83	5023	9.9	264	59	56	4379
A+L53M-20-240-63.0C-0300L	28	63739	850	6	3	30	0.47	86	5023	9.9	264	59	56	4638
A+L53M-20-300-63.0C-0300L	30	67344	718	6	3	30	0.419	86	6278	12.21	324	59	56	5382
A+L53M-24-270-63.0C-0200L	32	67909	671	6	2	36	0.262	86	6781	13.26	294	65	65	5442
A+L53M-28-300-43.0C-0300L	35	99168	756	4	3	42	0.375	90	5863	11.6	324	67	74	6156
A+L53M-24-270-83.0C-0200L	38	63721	629	8	2	36	0.226	86	9038	17.5	294	69	65	6024
A+L53M-20-300-83.0C-0500L	40	75314	803	8	5	30	0.483	86	8369	16.13	324	62	56	6263
A+L53M-20-300-83.0C-0500L	42	75313	803	8	5	30	0.483	86	8369	16.13	324	62	56	6263
A+L53M-28-300-63.0C-0500L	45	110460	842	6	5	42	0.437	92	8790	17.11	324	71	74	7242
A+L53M-20-300-103.0C-0750L	48	78694	839	10	7.5	30	0.537	87	10459	20.04	324	66	57	7075
A+L53M-20-300-103.0C-0750L	50	78694	839	10	7.5	30	0.537	87	10459	20.04	324	66	57	7075
A+L53M-24-270-103.0C-0500L	52	85046	840	10	5	36	0.398	90	11296	21.75	294	73	65	7282
A+L53M-28-300-83.0C-0500L	55	107234	817	8	5	42	0.341	89	11716	23.27	326	75	74	8083
A+L53M-28-300-83.0C-0500L	58	107233	817	8	5	42	0.341	89	11716	23.27	326	75	74	8083
A+L53M-28-300-83.0C-0500L	60	107233	817	8	5	42	0.341	89	11716	23.27	326	75	74	8083
A+L53M-28-300-103.0C-0500L	62	101518	774	10	5	42	0.308	89	14643	28.74	326	79	75	8818
A+L53M-28-300-103.0C-0500L	65	101518	774	10	5	42	0.308	89	14643	28.74	326	79	75	8818
A+L53M-28-300-103.0C-0750L	68	111176	847	10	7.5	42	0.389	93	14643	28.74	326	79	75	9068
A+L53M-28-300-103.0C-0750L	70	111176	847	10	7.5	42	0.389	93	14643	28.74	326	79	75	9068

*Ratings based on -10°F/85% rh air on temp, -20°F evaporating temp, 3 FPI fin spacing, 3:1 pumped ammonia (bottom feed).

Table 27: Wet Conditions**

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Surface Area (FT^2)	Internal Volume (FT^3)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+L53M-16-190-44.0C-0075L	15	28460	599	4	0.75	26	0.238	78	2747	4.1	212	48	46	2683
A+L53M-16-190-64.0C-0075L	18	28320	596	6	0.75	26	0.194	78	4119	6.1	212	52	46	2990
A+L53M-16-260-44.0C-0100L	20	38067	586	4	1	26	0.228	77	3760	5.57	282	48	47	3378
A+L53M-20-240-44.0C-0075L	22	40687	543	4	0.75	30	0.159	80	4338	6.45	262	55	55	3680
A+L53M-20-300-44.0C-0100L	25	47819	510	4	1	30	0.196	80	5423	7.99	322	55	56	4390
A+L53M-20-300-44.0C-0150L	28	55376	591	4	1.5	30	0.255	83	5423	7.99	322	55	56	4548
A+L53M-20-240-64.0C-0150L	30	44918	599	6	1.5	30	0.236	82	6503	9.74	263	59	56	4403
A+L53M-16-260-84.0C-0150L	32	38783	597	8	1.5	26	0.226	80	7513	11.12	283	56	47	4420
A+L53M-20-300-64.0C-0150L	35	51826	553	6	1.5	30	0.206	83	8129	12.04	323	59	56	5182
A+L53M-28-300-44.0C-0150L	38	66874	510	4	1.5	42	0.186	92	7592	11.37	323	67	74	5950
A+L53M-28-300-44.0C-0200L	40	76517	583	4	2	42	0.187	89	7592	11.4	323	67	74	6115
A+L53M-24-270-64.0C-0200L	42	60604	599	6	2	36	0.182	91	8780	13.09	293	65	65	5690
A+L53M-24-270-84.0C-0200L	45	59594	589	8	2	36	0.184	87	11703	17.33	293	69	65	6269
A+L53M-28-300-64.0C-0200L	48	73035	557	6	2	42	0.164	90	11381	16.88	323	71	74	6878
A+L53M-28-300-64.0C-0200L	50	73037	557	6	2	42	0.164	90	11381	16.88	323	71	74	6878
A+L53M-28-300-64.0C-0200L	52	73036	557	6	2	42	0.164	90	11381	16.88	323	71	74	6878
A+L53M-28-300-84.0C-0200L	55	67671	516	8	2	42	0.147	90	15170	22.36	323	75	74	7703
A+L53M-28-300-84.0C-0200L	58	67668	516	8	2	42	0.147	90	15170	22.36	323	75	74	7703
A+L53M-28-300-84.0C-0300L	60	78420	598	8	3	42	0.181	92	15170	22.36	323	75	74	7953
A+L53M-28-300-84.0C-0300L	62	78420	598	8	3	42	0.181	92	15170	22.36	323	75	74	7953
A+L53M-28-300-84.0C-0300L	65	78420	598	8	3	42	0.181	92	15170	22.36	323	75	74	7953
A+L53M-28-300-104.0C-0300L	68	75529	576	10	3	42	0.177	92	18960	27.85	323	79	75	8840
A+L53M-28-300-104.0C-0500L	70	78705	600	10	5	42	0.187	96	18960	28.09	324	79	75	9196

**Ratings based on +35°F/85% rh air on temp, +25°F evaporating temp, 4 FPI fin spacing, 3:1 pumped ammonia (bottom feed).

Additional models and custom selections available - contact your local Colmac Coil representative.

A+M MEDIUM PROFILE UNITS

Capacity Range: 2 - 50 TR

Featuring:

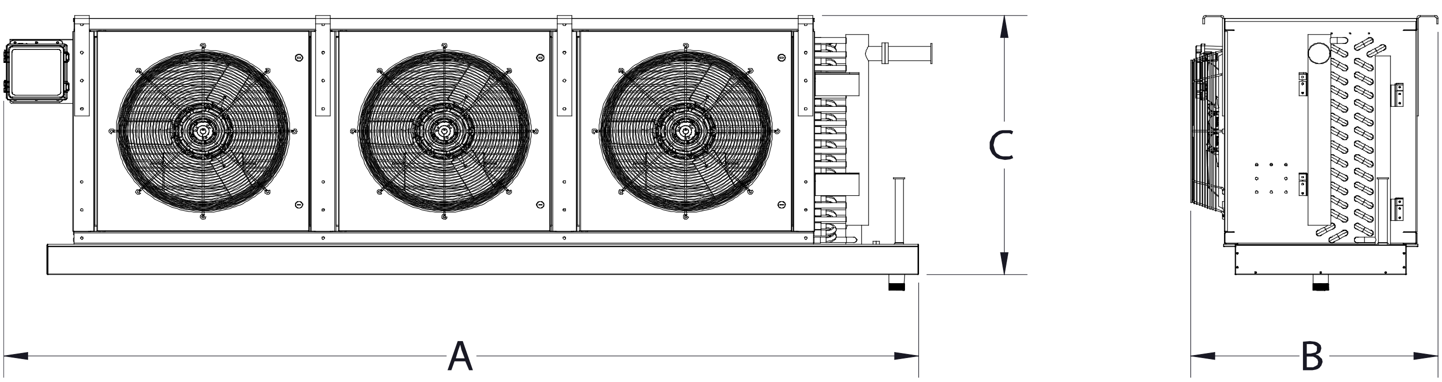
- 1/3 – 5 hp premium efficiency motors
- 16” – 42” diameter airfoil shaped fans
- 33.75” – 63” coil height
- 4 – 8 row deep coil
- Hinged fan panels
- Sloped fan boxes for water drainage

Options:

- Reheat coil
- Seal welded drainpan
- Full coverage drainpan

A+M Unit Dimensions

Dimensions and weights provided in the tables may change based on the options and features selected. Do not use these for construction, refer to the factory submittal provided at time of order.



(3 fan unit shown)

A+ Series™ Air Cooler Features

A+M Lowest Cost ($/TR) Models

Table 28: Frosted Conditions*

Model Number	Capacity (TR)	Fans	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Air Throw (FT)	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+M13M-16-38-43.0C-0050L	2	1	6214	654.1	4	0.5	30	0.209	98.18	76	424	0.96	59	37	45	425
A+M13M-16-54-43.0C-0075L	3	1	8271	613	4	0.75	30	0.243	131	74	603	1.28	75	38	46	545
A+M13M-20-54-43.0C-0150L	4	1	11248	667	4	1.5	30	0.369	178	74	754	1.6	75	39	55	651
A+M13M-20-54-63.0C-0150L	5	1	10575	627	6	1.5	30	0.292	167	75	1130	2.39	76	43	55	764
A+M13M-20-54-63.0C-0500L	6	1	14309	848	6	5	30	0.489	226	79	1130	2.39	76	47	55	917
A+M13M-28-66-43.0C-0500L	8	1	24528	850	4	5	42	0.482	277	85	1290	2.73	88	43	73	1089
A+M13M-24-60-83.0C-0500L	10	1	19036	846	8	5	36	0.39	251	81	2009	4.3	83	51	64	1260
A+M23M-20-108-63.0C-0300L	12	2	27150	805	6	3	30	0.445	215	82	2260	4.61	131	47	56	1628
A+M23M-28-132-43.0C-0300L	15	2	42014	728	4	3	42	0.352	237	86	2580	5.29	155	43	74	1863
A+M23M-20-108-103.0C-0500L	18	2	28633	848	10	5	30	0.471	226	83	3765	7.47	131	54	56	2171
A+M23M-24-120-83.0C-0500L	20	2	38072	846	8	5	36	0.389	251	84	4017	7.99	143	51	65	2300
A+M33M-28-198-43.0C-0500L	22	3	73585	850	4	5	42	0.51	277	89	3870	7.66	221	43	74	2959
A+M33M-28-174-63.0C-0300L	25	3	56652	744	6	3	42	0.304	213	89	5098	10.23	198	47	74	2953
A+M33M-28-198-63.0C-0300L	28	3	58197	672	6	3	42	0.277	219	88	5801	11.52	222	47	74	3213
A+M33M-24-180-83.0C-0500L	30	3	57109	846	8	5	36	0.388	251	86	6026	11.88	204	51	65	3361
A+M33M-28-174-83.0C-0500L	32	3	63119	829	8	5	42	0.353	237	91	6796	13.42	198	51	74	3593
A+M33M-28-174-83.0C-0500L	35	3	64491	847	8	5	42	0.366	243	90	6796	13.42	198	51	74	3640
A+M43M-28-264-63.0C-0300L	38	4	77596	672	6	3	42	0.277	219	89	7735	15.14	288	47	75	4225
A+M43M-28-264-63.0C-0500L	40	4	97463	844	6	5	42	0.408	275	89	7735	15.17	288	47	75	4556
A+M53M-28-290-63.0C-0300L	42	5	93221	734.7	6	3	42	0.31	210.43	91	8497	16.57	314	47	75	4791
A+M53M-28-290-63.0C-0500L	45	5	107625	848	6	5	42	0.476	243	93	8497	16.57	314	47	75	5255
A+M53M-24-300-83.0C-0500L	48	5	95181	846	8	5	36	0.408	251	88	10043	19.37	324	51	66	5474
A+M43M-28-264-83.0C-0500L	50	4	92271	799	8	5	42	0.332	260	89	10311	19.98	288	51	75	5202
A+M53M-28-290-83.0C-0500L	52	5	105200	829	8	5	42	0.348	237	93	11326	21.85	314	51	75	5845
A+M53M-28-290-83.0C-0500L	55	5	107485	847	8	5	42	0.36	243	93	11326	21.85	314	51	75	5923
A+M53M-28-290-83.0C-0500L	58	5	105198	829	8	5	42	0.348	237	93	11326	21.85	314	51	75	5845
A+M53M-28-290-103.0C-0500L	62	5	101810	802	10	5	42	0.312	230	89	14155	27.85	316	54	76	6667

*Ratings based on -10°F/85% rh air on temp, -20°F evaporating temp, 3 FPI fin spacing, 3:1 pumped ammonia (bottom feed).

Table 29: Wet Conditions**

Model Number	Capacity (TR)	Fans	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Air Throw (FT)	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+M13M-20-38-44.0C-0050L	3	1	5772	486	4	0.5	30	0.151	91	81	687	1.18	59	37	54	483
A+M13M-16-54-44.0C-0075L	4	1	8036	595	4	0.75	30	0.163	127	73	781	1.27	75	38	46	559
A+M13M-20-54-44.0C-0100L	5	1	9420	558	4	1	30	0.183	149	74	976	1.6	75	38	55	632
A+M13M-24-60-44.0C-0150L	6	1	12194	542	4	1.5	36	0.23	161	80	1301	2.11	81	39	64	786
A+M13M-28-58-44.0C-0200L	8	1	14591	575	4	2	42	0.176	165	84	1468	2.39	79	39	73	894
A+M23M-20-108-44.0C-0100L	10	2	18840	558	4	1	30	0.182	149	77	1952	2.99	129	38	55	1187
A+M23M-24-120-44.0C-0100L	12	2	21638	481	4	1	36	0.152	142	82	2603	3.95	141	38	64	1407
A+M23M-28-116-44.0C-0150L	15	2	26931	531	4	1.5	42	0.182	152	88	2935	4.53	138	39	73	1596
A+M23M-28-132-44.0C-0200L	18	2	33900	587	4	2	42	0.193	191	85	3340	5.1	154	39	73	1780
A+M23M-28-116-64.0C-0200L	20	2	30201	595	6	2	42	0.174	170	87	4401	6.69	138	43	73	1993
A+M33M-28-174-44.0C-0200L	22	3	43775	575	4	2	42	0.19	165	88	4403	6.61	196	39	74	2377
A+M33M-28-198-44.0C-0200L	25	3	50850	587	4	2	42	0.206	191	87	5010	7.47	220	39	74	2594
A+M23M-28-132-84.0C-0300L	28	2	34540	598	8	3	42	0.178	195	88	6675	9.99	154	51	74	2656
A+M33M-28-174-64.0C-0200L	30	3	45301	595	6	2	42	0.168	170	89	6601	10	197	43	74	2925
A+M43M-28-232-44.0C-0200L	32	4	58365	575	4	2	42	0.176	165	90	5871	8.93	255	39	74	3156
A+M43M-28-264-44.0C-0200L	35	4	67800	587	4	2	42	0.193	191	88	6681	10.08	287	39	75	3447
A+M53M-28-290-44.0C-0150L	38	5	67326	531	4	1.5	42	0.186	152	92	7338	11.01	313	39	75	3799
A+M43M-28-232-64.0C-0200L	40	4	60401	595	6	2	42	0.173	170	90	8801	13.23	255	43	74	3855
A+M43M-28-264-64.0C-0200L	42	4	62626	542	6	2	42	0.164	177	89	10015	14.95	287	43	75	4227
A+M53M-24-300-64.0C-0150L	45	5	62666	557	6	1.5	36	0.17	165	85	9755	14.47	323	43	66	4271
A+M53M-28-290-64.0C-0200L	48	5	73294	578	6	2	42	0.166	165	90	11002	16.34	313	43	75	4702
A+M53M-28-290-64.0C-0200L	50	5	73294	578	6	2	42	0.166	165	90	11002	16.34	313	43	75	4702
A+M53M-28-290-64.0C-0200L	52	5	73293	578	6	2	42	0.166	165	90	11002	16.34	313	43	75	4702
A+M43M-28-264-84.0C-0300L	55	4	69170	599	8	3	42	0.184	195	92	13350	19.78	287	51	75	5210
A+M43M-28-264-84.0C-0300L	58	4	69080	598	8	3	42	0.178	195	91	13350	19.78	287	51	75	5157
A+M53M-28-290-84.0C-0200L	60	5	70660	557	8	2	42	0.15	160	93	14665	21.64	313	47	75	5563
A+M53M-28-290-84.0C-0300L	62	5	76003	599	8	3	42	0.206	172	94	14665	21.64	313	51	75	5829
A+M53M-28-290-104.0C-0300L	65	5	75297	594	10	3	42	0.178	170	92	18328	26.95	313	54	76	6674
A+M53M-28-290-104.0C-0300L	68	5	75296	594	10	3	42	0.178	170	92	18328	26.95	313	54	76	6674

**Ratings based on +35°F/85% rh air on temp, +25°F evaporating temp, 4 FPI fin spacing, 3:1 pumped ammonia (bottom feed).

Additional models and custom selections available - contact your local Colmac Coil representative.

A+M One Fan Models

Table 30: Frosted Conditions*

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Air Throw (FT)	Sound @10FT (dB(A))	Surface Area (FT^2)	Internal Volume (FT^3)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+M13M-16-38-43.0C-0150L	2	5123	539	4	1.5	30	0.607	81	85	424	0.96	59	39	46	502
A+M13M-16-54-43.0C-0075L	3	8271	613	4	0.75	30	0.243	131	74	603	1.28	75	38	46	545
A+M13M-20-54-43.0C-0150L	4	11248	667	4	1.5	30	0.369	178	74	754	1.6	75	39	55	651
A+M13M-20-54-63.0C-0150L	5	10575	627	6	1.5	30	0.292	167	75	1130	2.39	76	43	55	764
A+M13M-20-54-63.0C-0500L	6	14309	848	6	5	30	0.489	226	79	1130	2.39	76	47	55	917
A+M13M-28-66-43.0C-0500L	8	24528	850	4	5	42	0.482	277	85	1290	2.73	88	43	73	1089
A+M13M-24-60-83.0C-0500L	10	19036	846	8	5	36	0.39	251	81	2009	4.3	83	51	64	1260
A+M13M-28-66-83.0C-0500L	12	23068	799	8	5	42	0.36	260	83	2578	5.45	89	51	73	1469

*Ratings based on -10°F/85% rh air on temp, -20°F evaporating temp, 3 FPI fin spacing, 3:1 pumped ammonia (bottom feed).

Table 31: Wet Conditions**

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Air Throw (FT)	Sound @10FT (dB(A))	Surface Area (FT^2)	Internal Volume (FT^3)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+M13M-20-38-44.0C-0050L	3	5772	486	4	0.5	30	0.151	91	81	687	1.18	59	37	54	483
A+M13M-16-54-44.0C-0075L	4	8036	595	4	0.75	30	0.163	127	73	781	1.27	75	38	46	559
A+M13M-20-54-44.0C-0100L	5	9420	558	4	1	30	0.183	149	74	976	1.6	75	38	55	632
A+M13M-24-60-44.0C-0150L	6	12194	542	4	1.5	36	0.23	161	80	1301	2.11	81	39	64	786
A+M13M-28-58-44.0C-0200L	8	14591	575	4	2	42	0.176	165	84	1468	2.39	79	39	73	894
A+M13M-28-58-64.0C-0200L	10	15100	595	6	2	42	0.169	170	84	2200	3.5	79	43	73	1084
A+M13M-28-66-84.0C-0200L	12	14763	511	8	2	42	0.138	167	85	3337	5.19	87	47	73	1374
A+M13M-28-66-104.0C-0300L	15	16549	573	10	3	42	0.172	187	84	4171	6.51	88	54	74	1647

**Ratings based on +35°F/85% rh air on temp, +25°F evaporating temp, 4 FPI fin spacing, 3:1 pumped ammonia (bottom feed).

Additional models and custom selections available - contact your local Colmac Coil representative.

A+ Series™ Air Cooler Features

A+M Two Fan Models

Table 32: Frosted Conditions*

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Air Throw (FT)	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+M23M-16-76-43.0C-0150L	4	10245	539	4	1.5	30	0.604	81	88	849	1.73	97	39	46	906
A+M23M-16-76-43.0C-0075L	5	15050	792	4	0.75	30	0.289	119	77	849	1.77	98	38	46	790
A+M23M-20-76-43.0C-0100L	6	17656	743	4	1	30	0.329	139	76	1061	2.21	98	38	55	925
A+M23M-16-108-63.0C-0100L	8	16891	626	6	1	30	0.238	133	76	1808	3.57	130	42	46	1175
A+M23M-20-108-63.0C-0100L	10	18003	533	6	1	30	0.198	142	76	2260	4.61	131	42	55	1374
A+M23M-20-108-63.0C-0300L	12	27150	805	6	3	30	0.445	215	82	2260	4.61	131	47	56	1628
A+M23M-28-132-43.0C-0300L	15	42014	728	4	3	42	0.352	237	86	2580	5.29	155	43	74	1863
A+M23M-20-108-103.0C-0500L	18	28633	848	10	5	30	0.471	226	83	3765	7.47	131	54	56	2171
A+M23M-24-120-83.0C-0500L	20	38072	846	8	5	36	0.389	251	84	4017	7.99	143	51	65	2300
A+M23M-28-116-103.0C-0300L	22	32560	642	10	3	42	0.234	184	88	5662	11.19	139	54	74	2621
A+M23M-28-116-103.0C-0500L	25	41517	818	10	5	42	0.339	234	86	5662	11.42	140	54	74	2805

*Ratings based on -10°F/85% rh air on temp, -20°F evaporating temp, 3 FPI fin spacing, 3:1 pumped ammonia (bottom feed).

Table 33: Wet Conditions**

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Air Throw (FT)	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+M23M-16-76-44.0C-0033L	5	9706	511	4	0.33	30	0.116	77	81	1099	1.74	97	37	46	779
A+M23M-20-76-44.0C-0050L	6	11544	486	4	0.5	30	0.15	91	84	1374	2.17	97	37	55	899
A+M23M-16-108-44.0C-0075L	8	16071	595	4	0.75	30	0.163	127	76	1562	2.39	129	38	46	1020
A+M23M-20-108-44.0C-0100L	10	18840	558	4	1	30	0.182	149	77	1952	2.99	129	38	55	1187
A+M23M-24-120-44.0C-0100L	12	21638	481	4	1	36	0.152	142	82	2603	3.95	141	38	64	1407
A+M23M-28-116-44.0C-0150L	15	26931	531	4	1.5	42	0.182	152	88	2935	4.53	138	39	73	1596
A+M23M-28-132-44.0C-0200L	18	33900	587	4	2	42	0.193	191	85	3340	5.1	154	39	73	1780
A+M23M-28-116-64.0C-0200L	20	30201	595	6	2	42	0.174	170	87	4401	6.69	138	43	73	1993
A+M23M-28-132-64.0C-0300L	22	34626	600	6	3	42	0.22	195	87	5008	7.55	154	47	74	2314
A+M23M-28-132-84.0C-0200L	25	29524	511	8	2	42	0.137	167	88	6675	9.99	154	47	74	2550
A+M23M-28-132-84.0C-0300L	28	34540	598	8	3	42	0.178	195	88	6675	9.99	154	51	74	2656
A+M23M-28-132-104.0C-0300L	30	33098	573	10	3	42	0.171	187	87	8342	12.63	155	54	74	3081

**Ratings based on +35°F/85% rh air on temp, +25°F evaporating temp, 4 FPI fin spacing, 3:1 pumped ammonia (bottom feed).

Additional models and custom selections available - contact your local Colmac Coil representative.

A+M Three Fan Models

Table 34: Frosted Conditions*

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Air Throw (FT)	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+M33M-16-114-43.0C-0050L	6	17793	624	4	0.5	30	0.22	94	79	1273	2.55	136	37	46	1116
A+M33M-16-114-43.0C-0100L	8	24053	844	4	1	30	0.327	127	78	1273	2.54	136	38	46	1210
A+M33M-16-162-43.0C-0100L	10	27300	674	4	1	30	0.291	144	77	1809	3.64	185	38	47	1521
A+M33M-20-114-63.0C-0100L	12	24549	689	6	1	30	0.247	129	80	2386	4.84	137	42	55	1568
A+M33M-16-162-63.0C-0200L	15	33731	833	6	2	30	0.362	178	81	2712	5.35	185	43	47	1949
A+M33M-20-162-63.0C-0300L	18	40726	805	6	3	30	0.462	215	83	3390	6.68	185	47	56	2354
A+M33M-20-162-83.0C-0200L	20	34073	673	8	2	30	0.273	179	81	4519	8.81	185	47	56	2462
A+M33M-28-198-43.0C-0500L	22	73585	850	4	5	42	0.51	277	89	3870	7.66	221	43	74	2959
A+M33M-28-174-63.0C-0300L	25	56652	744	6	3	42	0.304	213	89	5098	10.23	198	47	74	2953
A+M33M-28-198-63.0C-0300L	28	58197	672	6	3	42	0.277	219	88	5801	11.52	222	47	74	3213
A+M33M-24-180-83.0C-0500L	30	57109	846	8	5	36	0.388	251	86	6026	11.88	204	51	65	3361
A+M33M-28-174-83.0C-0500L	32	63119	829	8	5	42	0.353	237	91	6796	13.42	198	51	74	3593
A+M33M-28-174-83.0C-0500L	35	64491	847	8	5	42	0.366	243	90	6796	13.42	198	51	74	3640
A+M33M-28-198-103.0C-0500L	38	64377	743	10	5	42	0.308	242	87	9665	18.81	222	54	75	4439
A+M33M-28-198-103.0C-0500L	40	65711	759	10	5	42	0.325	247	88	9665	18.81	222	54	75	4439

*Ratings based on -10°F/85% rh air on temp, -20°F evaporating temp, 3 FPI fin spacing, 3:1 pumped ammonia (bottom feed).

Table 35: Wet Conditions**

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Air Throw (FT)	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+M33M-12-84-44.0C-0033L	5	9368	595	4	0.33	20	0.189	74	69	911	1.42	105	37	37	808
A+M33M-12-120-44.0C-0033L	6	10875	483	4	0.33	20	0.155	86	72	1301	1.98	141	37	37	1006
A+M33M-16-114-44.0C-0033L	8	14559	511	4	0.33	30	0.112	77	83	1648	2.51	135	37	46	1165
A+M33M-20-114-44.0C-0050L	10	19261	541	4	0.5	30	0.139	101	79	2061	3.14	135	37	55	1290
A+M33M-16-162-44.0C-0075L	12	24107	595	4	0.75	30	0.172	127	78	2343	3.5	183	38	47	1523
A+M33M-20-162-44.0C-0100L	15	28260	558	4	1	30	0.189	149	79	2928	4.42	184	38	56	1723
A+M33M-24-180-44.0C-0100L	18	32456	481	4	1	36	0.152	142	83	3904	5.85	202	38	65	2048
A+M33M-24-180-44.0C-0150L	20	40155	595	4	1.5	36	0.219	176	83	3904	5.85	202	39	65	2165
A+M33M-28-174-44.0C-0200L	22	43775	575	4	2	42	0.19	165	88	4403	6.61	196	39	74	2377
A+M33M-28-198-44.0C-0200L	25	50850	587	4	2	42	0.206	191	87	5010	7.47	220	39	74	2594
A+M33M-28-174-64.0C-0150L	28	37284	490	6	1.5	42	0.153	140	90	6601	9.81	196	43	74	2802
A+M33M-28-174-64.0C-0200L	30	45301	595	6	2	42	0.168	170	89	6601	10	197	43	74	2925
A+M33M-28-198-64.0C-0200L	32	46970	542	6	2	42	0.157	177	88	7511	11.29	221	43	74	3204
A+M33M-28-198-64.0C-0300L	35	51939	600	6	3	42	0.209	195	89	7511	11.29	221	47	74	3403
A+M33M-28-198-84.0C-0300L	38	51810	598	8	3	42	0.193	195	90	10012	14.95	221	51	75	3910
A+M33M-28-198-84.0C-0300L	40	51878	599	8	3	42	0.2	195	91	10012	14.95	221	51	75	3949
A+M33M-28-198-104.0C-0300L	42	47965	554	10	3	42	0.172	180	90	12514	18.58	221	54	75	4456
A+M33M-28-198-104.0C-0300L	45	49647	573	10	3	42	0.173	187	89	12514	18.58	221	54	75	4493

**Ratings based on +35°F/85% rh air on temp, +25°F evaporating temp, 4 FPI fin spacing, 3:1 pumped ammonia (bottom feed).

Additional models and custom selections available - contact your local Colmac Coil representative.

A+ Series™ Air Cooler Features

A+M Four Fan Models

Table 36: Frosted Conditions*

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Air Throw (FT)	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+M43M-16-152-43.0C-0150L	8	20491	539	4	1.5	30	0.604	81	91	1697	3.32	174	39	47	1766
A+M43M-16-152-43.0C-0075L	10	30100	792	4	0.75	30	0.288	119	80	1697	3.44	175	38	46	1545
A+M43M-20-152-43.0C-0100L	12	35311	743	4	1	30	0.328	139	79	2122	4.3	175	38	55	1740
A+M43M-16-152-83.0C-0100L	15	26687	702	8	1	30	0.242	105	79	3392	6.64	175	46	47	2033
A+M43M-24-184-43.0C-0200L	18	57869	839	4	2	36	0.379	191	84	3082	6.14	207	39	65	2387
A+M43M-24-184-63.0C-0100L	20	37387	542	6	1	36	0.179	123	86	4621	9.03	207	42	65	2539
A+M43M-24-240-43.0C-0200L	22	61228	680	4	2	36	0.313	202	84	4020	7.9	263	39	65	2842
A+M43M-24-184-63.0C-0300L	25	58608	849	6	3	36	0.405	193	86	4621	9.23	208	47	65	3063
A+M43M-28-232-43.0C-0300L	28	80683	795	4	3	42	0.375	228	89	4534	9.15	256	43	74	3300
A+M43M-28-264-43.0C-0300L	30	84028	728	4	3	42	0.352	237	89	5159	10.3	288	43	75	3575
A+M43M-28-264-43.0C-0500L	32	98114	850	4	5	42	0.48	277	91	5159	10.3	288	43	75	3916
A+M43M-28-264-63.0C-0300L	35	78646	681	6	3	42	0.284	222	90	7735	15.14	288	47	75	4225
A+M43M-28-264-63.0C-0300L	38	77596	672	6	3	42	0.277	219	89	7735	15.14	288	47	75	4225
A+M43M-28-264-63.0C-0500L	40	97463	844	6	5	42	0.408	275	89	7735	15.17	288	47	75	4556
A+M43M-28-264-103.0C-0300L	45	69769	604	10	3	42	0.233	197	90	12886	24.85	288	54	75	5529
A+M43M-28-264-63.0C-0500L	48	95263	825	6	5	42	0.385	269	89	7735	15.17	288	47	75	4556
A+M43M-28-264-83.0C-0500L	50	92271	799	8	5	42	0.332	260	89	10311	19.98	288	51	75	5202
A+M43M-28-264-83.0C-0500L	52	90303	782	8	5	42	0.315	255	88	10311	19.98	288	51	75	5202
A+M43M-28-264-103.0C-0500L	55	87614	759	10	5	42	0.3	247	89	12886	24.85	288	54	75	5856

*Ratings based on -10°F/85% rh air on temp, -20°F evaporating temp, 3 FPI fin spacing, 3:1 pumped ammonia (bottom feed).

Table 37: Wet Conditions**

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Air Throw (FT)	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+M43M-12-112-44.0C-0033L	6	12491	595	4	0.33	20	0.2	74	70	1215	1.86	133	37	37	1096
A+M43M-12-160-44.0C-0033L	8	14501	483	4	0.33	20	0.15	86	74	1735	2.59	181	37	37	1346
A+M43M-16-152-44.0C-0033L	10	19411	511	4	0.33	30	0.116	77	84	2198	3.29	173	37	46	1509
A+M43M-20-152-44.0C-0050L	12	23089	486	4	0.5	30	0.149	91	87	2747	4.12	173	37	55	1672
A+M43M-16-216-44.0C-0050L	15	26594	493	4	0.5	30	0.125	105	80	3123	4.66	238	37	47	1940
A+M43M-20-152-64.0C-0075L	18	27477	579	6	0.75	30	0.156	109	79	4119	6.16	174	42	56	2058
A+M43M-20-216-44.0C-0100L	20	37680	558	4	1	30	0.182	149	80	3904	5.83	238	38	56	2266
A+M43M-16-216-64.0C-0100L	22	32341	599	6	1	30	0.176	128	82	4682	6.94	238	42	47	2410
A+M43M-20-216-64.0C-0100L	25	35346	524	6	1	30	0.156	140	81	5853	8.67	238	42	56	2711
A+M43M-24-184-84.0C-0100L	28	33995	493	8	1	36	0.136	112	86	7975	11.76	206	46	65	3124
A+M43M-28-232-44.0C-0150L	30	53861	531	4	1.5	42	0.181	152	91	5871	8.93	255	39	74	3076
A+M43M-28-232-44.0C-0200L	32	58365	575	4	2	42	0.176	165	90	5871	8.93	255	39	74	3156
A+M43M-28-264-44.0C-0200L	35	67800	587	4	2	42	0.193	191	88	6681	10.08	287	39	75	3447
A+M43M-28-232-64.0C-0200L	38	58636	578	6	2	42	0.172	165	89	8801	13.23	255	43	74	3806
A+M43M-28-232-64.0C-0200L	40	60401	595	6	2	42	0.173	170	90	8801	13.23	255	43	74	3855
A+M43M-28-264-64.0C-0200L	42	62626	542	6	2	42	0.164	177	89	10015	14.95	287	43	75	4227
A+M43M-28-232-84.0C-0200L	45	56529	557	8	2	42	0.162	160	92	11732	17.49	255	47	75	4501
A+M43M-24-240-104.0C-0300L	48	53993	600	10	3	36	0.193	178	90	13001	19.26	263	54	66	4996
A+M43M-28-264-84.0C-0200L	50	59049	511	8	2	42	0.137	167	91	13350	19.78	287	47	75	4953
A+M43M-28-232-104.0C-0300L	52	60237	594	10	3	42	0.184	170	92	14662	21.75	255	54	75	5397
A+M43M-28-264-84.0C-0300L	55	69170	599	8	3	42	0.184	195	92	13350	19.78	287	51	75	5210
A+M43M-28-264-84.0C-0300L	58	69080	598	8	3	42	0.178	195	91	13350	19.78	287	51	75	5157
A+M43M-28-264-104.0C-0500L	60	68786	596	10	5	42	0.179	194	93	16685	24.62	287	54	75	6205
A+M43M-28-264-104.0C-0500L	62	68786	596	10	5	42	0.179	194	93	16685	24.62	287	54	75	6205

**Ratings based on +35°F/85% rh air on temp, +25°F evaporating temp, 4 FPI fin spacing, 3:1 pumped ammonia (bottom feed).

Additional models and custom selections available - contact your local Colmac Coil representative.

A+M Five Fan Models

Table 38: Frosted Conditions*

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Air Throw (FT)	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+M53M-16-190-43.0C-0150L	10	25614	539	4	1.5	30	0.618	81	92	2122	4.22	213	39	47	2202
A+M53M-20-190-43.0C-0075L	12	34838	587	4	0.75	30	0.271	110	84	2652	5.27	213	38	56	2066
A+M53M-20-190-43.0C-0100L	15	44139	743	4	1	30	0.327	139	80	2652	5.27	213	38	56	2144
A+M53M-16-190-83.0C-0100L	18	33359	702	8	1	30	0.247	105	79	4240	8.2	213	46	47	2509
A+M53M-16-270-63.0C-0075L	20	38517	571	6	0.75	30	0.183	122	81	4520	8.71	293	42	48	2818
A+M53M-20-190-63.0C-0200L	22	50463	850	6	2	30	0.353	159	83	3976	7.76	213	43	56	2779
A+M53M-20-190-83.0C-0200L	25	49672	837	8	2	30	0.359	157	84	5300	10.42	214	47	56	3151
A+M53M-20-270-63.0C-0200L	28	58347	692	6	2	30	0.309	184	82	5651	11.05	294	43	57	3522
A+M53M-24-300-43.0C-0300L	30	88568	787	4	3	36	0.441	233	86	5025	9.94	324	43	66	3839
A+M53M-24-230-63.0C-0300L	32	73260	849	6	3	36	0.401	193	87	5776	11.42	254	47	66	3795
A+M53M-24-300-63.0C-0200L	35	73430	653	6	2	36	0.26	193	86	7534	14.65	324	43	66	4171
A+M53M-24-300-63.0C-0500L	38	94140	837	6	5	36	0.431	248	88	7534	14.65	324	47	66	4831
A+M53M-28-290-63.0C-0300L	40	94418	744	6	3	42	0.318	213	91	8497	16.57	314	47	75	4791
A+M53M-28-290-63.0C-0500L	42	103365	815	6	5	42	0.456	233	93	8497	16.57	314	47	75	5080
A+M53M-28-290-63.0C-0300L	42	93221	734.7	6	3	42	0.31	210.43	91	8497	16.57	314	47	75	4791
A+M53M-28-290-63.0C-0500L	45	107625	848	6	5	42	0.476	243	93	8497	16.57	314	47	75	5255
A+M53M-24-300-83.0C-0500L	48	95181	846	8	5	36	0.408	251	88	10043	19.37	324	51	66	5474
A+M53M-28-290-83.0C-0300L	50	87946	693	8	3	42	0.257	199	91	11326	21.85	314	51	75	5502
A+M53M-28-290-83.0C-0500L	52	105200	829	8	5	42	0.348	237	93	11326	21.85	314	51	75	5845
A+M53M-28-290-83.0C-0500L	55	107485	847	8	5	42	0.36	243	93	11326	21.85	314	51	75	5923
A+M53M-28-290-83.0C-0500L	58	105198	829	8	5	42	0.348	237	93	11326	21.85	314	51	75	5845
A+M53M-28-290-103.0C-0500L	62	101810	802	10	5	42	0.312	230	89	14155	27.85	316	54	76	6667

*Ratings based on -10°F/85% rh air on temp, -20°F evaporating temp, 3 FPI fin spacing, 3:1 pumped ammonia (bottom feed).

Table 39: Wet Conditions**

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Air Throw (FT)	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+M53M-12-140-44.0C-0033L	8	15614	595	4	0.33	20	0.191	74	71	1518	2.29	161	37	37	1339
A+M53M-12-140-64.0C-0033L	10	14590	556	6	0.33	20	0.153	69	77	2276	3.39	161	41	38	1525
A+M53M-16-190-44.0C-0033L	12	22594	476	4	0.33	30	0.133	71	90	2747	4.07	211	37	47	1864
A+M53M-16-190-44.0C-0050L	15	28283	595	4	0.5	30	0.143	89	86	2747	4.1	212	37	47	1868
A+M53M-20-190-44.0C-0075L	18	35598	600	4	0.75	30	0.185	113	84	3434	5.13	212	38	56	2154
A+M53M-16-270-44.0C-0075L	20	40178	595	4	0.75	30	0.166	127	80	3904	5.77	292	38	47	2479
A+M53M-20-190-64.0C-0075L	22	34346	579	6	0.75	30	0.145	109	80	5149	7.62	212	42	56	2543
A+M53M-20-190-64.0C-0100L	25	35599	600	6	1	30	0.174	113	85	5149	7.62	212	42	56	2592
A+M63M-20-228-64.0C-0075L	28	41215	579	6	0.75	30	0.15	109	81	6178	9.13	250	42	56	3042
A+M53M-24-300-44.0C-0100L	30	54094	481	4	1	36	0.145	142	86	6507	9.75	323	38	66	3361
A+M53M-16-270-84.0C-0100L	32	36798	545	8	1	30	0.154	116	84	7802	11.53	293	46	48	3456
A+M53M-24-300-44.0C-0150L	35	66924	595	4	1.5	36	0.207	176	85	6507	9.75	323	39	66	3552
A+M53M-28-290-44.0C-0150L	38	67326	531	4	1.5	42	0.186	152	92	7338	11.01	313	39	75	3799
A+M53M-28-290-44.0C-0300L	40	75894	598	4	3	42	0.263	171	95	7338	11.04	313	43	75	4231
A+M53M-24-300-64.0C-0150L	42	61886	550	6	1.5	36	0.167	163	85	9755	14.47	323	43	66	4270
A+M53M-24-300-64.0C-0150L	45	62666	557	6	1.5	36	0.17	165	85	9755	14.47	323	43	66	4271
A+M53M-28-290-64.0C-0200L	48	73294	578	6	2	42	0.166	165	90	11002	16.34	313	43	75	4702
A+M53M-28-290-64.0C-0200L	50	75501	595	6	2	42	0.167	170	91	11002	16.34	313	43	75	4763
A+M63M-24-276-104.0C-0200L	52	60998	589	10	2	36	0.177	134	87	14951	22.03	299	51	66	5722
A+M53M-24-300-84.0C-0300L	55	67450	600	8	3	36	0.221	178	88	13003	19.17	323	51	66	5438
A+M53M-28-290-84.0C-0200L	58	67611	533	8	2	42	0.147	153	90	14665	21.64	313	47	75	5501
A+M53M-28-290-84.0C-0200L	60	70660	557	8	2	42	0.15	160	93	14665	21.64	313	47	75	5563
A+M53M-28-290-84.0C-0300L	62	76003	599	8	3	42	0.206	172	94	14665	21.64	313	51	75	5829
A+M53M-28-290-104.0C-0300L	65	75297	594	10	3	42	0.178	170	92	18328	26.95	313	54	76	6674
A+M53M-28-290-104.0C-0300L	68	75296	594	10	3	42	0.178	170	92	18328	26.95	313	54	76	6674

**Ratings based on +35°F/85% rh air on temp, +25°F evaporating temp, 4 FPI fin spacing, 3:1 pumped ammonia (bottom feed).

Additional models and custom selections available - contact your local Colmac Coil representative.

A+M Six Fan Models

Table 40: Frosted Conditions*

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Air Throw (FT)	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+M63M-16-228-43.0C-0050L	12	35586	624	4	0.5	30	0.219	94	82	2546	5.03	251	37	47	2145
A+M63M-16-228-43.0C-0075L	15	45150	792	4	0.75	30	0.285	119	81	2546	5.02	251	38	47	2272
A+M63M-20-228-43.0C-0100L	18	52967	743	4	1	30	0.314	139	81	3183	6.27	251	38	56	2557
A+M63M-20-228-43.0C-0150L	20	60549	850	4	1.5	30	0.439	159	83	3183	6.27	251	39	56	2755
A+M63M-16-228-83.0C-0100L	22	40031	702	8	1	30	0.256	105	80	5088	9.81	251	46	48	3001
A+M63M-20-228-63.0C-0200L	25	60556	850	6	2	30	0.346	159	84	4772	9.44	252	43	56	3338
A+M63M-24-276-63.0C-0100L	28	56080	542	6	1	36	0.181	123	88	6931	13.54	300	42	66	3763
A+M63M-24-276-63.0C-0100L	30	56081	542	6	1	36	0.181	123	88	6931	13.54	300	42	66	3763
A+M63M-24-276-63.0C-0150L	32	70114	677	6	1.5	36	0.263	154	85	6931	13.54	300	43	66	4016
A+M63M-24-276-63.0C-0200L	35	79255	766	6	2	36	0.298	174	86	6931	13.54	300	43	66	4137
A+M63M-24-276-83.0C-0150L	38	65161	630	8	1.5	36	0.227	143	85	9239	17.86	300	47	66	4613
A+M63M-24-276-83.0C-0200L	40	73796	713	8	2	36	0.257	162	87	9239	17.89	300	47	66	4823
A+M63M-24-276-83.0C-0200L	42	72863	704	8	2	36	0.251	160	87	9239	17.89	300	47	66	4736
A+M63M-24-276-83.0C-0300L	45	85837	829	8	3	36	0.36	188	91	9239	17.89	300	51	66	5110
A+M63M-24-276-103.0C-0300L	48	80179	775	10	3	36	0.311	176	89	11547	22.21	300	54	66	5719
A+M63M-24-276-103.0C-0300L	50	80282	776	10	3	36	0.323	176	92	11547	22.21	300	54	66	5706
A+M63M-24-276-103.0C-0500L	52	87944	850	10	5	36	0.357	193	91	11547	22.21	300	54	66	6196

*Ratings based on -10°F/85% rh air on temp, -20°F evaporating temp, 3 FPI fin spacing, 3:1 pumped ammonia (bottom feed).

Table 41: Wet Conditions**

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Air Throw (FT)	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+M63M-12-168-44.0C-0033L	8	15515	493	4	0.33	20	0.114	61	73	1822	2.72	189	37	38	1578
A+M63M-12-168-64.0C-0033L	10	14591	463	6	0.33	20	0.127	58	72	2731	4.04	189	41	38	1824
A+M63M-12-240-44.0C-0033L	12	21751	483	4	0.33	20	0.155	86	75	2603	3.84	261	37	38	1990
A+M63M-12-168-84.0C-0075L	15	18873	599	8	0.75	20	0.231	75	74	3641	5.39	190	46	38	2153
A+M63M-16-228-44.0C-0050L	18	33939	595	4	0.5	30	0.143	89	87	3297	4.91	250	37	47	2233
A+M63M-20-228-44.0C-0050L	20	38522	541	4	0.5	30	0.139	101	82	4121	6.14	250	37	56	2473
A+M63M-20-228-44.0C-0075L	22	42718	600	4	0.75	30	0.189	113	85	4121	6.14	250	38	56	2576
A+M63M-20-228-64.0C-0050L	25	33718	473	6	0.5	30	0.107	89	85	6178	9.13	250	41	56	2948
A+M63M-20-228-64.0C-0075L	28	41215	579	6	0.75	30	0.15	109	81	6178	9.13	250	42	56	3042
A+M63M-24-276-44.0C-0100L	30	60810	588	4	1	36	0.177	133	86	5986	9.01	299	38	66	3316
A+M63M-24-276-44.0C-0100L	32	60809	588	4	1	36	0.177	133	86	5986	9.01	299	38	66	3316
A+M63M-20-228-84.0C-0100L	35	42060	590	8	1	30	0.169	111	85	8235	12.26	251	46	57	3605
A+M63M-20-228-104.0C-0150L	38	42432	596	10	1.5	30	0.214	112	89	10293	15.28	251	51	57	4292
A+M63M-24-276-64.0C-0150L	40	61846	598	6	1.5	36	0.212	136	91	8975	13.36	299	43	66	4214
A+M63M-24-276-64.0C-0150L	42	61674	596	6	1.5	36	0.169	135	85	8975	13.36	299	43	66	4195
A+M63M-24-276-84.0C-0200L	45	61867	598	8	2	36	0.181	136	90	11963	17.7	299	47	66	4997
A+M63M-24-276-104.0C-0150L	48	55555	537	10	1.5	36	0.176	122	87	14951	22.03	299	51	66	5530
A+M63M-24-276-104.0C-0150L	50	57365	554	10	1.5	36	0.176	126	87	14951	22.03	299	51	66	5602

**Ratings based on +35°F/85% rh air on temp, +25°F evaporating temp, 4 FPI fin spacing, 3:1 pumped ammonia (bottom feed).

Additional models and custom selections available - contact your local Colmac Coil representative.

A+S LOW PROFILE UNITS

Capacity Range: 5 - 35 TR

Featuring:

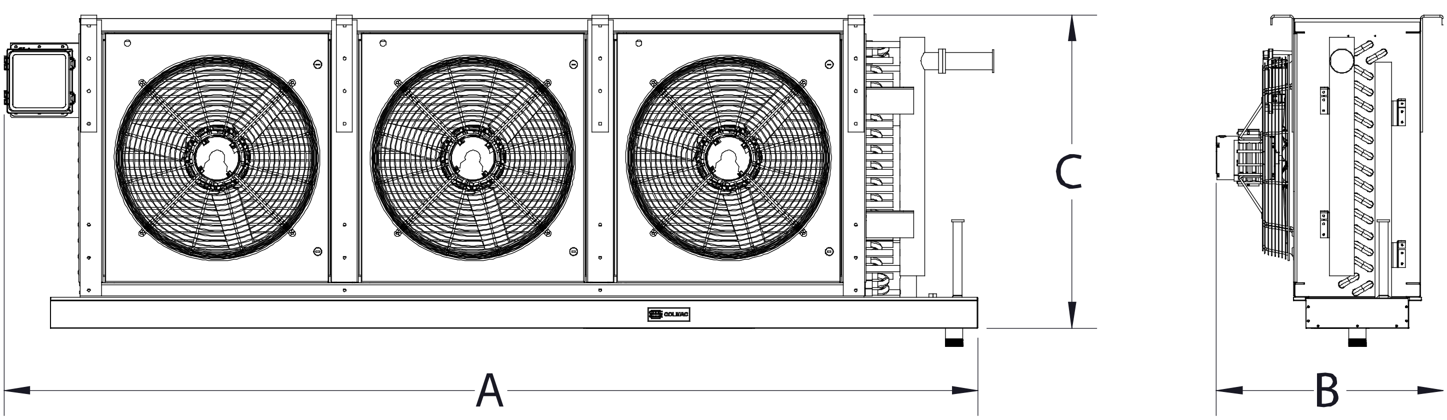
- 1/3 – 1 hp premium efficiency motors
- 16” – 30” diameter airfoil shaped fans
- 33.75” – 45” coil height
- 4 – 10 row deep coil
- Hinged fan panels
- Guard mounted motors
- Sloped fan boxes for water drainage

Options:

- Reheat coil
- Seal welded drainpan
- Full coverage drainpan

A+S Unit Dimensions

Dimensions and weights provided in the tables may change based on the options and features selected. Do not use these for construction, refer to the factory submittal provided at time of order.



(3 fan unit shown)

A+ Series™ Air Cooler Features

A+S Lowest Cost ($/TR) Models

Table 42: Frosted Conditions*

Model Number	Capacity (TR)	Fans	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Air Throw (FT)	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+S13M-20-38-43.0C-0100L	3	1	8828	743	4	1	30	0.33	73	139	530	1.19	59	28	54	401
A+S13M-16-54-63.0C-0100L	4	1	8445	626	6	1	30	0.239	73	133	904	1.88	75	32	45	541
A+S23M-16-76-43.0C-0075L	5	2	15050	792	4	0.75	30	0.289	77	119	849	1.77	98	28	45	643
A+S23M-20-76-43.0C-0100L	6	2	17656	743	4	1	30	0.329	76	139	1061	2.21	98	28	54	715
A+S23M-20-108-43.0C-0075L	7	2	17250	511	4	0.75	30	0.208	77	136	1508	3.03	130	28	54	916
A+S23M-16-108-63.0C-0075L	8	2	15407	571	6	0.75	30	0.186	77	122	1808	3.57	130	32	46	985
A+S33M-20-114-43.0C-0075L	9	3	24078	676	4	0.75	30	0.246	78	127	1591	3.18	136	28	54	1029
A+S23M-20-108-63.0C-0100L	10	2	18003	533	6	1	30	0.198	76	142	2260	4.61	131	32	55	1137
A+S33M-20-114-63.0C-0100L	12	3	24549	689	6	1	30	0.247	80	129	2386	4.84	137	32	55	1302
A+S43M-16-152-83.0C-0100L	15	4	26687	702	8	1	30	0.242	79	105	3392	6.64	175	36	46	1698
A+S53M-16-190-83.0C-0100L	18	5	33359	702	8	1	30	0.247	79	105	4240	8.2	213	36	47	2094
A+S53M-16-270-63.0C-0075L	20	5	38517	571	6	0.75	30	0.183	81	122	4520	8.71	293	32	47	2397
A+S63M-16-228-83.0C-0100L	22	6	40031	702	8	1	30	0.256	80	105	5088	9.81	47	36	36	2507
A+S63M-20-228-83.0C-0075L	25	6	40836	573	8	0.75	30	0.176	82	108	6360	12.44	252	36	56	2924

*Ratings based on -10°F/85% rh air on temp, -20°F evaporating temp, 3 FPI fin spacing, 3:1 pumped ammonia (bottom feed).

Table 43: Wet Conditions**

Model Number	Capacity (TR)	Fans	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Air Throw (FT)	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+S13M-12-40-44.0C-0033L	2	1	3625	483	4	0.33	20	0.145	68	86	434	0.74	61	28	36	324
A+S13M-20-38-44.0C-0050L	3	1	5772	486	4	0.5	30	0.151	81	91	687	1.18	59	28	54	412
A+S13M-16-54-44.0C-0075L	4	1	8036	595	4	0.75	30	0.163	73	127	781	1.27	75	28	45	465
A+S13M-20-54-44.0C-0100L	5	1	9420	558	4	1	30	0.183	74	149	976	1.6	75	28	54	525
A+S23M-20-76-44.0C-0050L	6	2	11544	486	4	0.5	30	0.15	84	91	1374	2.17	97	28	54	741
A+S23M-20-76-44.0C-0050L	7	2	12841	541	4	0.5	30	0.135	78	101	1374	2.17	97	28	54	741
A+S23M-16-108-44.0C-0075L	8	2	16071	595	4	0.75	30	0.163	76	127	1562	2.39	129	28	45	849
A+S23M-20-108-44.0C-0075L	9	2	17057	505	4	0.75	30	0.145	76	135	1952	2.99	129	28	54	955
A+S23M-20-108-44.0C-0100L	10	2	18840	558	4	1	30	0.182	77	149	1952	2.99	129	28	54	955
A+S33M-16-162-44.0C-0075L	12	3	24107	595	4	0.75	30	0.172	78	127	2343	3.5	183	28	46	1233
A+S33M-20-162-44.0C-0100L	15	3	28260	558	4	1	30	0.189	79	149	2928	4.42	184	28	55	1390
A+S33M-20-162-64.0C-0100L	18	3	26508	524	6	1	30	0.167	80	140	4390	6.55	184	32	55	1759
A+S43M-20-216-44.0C-0100L	20	4	37680	558	4	1	30	0.182	80	149	3904	5.83	238	28	55	1875
A+S43M-16-216-64.0C-0100L	22	4	32341	599	6	1	30	0.176	82	128	4682	6.94	47	32	32	2029
A+S53M-20-190-64.0C-0100L	25	5	35599	600	6	1	30	0.174	85	113	5149	7.62	212	32	55	2167
A+S53M-16-270-64.0C-0100L	28	5	40426	599	6	1	30	0.171	83	128	5853	8.6	47	32	32	2509
A+S53M-20-270-64.0C-0100L	30	5	44181	524	6	1	30	0.166	82	140	7316	10.89	293	32	56	2890
A+S53M-16-270-84.0C-0100L	32	5	36798	545	8	1	30	0.154	84	116	7802	11.53	47	36	36	2985
A+S63M-20-228-84.0C-0100L	35	6	42060	590	8	1	30	0.169	85	111	8235	12.26	251	36	56	3098

**Ratings based on +35°F/85% rh air on temp, +25°F evaporating temp, 4 FPI fin spacing, 3:1 pumped ammonia (bottom feed).

Additional models and custom selections available - contact your local Colmac Coil representative.

A+S One Fan Models

Table 44: Frosted Conditions*

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Air Throw (FT)	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+S13M-20-38-43.0C-0100L	2	8828	743	4	1	30	0.33	73	139	530	1.19	59	28	54	401
A+S13M-16-54-63.0C-0100L	3	8445	626	6	1	30	0.239	73	133	904	1.88	75	32	45	541
A+S13M-20-54-83.0C-0100L	4	8517	505	8	1	30	0.189	73	135	1506	3.14	76	36	54	726

*Ratings based on -10°F/85% rh air on temp, -20°F evaporating temp, 3 FPI fin spacing, 3:1 pumped ammonia (bottom feed).

Table 45: Wet Conditions**

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Air Throw (FT)	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+S13M-12-40-44.0C-0033L	2	3625	483	4	0.33	20	0.145	68	86	434	0.74	61	28	36	324
A+S13M-20-38-44.0C-0050L	3	5772	486	4	0.5	30	0.151	81	91	687	1.18	59	28	54	412
A+S13M-16-54-44.0C-0075L	4	8036	595	4	0.75	30	0.163	73	127	781	1.27	75	28	45	465
A+S13M-20-54-44.0C-0100L	5	9420	558	4	1	30	0.183	74	149	976	1.6	75	28	54	525
A+S13M-20-38-104.0C-0100L	6	6379	537	10	1	30	0.16	81	101	1715	2.82	59	40	54	686
A+S13M-20-54-84.0C-0100L	7	8155	483	8	1	30	0.134	76	129	1950	3.1	75	36	54	767

**Ratings based on +35°F/85% rh air on temp, +25°F evaporating temp, 4 FPI fin spacing, 3:1 pumped ammonia (bottom feed).

A+S Two Fan Models

Table 46: Frosted Conditions*

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Air Throw (FT)	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+S23M-16-76-43.0C-0075L	5	15050	792	4	0.75	30	0.289	77	119	849	1.77	98	28	45	643
A+S23M-20-76-43.0C-0100L	6	17656	743	4	1	30	0.329	76	139	1061	2.21	98	28	54	715
A+S23M-20-108-43.0C-0075L	7	17250	511	4	0.75	30	0.208	77	136	1508	3.03	130	28	54	916
A+S23M-16-108-63.0C-0075L	8	15407	571	6	0.75	30	0.186	77	122	1808	3.57	130	32	46	985
A+S23M-20-76-83.0C-0100L	9	15021	633	8	1	30	0.215	78	119	2120	4.26	98	36	55	1011
A+S23M-20-108-63.0C-0100L	10	18003	533	6	1	30	0.198	76	142	2260	4.61	131	32	55	1137

*Ratings based on -10°F/85% rh air on temp, -20°F evaporating temp, 3 FPI fin spacing, 3:1 pumped ammonia (bottom feed).

Table 47: Wet Conditions**

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Air Throw (FT)	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+S23M-12-56-44.0C-0033L	3	6246	595	4	0.33	20	0.201	67	74	607	0.98	77	28	36	471
A+S23M-12-80-44.0C-0033L	4	7250	483	4	0.33	20	0.145	71	86	868	1.35	101	28	36	580
A+S23M-16-76-44.0C-0033L	5	9706	511	4	0.33	30	0.116	81	77	1099	1.74	97	28	45	663
A+S23M-20-76-44.0C-0050L	6	11544	486	4	0.5	30	0.15	84	91	1374	2.17	97	28	54	741
A+S23M-20-76-44.0C-0050L	7	12841	541	4	0.5	30	0.135	78	101	1374	2.17	97	28	54	741
A+S23M-16-108-44.0C-0075L	8	16071	595	4	0.75	30	0.163	76	127	1562	2.39	129	28	45	849
A+S23M-20-108-44.0C-0075L	9	17057	505	4	0.75	30	0.145	76	135	1952	2.99	129	28	54	955
A+S23M-20-108-44.0C-0100L	10	18840	558	4	1	30	0.182	77	149	1952	2.99	129	28	54	955

**Ratings based on +35°F/85% rh air on temp, +25°F evaporating temp, 4 FPI fin spacing, 3:1 pumped ammonia (bottom feed).

Additional models and custom selections available - contact your local Colmac Coil representative.

A+ Series™ Air Cooler Features

A+S Three Fan Models

Table 48: Frosted Conditions*

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Air Throw (FT)	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+S33M-16-114-43.0C-0050L	6	17793	624	4	0.5	30	0.22	79	94	1273	2.55	136	28	45	907
A+S33M-20-114-43.0C-0075L	7	20164	566	4	0.75	30	0.271	80	106	1591	3.18	136	28	54	1011
A+S33M-16-114-43.0C-0100L	8	24053	844	4	1	30	0.327	78	127	1273	2.54	136	28	45	924
A+S33M-20-114-43.0C-0075L	9	24078	676	4	0.75	30	0.246	78	127	1591	3.18	136	28	54	1029
A+S33M-16-162-43.0C-0100L	10	27300	674	4	1	30	0.291	77	144	1809	3.64	185	28	46	1202
A+S33M-20-114-63.0C-0100L	12	24549	689	6	1	30	0.247	80	129	2386	4.84	137	32	55	1302
A+S33M-16-162-83.0C-0100L	15	23894	590	8	1	30	0.196	80	126	3615	7.05	185	36	46	1725

*Ratings based on -10°F/85% rh air on temp, -20°F evaporating temp, 3 FPI fin spacing, 3:1 pumped ammonia (bottom feed).

Table 49: Wet Conditions**

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Air Throw (FT)	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+S33M-12-84-44.0C-0033L	5	9368	595	4	0.33	20	0.189	69	74	911	1.42	105	28	36	668
A+S33M-12-120-44.0C-0033L	6	10875	483	4	0.33	20	0.155	72	86	1301	1.98	141	28	37	840
A+S33M-16-114-44.0C-0033L	7	14559	511	4	0.33	30	0.112	83	77	1648	2.51	135	28	45	956
A+S33M-16-114-44.0C-0033L	8	14559	511	4	0.33	30	0.112	83	77	1648	2.51	135	28	45	956
A+S33M-16-114-44.0C-0050L	9	16970	595	4	0.5	30	0.144	84	89	1648	2.51	135	28	45	957
A+S33M-20-114-44.0C-0050L	10	19261	541	4	0.5	30	0.139	79	101	2061	3.14	135	28	54	1069
A+S33M-16-162-44.0C-0075L	12	24107	595	4	0.75	30	0.172	78	127	2343	3.5	183	28	46	1233
A+S33M-20-162-44.0C-0100L	15	28260	558	4	1	30	0.189	79	149	2928	4.42	184	28	55	1390
A+S33M-20-162-64.0C-0100L	18	26508	524	6	1	30	0.167	80	140	4390	6.55	184	32	55	1759
A+S33M-20-162-84.0C-0100L	20	24465	483	8	1	30	0.143	81	129	5851	8.68	184	36	55	2095

**Ratings based on +35°F/85% rh air on temp, +25°F evaporating temp, 4 FPI fin spacing, 3:1 pumped ammonia (bottom feed).

A+S Four Fan Models

Table 50: Frosted Conditions*

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Air Throw (FT)	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+S43M-16-152-43.0C-0050L	9	24854	654	4	0.5	30	0.208	82	98	1697	3.32	174	46	28	1199
A+S43M-16-152-43.0C-0075L	10	30100	792	4	0.75	30	0.288	80	119	1697	3.44	175	46	28	1215
A+S43M-20-152-43.0C-0100L	12	35311	743	4	1	30	0.328	79	139	2122	4.3	175	55	28	1396
A+S43M-16-152-83.0C-0100L	15	26687	702	8	1	30	0.242	79	105	3392	6.64	175	46	36	1698
A+S43M-20-152-83.0C-0100L	18	30042	633	8	1	30	0.214	81	119	4240	8.3	175	55	36	1969
A+S43M-20-152-103.0C-0100L	20	27779	585	10	1	30	0.196	82	110	5299	10.3	175	55	40	2257

*Ratings based on -10°F/85% rh air on temp, -20°F evaporating temp, 3 FPI fin spacing, 3:1 pumped ammonia (bottom feed).

Table 51: Wet Conditions**

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Air Throw (FT)	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+S43M-12-112-44.0C-0033L	6	12491	595	4	0.33	20	0.2	70	74	1215	1.86	133	36	28	870
A+S43M-12-112-64.0C-0033L	7	10327	492	6	0.33	20	0.122	71	61	1821	2.75	133	37	32	1014
A+S43M-12-160-44.0C-0033L	8	14501	483	4	0.33	20	0.15	74	86	1735	2.59	181	37	28	1091
A+S43M-12-160-44.0C-0075L	9	17403	580	4	0.75	20	0.229	74	103	1735	2.59	181	37	28	1094
A+S43M-16-152-44.0C-0033L	10	19411	511	4	0.33	30	0.116	84	77	2198	3.29	173	46	28	1242
A+S43M-20-152-44.0C-0050L	12	23089	486	4	0.50	30	0.149	87	91	2747	4.12	173	55	28	1431
A+S43M-16-216-44.0C-0050L	15	26594	493	4	0.50	30	0.125	80	105	3123	4.66	238	46	28	1627
A+S43M-20-216-44.0C-0075L	18	34113	505	4	0.75	30	0.145	79	135	3904	5.83	238	55	28	1875
A+S43M-20-216-44.0C-0100L	20	37680	558	4	1.00	30	0.182	80	149	3904	5.83	238	55	28	1875
A+S43M-20-216-64.0C-0100L	25	35346	524	6	1	30	0.156	81	140	5853	8.67	238	56	32	2320
A+S43M-16-216-64.0C-0100L	22	32341	599	6	1	30	0.176	82	128	4682	6.94	238	47	32	2029

**Ratings based on +35°F/85% rh air on temp, +25°F evaporating temp, 4 FPI fin spacing, 3:1 pumped ammonia (bottom feed).

Additional models and custom selections available - contact your local Colmac Coil representative.

A+S Five Fan Models

Table 52: Frosted Conditions*

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Air Throw (FT)	Surface Area (FT^2)	Internal Volume (FT^3)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+S53M-20-190-43.0C-0075L	12	34838	587	4	0.75	30	0.271	84	110	2652	5.27	213	28	55	1690
A+S53M-20-190-43.0C-0100L	15	44139	743	4	1	30	0.327	80	139	2652	5.27	213	28	55	1719
A+S53M-16-190-83.0C-0100L	18	33359	702	8	1	30	0.247	79	105	4240	8.2	213	36	47	2094
A+S53M-16-270-63.0C-0075L	20	38517	571	6	0.75	30	0.183	81	122	4520	8.71	293	32	47	2397
A+S53M-20-190-83.0C-0100L	22	37553	633	8	1	30	0.224	82	119	5300	10.25	213	36	56	2429
A+S53M-20-270-83.0C-0100L	25	42583	505	8	1	30	0.187	80	135	7532	14.59	294	36	56	3236

*Ratings based on -10°F/85% rh air on temp, -20°F evaporating temp, 3 FPI fin spacing, 3:1 pumped ammonia (bottom feed).

Table 53: Wet Conditions**

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Air Throw (FT)	Surface Area (FT^2)	Internal Volume (FT^3)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+S53M-12-140-44.0C-0033L	8	15614	595	4	0.33	20	0.191	71	74	1518	2.29	161	28	37	1065
A+S53M-12-200-44.0C-0033L	9	18126	483	4	0.33	20	0.148	75	86	2169	3.21	221	28	37	1350
A+S53M-12-200-44.0C-0033L	10	18126	483	4	0.33	20	0.148	75	86	2169	3.21	221	28	37	1350
A+S53M-16-190-44.0C-0033L	12	22594	476	4	0.33	30	0.133	90	71	2747	4.07	211	28	46	1578
A+S53M-16-190-44.0C-0050L	15	28283	595	4	0.5	30	0.143	86	89	2747	4.1	212	28	46	1583
A+S53M-20-190-44.0C-0075L	18	35598	600	4	0.75	30	0.185	84	113	3434	5.13	212	28	55	1779
A+S53M-16-270-44.0C-0075L	20	40178	595	4	0.75	30	0.166	80	127	3904	5.77	292	28	47	2058
A+S53M-20-270-44.0C-0075L	22	42641	505	4	0.75	30	0.151	80	135	4880	7.22	292	28	56	2319
A+S53M-20-190-64.0C-0100L	25	35599	600	6	1	30	0.174	85	113	5149	7.62	212	32	55	2167
A+S53M-16-270-64.0C-0100L	28	40426	599	6	1	30	0.171	83	128	5853	8.6	292	32	47	2509
A+S53M-20-270-64.0C-0100L	30	44181	524	6	1	30	0.166	82	140	7316	10.89	293	32	56	2890
A+S53M-16-270-84.0C-0100L	32	36798	545	8	1	30	0.154	84	116	7802	11.53	293	36	47	2985
A+S53M-20-270-84.0C-0100L	35	40775	483	8	1	30	0.137	83	129	9752	14.42	293	36	56	3440

**Ratings based on +35°F/85% rh air on temp, +25°F evaporating temp, 4 FPI fin spacing, 3:1 pumped ammonia (bottom feed).

Additional models and custom selections available - contact your local Colmac Coil representative.

A+ Series™ Air Cooler Features

A+S Six Fan Models

Table 54: Frosted Conditions*

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Air Throw (FT)	Surface Area (FT^2)	Internal Volume (FT^3)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+S63M-16-228-43.0C-0050L	12	35586	624	4	0.5	30	0.219	82	94	2546	5.03	251	28	46	1805
A+S63M-16-228-43.0C-0075L	15	45150	792	4	0.75	30	0.285	81	119	2546	5.02	251	28	46	1839
A+S63M-20-228-43.0C-0100L	18	52967	743	4	1	30	0.314	81	139	3183	6.27	251	28	55	2051
A+S63M-20-228-63.0C-0075L	20	44226	621	6	0.75	30	0.205	81	116	4772	9.27	251	32	56	2480
A+S63M-16-228-83.0C-0100L	22	40031	702	8	1	30	0.256	80	105	5088	9.81	251	36	47	2507
A+S63M-20-228-83.0C-0075L	25	40836	573	8	0.75	30	0.176	82	108	6360	12.44	252	36	56	2924

*Ratings based on -10°F/85% rh air on temp, -20°F evaporating temp, 3 FPI fin spacing, 3:1 pumped ammonia (bottom feed).

Table 55: Wet Conditions**

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Air Throw (FT)	Surface Area (FT^2)	Internal Volume (FT^3)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+S63M-12-168-44.0C-0033L	8	15515	493	4	0.33	20	0.114	73	61	1822	2.72	189	28	37	1292
A+S63M-12-168-44.0C-0033L	9	18737	595	4	0.33	20	0.2	72	74	1822	2.72	189	28	37	1308
A+S63M-12-168-64.0C-0033L	10	14591	463	6	0.33	20	0.127	72	58	2731	4.04	189	32	37	1538
A+S63M-12-240-44.0C-0033L	12	21751	483	4	0.33	20	0.155	75	86	2603	3.84	261	28	38	1655
A+S63M-12-168-84.0C-0075L	15	18873	599	8	0.75	20	0.231	74	75	3641	5.39	190	36	37	1773
A+S63M-16-228-44.0C-0050L	18	33939	595	4	0.5	30	0.143	87	89	3297	4.91	250	28	46	1893
A+S63M-20-228-44.0C-0050L	20	38522	541	4	0.5	30	0.139	82	101	4121	6.14	250	28	55	2120
A+S63M-20-228-44.0C-0075L	22	42718	600	4	0.75	30	0.189	85	113	4121	6.14	250	28	55	2130
A+S63M-20-228-64.0C-0050L	25	33718	473	6	0.5	30	0.107	85	89	6178	9.13	250	32	56	2596
A+S63M-20-228-64.0C-0075L	28	41215	579	6	0.75	30	0.15	81	109	6178	9.13	250	32	56	2596
A+S63M-20-228-84.0C-0075L	30	37166	522	8	0.75	30	0.13	81	98	8235	12.26	251	36	56	3090
A+S63M-20-228-84.0C-0075L	32	37163	522	8	0.75	30	0.13	81	98	8235	12.26	251	36	56	3090
A+S63M-20-228-84.0C-0100L	35	42060	590	8	1	30	0.169	85	111	8235	12.26	251	36	56	3098

**Ratings based on +35°F/85% rh air on temp, +25°F evaporating temp, 4 FPI fin spacing, 3:1 pumped ammonia (bottom feed).

Additional models and custom selections available - contact your local Colmac Coil representative.

A+R PROCESS ROOM UNITS

Capacity Range: 3 - 25 TR

Featuring:

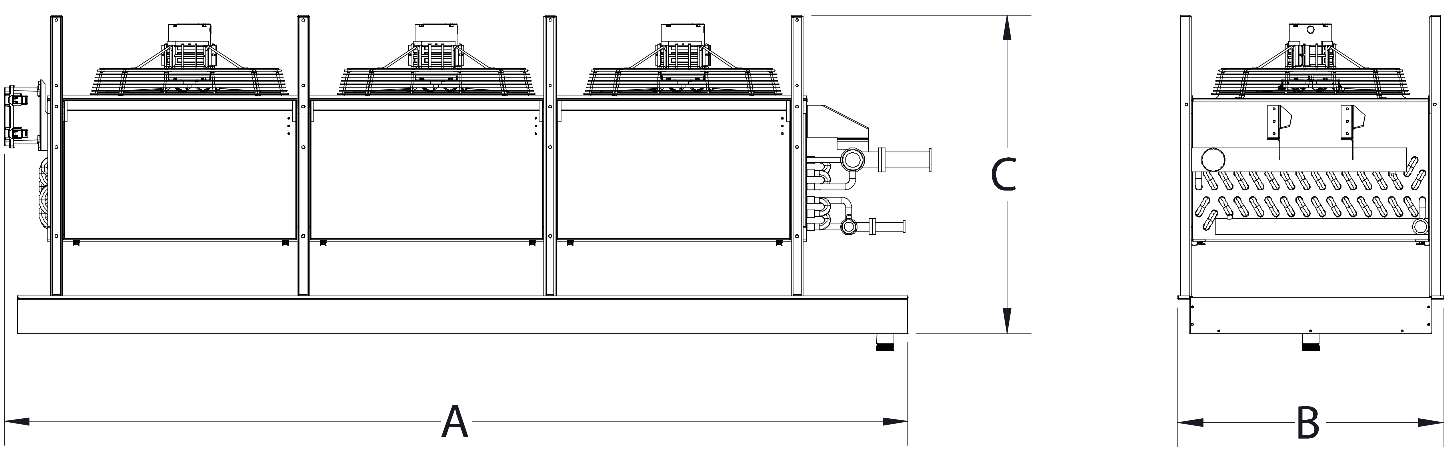
- 1/3 – 1 hp premium efficiency motors
- 16” – 30” diameter airfoil shaped fans
- 4 – 12 row coil
- Hinged side access panels
- Full coverage drainpan

Options:

- Air deflectors
- CIP piping
- Seal welded drainpan
- Reheat coil

A+R Unit Dimensions

Dimensions and weights provided in the tables may change based on the options and features selected. Do not use these for construction, refer to the factory submittal provided at time of order.



(3 fan unit shown)

A+R Lowest Cost ($/TR) Models

Table 56: Frosted Conditions*

Model Number	Capacity (TR)	Fans	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Surface Area (FT^2)	Internal Volume (FT^3)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+R13M-16-54-43.0C-0075L	3	1	8271	613	4	0.75	30	0.243	74	603	1.28	75	41	37	508
A+R13M-16-54-63.0C-0100L	4	1	8445	626	6	1	30	0.239	73	904	1.88	75	41	41	595
A+R23M-16-76-43.0C-0075L	5	2	15049	792	4	0.75	30	0.289	77	849	1.77	98	41	37	715
A+R23M-16-108-43.0C-0075L	6	2	16541	613	4	0.75	30	0.241	77	1206	2.43	130	41	37	901
A+R23M-16-108-63.0C-0075L	8	2	15407	571	6	0.75	30	0.186	77	1808	3.57	130	41	41	1063
A+R33M-16-162-43.0C-0100L	10	3	27299	674	4	1	30	0.291	77	1809	3.64	185	41	37	1309
A+R33M-16-162-63.0C-0100L	12	3	25336	626	6	1	30	0.246	78	2712	5.35	185	41	41	1548
A+R43M-16-152-83.0C-0100L	15	4	26687	702	8	1	30	0.242	79	3392	6.64	175	41	45	1805
A+R53M-16-190-83.0C-0100L	18	5	33359	702	8	1	30	0.247	79	4240	8.2	213	41	45	2222
A+R53M-16-270-63.0C-0075L	20	5	38517	571	6	0.75	30	0.183	81	4520	8.71	293	41	41	2544
A+R63M-16-228-83.0C-0100L	22	6	40031	702	8	1	30	0.256	80	5088	9.81	251	41	45	2655
A+R73M-16-266-83.0C-0075L	25	7	42592	641	8	0.75	30	0.194	82	5936	11.51	290	41	45	3118
A+R73M-16-266-83.0C-0100L	28	7	46700	702	8	1	30	0.241	81	5936	11.49	290	41	45	3074

*Ratings based on -10°F/85% rh air on temp, -20°F evaporating temp, 3 FPI fin spacing, 3:1 pumped ammonia (bottom feed).

Table 57: Wet Conditions**

Model Number	Capacity (TR)	Fans	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Surface Area (FT^2)	Internal Volume (FT^3)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+R13M-12-40-44.0C-0033L	2	1	3625	483	4	0.33	20	0.145	68	434	0.74	61	32	37	356
A+R13M-12-40-84.0C-0050L	3	1	3453	460	8	0.5	20	0.142	72	867	1.42	61	32	45	473
A+R13M-16-54-44.0C-0075L	4	1	8036	595	4	0.75	30	0.163	73	781	1.27	75	41	37	522
A+R13M-16-54-64.0C-0075L	5	1	7266	538	6	0.75	30	0.137	73	1171	1.88	75	41	41	621
A+R23M-12-80-84.0C-0050L	6	2	6905	460	8	0.5	20	0.145	75	1734	2.66	101	32	45	844
A+R23M-16-108-44.0C-0075L	8	2	16071	595	4	0.75	30	0.163	76	1562	2.39	129	41	37	931
A+R23M-16-108-64.0C-0075L	10	2	14532	538	6	0.75	30	0.137	76	2341	3.54	129	41	41	1112
A+R33M-16-162-44.0C-0075L	12	3	24107	595	4	0.75	30	0.172	78	2343	3.5	183	41	37	1340
A+R33M-16-162-64.0C-0075L	15	3	21799	538	6	0.75	30	0.136	78	3512	5.24	184	41	41	1609
A+R33M-16-162-84.0C-0100L	18	3	22080	545	8	1	30	0.157	82	4681	6.94	184	41	45	1879
A+R43M-16-216-64.0C-0075L	20	4	29065	538	6	0.75	30	0.136	79	4682	6.94	238	41	41	2152
A+R43M-16-216-64.0C-0100L	22	4	32341	599	6	1	30	0.176	82	4682	6.94	238	41	41	2152
A+R53M-16-270-64.0C-0100L	25	5	40426	599	6	1	30	0.171	83	5853	8.6	292	41	41	2656
A+R53M-16-270-64.0C-0100L	28	5	40426	599	6	1	30	0.171	83	5853	8.6	292	41	41	2656
A+R53M-16-270-84.0C-0100L	30	5	36799	545	8	1	30	0.154	84	7802	11.53	293	41	45	3126
A+R53M-16-270-84.0C-0100L	32	5	36798	545	8	1	30	0.154	84	7802	11.53	293	41	45	3126
A+R73M-16-266-104.0C-0100L	35	7	39010	587	10	1	30	0.19	89	9606	14.16	289	41	49	3746

**Ratings based on +35°F/85% rh air on temp, +25°F evaporating temp, 4 FPI fin spacing, 3:1 pumped ammonia (bottom feed).

Additional models and custom selections available - contact your local Colmac Coil representative.

A+R One Fan Models

Table 58: Frosted Conditions*

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+R13M-16-54-43.0C-0075L	3	8271	613	4	0.75	30	0.243	74	603	1.28	75	41	37	508
A+R13M-16-54-63.0C-0100L	4	8445	626	6	1	30	0.239	73	904	1.88	75	41	41	595
A+R13M-16-54-103.0C-0100L	5	7425	550	10	1	30	0.194	75	1506	3.11	76	41	49	772

*Ratings based on -10°F/85% rh air on temp, -20°F evaporating temp, 3 FPI fin spacing, 3:1 pumped ammonia (bottom feed).

Table 59: Wet Conditions**

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+R13M-12-40-44.0C-0033L	2	3625	483	4	0.33	20	0.145	68	434	0.74	61	32	37	356
A+R13M-12-40-84.0C-0050L	3	3453	460	8	0.5	20	0.142	72	867	1.42	61	32	45	473
A+R13M-16-54-44.0C-0075L	4	8036	595	4	0.75	30	0.163	73	781	1.27	75	41	37	522
A+R13M-16-54-64.0C-0075L	5	7266	538	6	0.75	30	0.137	73	1171	1.88	75	41	41	621
A+R13M-16-54-104.0C-0075L	6	6083	451	10	0.75	30	0.113	73	1950	3.07	75	41	49	813

**Ratings based on +35°F/85% rh air on temp, +25°F evaporating temp, 4 FPI fin spacing, 3:1 pumped ammonia (bottom feed).

A+R Two Fan Models

Table 60: Frosted Conditions*

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+R23M-16-76-43.0C-0075L	5	15049	792	4	0.75	30	0.289	77	849	1.77	98	41	37	715
A+R23M-16-108-43.0C-0075L	6	16541	613	4	0.75	30	0.241	77	1206	2.43	130	41	37	901
A+R23M-16-108-63.0C-0075L	8	15407	571	6	0.75	30	0.186	77	1808	3.57	130	41	41	1063
A+R23M-16-108-103.0C-0100L	10	14851	550	10	1	30	0.193	78	3012	5.99	131	41	49	1406

*Ratings based on -10°F/85% rh air on temp, -20°F evaporating temp, 3 FPI fin spacing, 3:1 pumped ammonia (bottom feed).

Table 61: Wet Conditions**

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+R23M-12-56-44.0C-0033L	3	6246	595	4	0.33	20	0.201	67	607	0.98	77	32	37	517
A+R23M-12-80-44.0C-0033L	4	7250	483	4	0.33	20	0.145	71	868	1.35	101	32	37	626
A+R23M-16-76-44.0C-0033L	5	9706	511	4	0.33	30	0.116	81	1099	1.74	97	41	37	735
A+R23M-12-80-84.0C-0050L	6	6905	460	8	0.5	20	0.145	75	1734	2.66	101	32	45	844
A+R23M-16-108-44.0C-0075L	8	16071	595	4	0.75	30	0.163	76	1562	2.39	129	41	37	931
A+R23M-16-108-64.0C-0075L	10	14532	538	6	0.75	30	0.137	76	2341	3.54	129	41	41	1112
A+R23M-16-108-104.0C-0100L	12	13509	500	10	1	30	0.155	76	3900	5.84	129	41	49	1475

**Ratings based on +35°F/85% rh air on temp, +25°F evaporating temp, 4 FPI fin spacing, 3:1 pumped ammonia (bottom feed).

Additional models and custom selections available - contact your local Colmac Coil representative.

A+ Series™ Air Cooler Features

A+R Three Fan Models

Table 62: Frosted Conditions*

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+R33M-16-114-43.0C-0050L	6	17793	624	4	0.5	30	0.22	79	1273	2.55	136	41	37	1002
A+R33M-16-162-43.0C-0050L	8	20240	500	4	0.5	30	0.165	79	1809	3.53	184	41	37	1292
A+R33M-16-162-43.0C-0100L	10	27299	674	4	1	30	0.291	77	1809	3.64	185	41	37	1309
A+R33M-16-162-63.0C-0100L	12	25336	626	6	1	30	0.246	78	2712	5.35	185	41	41	1548
A+R33M-16-162-83.0C-0100L	15	23894	590	8	1	30	0.196	80	3615	7.05	185	41	45	1786

*Ratings based on -10°F/85% rh air on temp, -20°F evaporating temp, 3 FPI fin spacing, 3:1 pumped ammonia (bottom feed).

Table 63: Wet Conditions**

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+R33M-12-84-44.0C-0033L	5	9368	595	4	0.33	20	0.189	69	911	1.42	105	32	37	725
A+R33M-12-120-44.0C-0033L	6	10875	483	4	0.33	20	0.155	72	1301	1.98	141	32	37	899
A+R33M-16-114-44.0C-0033L	8	14559	511	4	0.33	30	0.112	83	1648	2.51	135	41	37	1050
A+R33M-12-120-84.0C-0075L	10	11913	530	8	0.75	20	0.199	72	2601	3.89	141	32	45	1221
A+R33M-16-162-44.0C-0075L	12	24107	595	4	0.75	30	0.172	78	2343	3.5	183	41	37	1340
A+R33M-16-162-64.0C-0075L	15	21799	538	6	0.75	30	0.136	78	3512	5.24	184	41	41	1609
A+R33M-16-162-84.0C-0100L	18	22080	545	8	1	30	0.157	82	4681	6.94	184	41	45	1879

**Ratings based on +35°F/85% rh air on temp, +25°F evaporating temp, 4 FPI fin spacing, 3:1 pumped ammonia (bottom feed).

A+R Four Fan Models

Table 64: Frosted Conditions*

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+R43M-16-152-43.0C-0075L	10	30098	792	4	0.75	30	0.288	80	1697	3.44	175	41	37	1328
A+R43M-16-152-63.0C-0100L	12	28487	750	6	1	30	0.305	84	2545	5.04	175	41	41	1599
A+R43M-16-152-83.0C-0100L	15	26687	702	8	1	30	0.242	79	3392	6.64	175	41	45	1805
A+R43M-16-216-83.0C-0075L	18	28733	532	8	0.75	30	0.161	80	4820	9.32	239	41	45	2388
A+R43M-16-216-103.0C-0100L	20	29702	550	10	1	30	0.192	81	6025	11.59	239	41	49	2713

*Ratings based on -10°F/85% rh air on temp, -20°F evaporating temp, 3 FPI fin spacing, 3:1 pumped ammonia (bottom feed).

Table 65: Wet Conditions**

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+R43M-12-160-44.0C-0033L	8	14501	483	4	0.33	20	0.15	74	1735	2.59	181	32	37	1161
A+R43M-16-152-44.0C-0033L	10	19411	511	4	0.33	30	0.116	84	2198	3.29	173	41	37	1354
A+R43M-12-160-84.0C-0050L	12	13811	460	8	0.5	20	0.144	78	3468	5.12	181	32	45	1576
A+R43M-16-216-44.0C-0050L	15	26594	493	4	0.5	30	0.125	80	3123	4.66	238	41	37	1759
A+R43M-16-152-84.0C-0075L	18	21940	577	8	0.75	30	0.162	82	4392	6.53	174	41	45	1908
A+R43M-16-216-64.0C-0075L	20	29065	538	6	0.75	30	0.136	79	4682	6.94	238	41	41	2152
A+R43M-16-216-64.0C-0100L	22	32341	599	6	1	30	0.176	82	4682	6.94	238	41	41	2152

**Ratings based on +35°F/85% rh air on temp, +25°F evaporating temp, 4 FPI fin spacing, 3:1 pumped ammonia (bottom feed).

Additional models and custom selections available - contact your local Colmac Coil representative.

A+R Five Fan Models

Table 66: Frosted Conditions*

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+R53M-16-190-43.0C-0075L	12	37623	792	4	0.75	30	0.299	81	2122	4.22	213	41	37	1671
A+R53M-16-190-63.0C-0075L	15	33559	707	6	0.75	30	0.23	81	3181	6.21	213	41	41	1961
A+R53M-16-190-83.0C-0100L	18	33359	702	8	1	30	0.247	79	4240	8.2	213	41	45	2222
A+R53M-16-270-63.0C-0075L	20	38517	571	6	0.75	30	0.183	81	4520	8.71	293	41	41	2544
A+R53M-16-270-83.0C-0075L	22	35915	532	8	0.75	30	0.17	81	6026	11.53	293	41	45	2945
A+R53M-16-270-103.0C-0100L	25	37127	550	10	1	30	0.192	82	7531	14.5	294	41	49	3360

*Ratings based on -10°F/85% rh air on temp, -20°F evaporating temp, 3 FPI fin spacing, 3:1 pumped ammonia (bottom feed).

Table 67: Wet Conditions**

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+R53M-12-140-44.0C-0033L	8	15614	595	4	0.33	20	0.191	71	1518	2.29	161	32	37	1147
A+R53M-12-200-44.0C-0033L	10	18126	483	4	0.33	20	0.148	75	2169	3.21	221	32	37	1433
A+R53M-16-190-44.0C-0033L	12	22594	476	4	0.33	30	0.133	90	2747	4.07	211	41	37	1708
A+R53M-16-190-44.0C-0050L	15	28283	595	4	0.5	30	0.143	86	2747	4.1	212	41	37	1713
A+R53M-16-270-44.0C-0050L	18	33242	493	4	0.5	30	0.127	81	3904	5.77	292	41	37	2208
A+R53M-16-270-44.0C-0075L	20	40178	595	4	0.75	30	0.166	80	3904	5.77	292	41	37	2210
A+R53M-16-190-84.0C-0075L	22	27426	577	8	0.75	30	0.17	83	5490	8.09	212	41	45	2355
A+R53M-16-190-104.0C-0100L	25	27864	587	10	1	30	0.196	87	6862	10.08	212	41	49	2696
A+R53M-16-270-64.0C-0100L	25	40426	599	6	1	30	0.171	83	5853	8.6	292	41	41	2656
A+R53M-16-270-64.0C-0100L	28	40426	599	6	1	30	0.171	83	5853	8.6	292	41	41	2656
A+R53M-16-270-84.0C-0100L	30	36799	545	8	1	30	0.154	84	7802	11.53	293	41	45	3126
A+R53M-16-270-84.0C-0100L	32	36798	545	8	1	30	0.154	84	7802	11.53	293	41	45	3126

**Ratings based on +35°F/85% rh air on temp, +25°F evaporating temp, 4 FPI fin spacing, 3:1 pumped ammonia (bottom feed).

Additional models and custom selections available - contact your local Colmac Coil representative.

A+R Six Fan Models

Table 68: Frosted Conditions*

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+R63M-16-228-43.0C-0050L	12	35586	624	4	0.5	30	0.219	82	2546	5.03	251	41	37	1957
A+R63M-16-228-43.0C-0075L	15	45147	792	4	0.75	30	0.285	81	2546	5.02	251	41	37	1991
A+R63M-16-228-63.0C-0100L	18	42731	750	6	1	30	0.305	86	3817	7.42	251	41	41	2347
A+R63M-16-228-83.0C-0075L	20	36508	641	8	0.75	30	0.205	82	5088	9.81	251	41	45	2690
A+R63M-16-228-83.0C-0100L	22	40031	702	8	1	30	0.256	80	5088	9.81	251	41	45	2655
A+R63M-16-228-103.0C-0100L	25	37373	656	10	1	30	0.237	86	6359	12.35	252	41	49	3073

*Ratings based on -10°F/85% rh air on temp, -20°F evaporating temp, 3 FPI fin spacing, 3:1 pumped ammonia (bottom feed).

Table 69: Wet Conditions**

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+R63M-12-168-64.0C-0033L	10	14591	463	6	0.33	20	0.127	72	2731	4.04	189	32	41	1628
A+R63M-12-240-44.0C-0033L	12	21751	483	4	0.33	20	0.155	75	2603	3.84	261	32	37	1713
A+R63M-12-168-84.0C-0075L	15	18873	599	8	0.75	20	0.231	74	3641	5.39	190	32	45	1863
A+R63M-16-228-44.0C-0050L	18	33939	595	4	0.5	30	0.143	87	3297	4.91	250	41	37	2045
A+R63M-12-240-84.0C-0075L	20	23826	530	8	0.75	20	0.199	75	5201	7.65	262	32	45	2394
A+R63M-16-228-64.0C-0075L	22	34176	600	6	0.75	30	0.178	86	4943	7.31	250	41	41	2447
A+R63M-16-228-104.0C-0100L	25	30674	538	10	1	30	0.191	89	8234	12.1	250	41	49	3219
A+R63M-16-228-84.0C-0075L	28	32910	577	8	0.75	30	0.158	83	6588	9.7	250	41	45	2817

**Ratings based on +35°F/85% rh air on temp, +25°F evaporating temp, 4 FPI fin spacing, 3:1 pumped ammonia (bottom feed).

A+R Seven Fan Models

Table 70: Frosted Conditions*

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+R73M-16-266-43.0C-0075L	18	52672	792	4	0.75	30	0.286	82	2971	5.8	289	41	37	2292
A+R73M-16-266-63.0C-0050L	20	39574	595	6	0.5	30	0.17	86	4453	8.58	289	41	41	2698
A+R73M-16-266-63.0C-0075L	22	46983	707	6	0.75	30	0.232	82	4453	8.58	289	41	41	2698
A+R73M-16-266-83.0C-0075L	25	42592	641	8	0.75	30	0.194	82	5936	11.51	290	41	45	3118
A+R73M-16-266-83.0C-0100L	28	46700	702	8	1	30	0.241	81	5936	11.49	290	41	45	3074

*Ratings based on -10°F/85% rh air on temp, -20°F evaporating temp, 3 FPI fin spacing, 3:1 pumped ammonia (bottom feed).

Table 71: Wet Conditions**

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+R73M-12-280-44.0C-0050L	15	29153	555	4	0.5	20	0.209	74	3037	4.49	302	32	37	2042
A+R73M-16-266-44.0C-0033L	18	33970	511	4	0.33	30	0.113	87	3846	5.69	288	41	37	2355
A+R73M-16-266-44.0C-0050L	20	39596	595	4	0.5	30	0.145	87	3846	5.69	288	41	37	2359
A+R73M-12-280-64.0C-0100L	22	31038	591	6	1	20	0.248	75	4552	6.68	302	32	41	2415
A+R73M-16-266-64.0C-0075L	25	39872	600	6	0.75	30	0.17	87	5766	8.47	288	41	41	2823
A+R73M-16-266-64.0C-0075L	28	39872	600	6	0.75	30	0.17	87	5766	8.47	288	41	41	2823
A+R73M-16-266-84.0C-0075L	30	38396	577	8	0.75	30	0.159	84	7686	11.37	289	41	45	3270
A+R73M-16-266-84.0C-0075L	32	38395	577	8	0.75	30	0.159	84	7686	11.37	289	41	45	3270
A+R73M-16-266-104.0C-0100L	35	39010	587	10	1	30	0.19	89	9606	14.16	289	41	49	3746

**Ratings based on +35°F/85% rh air on temp, +25°F evaporating temp, 4 FPI fin spacing, 3:1 pumped ammonia (bottom feed).

Additional models and custom selections available - contact your local Colmac Coil representative.

Notes:

Additional models and custom selections available - contact your local Colmac Coil representative.

COLMAC COIL
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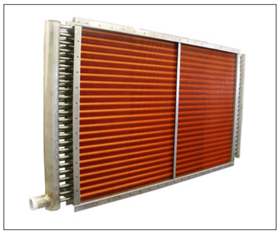
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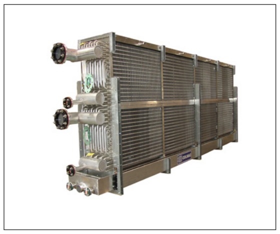
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Product Information
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North American Headquarters
Colmac Coil Manufacturing, Inc.
370 N. Lincoln St. | P.O. Box 571
Colville, WA 99114 | USA
+1.509.684.2595 | +1.800.845.6778

Midwest US Manufacturing
Colmac Coil Midwest
350 Baltimore Dr. | Paxton, IL 60957 | USA

"The Heat Transfer Experts"

Engineering Catalog

COLMAC COIL
Manufacturing Inc.

A+ Series™
CO_2 Engineering Catalog
IP Units

Covers:

Refrigeration Air Coolers

- A+L - High Profile Unit
- A+M - Medium Profile Unit
- A+S - Low Profile Unit
- A+R - Process Room Unit

Refrigerant

- CO_2

ENG00019655 Rev0

Table Of Contents

A+ Series™ CO_2 Air Cooler Features

COLMAC COIL Manufacturing Inc.

A+L High Profile Unit

- High profile for medium to large industrial applications
- “Plug-in” fan section for horizontal, 45° down, or penthouse air discharge
- High efficiency fans and premium efficiency motors standard
- Hinged fan panels standard
- Capacity range: 5 – 100 TR

A+M Medium Profile Unit

- Medium profile for small to medium industrial applications
- High efficiency fans and foot mounted motors with up to 3 Hp
- Hinged fan panels standard
- Optional full coverage drainpan
- Capacity range: 2 – 50 TR

A+S Low Profile Unit

- Low profile for small to medium industrial applications
- High efficiency fans and motors up to 1 Hp
- Hinged fan panels standard
- Optional full coverage drainpan
- Capacity range: 2 – 35 TR

A+R Process Room Unit

- "Above Rail" style air cooler for use in food processing rooms where cleanability is critical
- Optional "clean-in-place" piping available
- Hinged access panels standard
- Full coverage insulated drainpan standard
- Capacity range: 3 – 25 TR

MODEL NOMENCLATURE

A+M 3 3 I - 16 - 144 - 6 1R 4 V C - 0100 L - A RB - GG - S D - L

MODEL SERIES
A+S
A+M
A+L
A+R

NUMBER OF FANS

COIL MATERIALS
3 - SST/AL
A - AL/AL
C - CU/AL
S - GALV
3CN - SST/AM
33 - SST/SST
CC - CU/CU

TUBE PATTERN
I - 5/8" STAGGERED
M - 7/8" STAGGERED
T - 5/8" INLINE

TUBES HIGH

FINNED LENGTH

ROWS DEEP

REHEAT ROWS
1R - 1 ROW
2R - 2 ROWS

FIN SPACING (FPI)

VARIABLE FINS

FIN TYPE
F - FLAT
C - CONFIGURED

MOTOR HP
0033 - 0.33
0050 - 0.5
0075 - 0.75
0100 - 1
0150 - 1.5
0200 - 2
0300 - 3
0500 - 5
0750 - 7.5
1000 - 10
1500 - 15

MOTOR SPEED
S - 900
L - 1200
H - 1800
R - 750
K - 1000
G - 1500

FLUID
A - AMMONIA
C - CO2
F - R22, R507A, R404A, R404C
B - BRINE, WATER, GLYCOL

FEED
FL - FLOODED
RB - RECIRC. BOTTOM
RT - RECIRC. TOP
DX - DIRECT EXPANSION
BR - BRINE
PT - CPR TOP
PB - CPR BOTTOM

DEFROST
AD - AIR COIL, AIR PAN
AG - AIR COIL, HOT GAS PAN
AE - AIR COIL, ELECTRIC PAN
GA - HOT GAS COIL, AIR PAN
GG - HOT GAS COIL, HOT GAS PAN
GE - HOT GAS COIL, ELECTRIC PAN
EA - ELECTRIC COIL, AIR PAN
EG - ELECTRIC COIL, ELECTRIC PAN
EE - ELECTRIC COIL, ELECTRIC PAN
WW - WATER COIL, WATER PAN

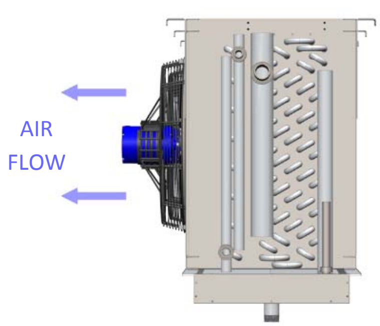
DISCHARGE
S - STANDARD
L - LONG THROW
F - 45° DOWN
P - PENTHOUSE
1 - 1/4" STATIC
2 - 1/2" STATIC
3 - 3/4" STATIC

FAN ORIENTATION
D - DRAW THROUGH
B - BLOW THROUGH

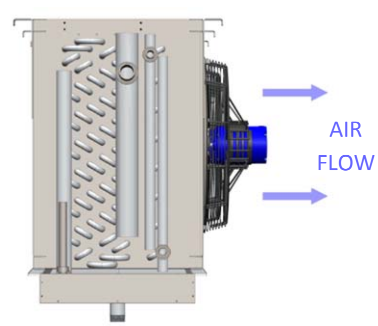
COIL HAND
R- RIGHT
L - LEFT

UNIT HAND DESIGNATION

Left Hand



Right Hand



CONSTRUCTION

Colmac A+Series™ air coolers are designed to be compatible with CO_2 (R-744) as the refrigerant. The process for selecting a CO_2 cooler is similar to that of an ammonia or freon cooler, but there are different material and pressure requirements. This catalog focuses on the options, features and ratings available when selecting A+Series™ air coolers for use with CO_2.

COIL MATERIALS

Coil construction materials available for CO_2 evaporators include:

- Stainless steel tubes/aluminum fins (standard)
- Stainless steel tubes and fins
- Stainless steel tubes/anti-microbial fins
- Copper tubes/aluminum fins (low pressure only)
- Copper tubes and fins (low pressure only)

COIL PRESSURE RATINGS

Due to the higher working pressures of CO_2 refrigerant, evaporators for use with it must be rated for higher pressures. All coils are designed and manufactured per ASME B31.5 (2001). Stainless steel tube (standard) construction evaporators are tested for a 970 psig (67 barg) maximum working pressure. Copper tube (low pressure systems only) construction evaporators are tested for a 400 psig (27.6 barg) maximum working pressure.

REFRIGERANT FEED METHODS

A+ Series™ CO_2 air coolers can be designed for pump recirculated, DX and brine feed methods. Coil circuiting is customized to match each application for optimal heat transfer with the appropriate tube side pressure drop.

TUBES

All CO_2 selections feature 5/8" diameter tubes in an inline arrangement. This pattern provides the lowest air pressure drop and offers a large amount of secondary (fin) surface area for maximum frost carrying capacity and extended runtime between defrosts.

FINS

All fins are a continuous design with a clean, full collar to optimize performance and cleanability while minimizing airflow resistance. Multiple fin spacing options are available to match every application.

- 3 or 4 FPI: Standard applications with light to moderate frost loads
- 6 FPI: Above freezing/wet fin applications
- Variable Spacing: High frost load applications

Fin Configurations

- Enhanced fins (standard): Highest heat transfer
- Flat fins: Reduced fan power, improved cleanability

A+ Series™ CO_2 Air Cooler Features

CASING

All A+ Series™ air coolers feature hinged fan panels for ease of inspection, cleaning, and service. Care has also been taken to eliminate areas near the evaporator fins that are difficult to inspect and clean. Fan sections are sloped to allow for water drainage. Casings are constructed of durable, corrosion resistant G-90 galvanized steel as standard with stainless steel available as an option.

DRAINPAN

Colmac Coil's innovative "Triple Pitch" V-bottom drainpan design provides for rapid and complete drainage of melted frost and ice. Low spots and pooling of melted frost are completely eliminated. The pan drains to a single drain connection on one end, simplifying drain piping.

Materials

Inner:

- Aluminum (standard)
- Stainless steel (optional)

Outer cover (insulated pans):

- Matches casing as standard
- Available in any casing material
- Fully seal welded seams available as an option

FANS

All Colmac Coil A+ Series™ air coolers use high efficiency fan blades with a true airfoil shape. The airfoil shape can achieve mechanical efficiencies above 70% and lower sound levels during operation. These blades are also non-overloading to accommodate variations in static pressure due to frost buildup or condensing water. A wide range of fan diameters and speeds are available to match performance and sound requirements.

Materials

- PPG Composite (above 0°F operating temperature)
- PAG Composite (above -20°F operating temperature)
- Cast aluminum available on request (low temperature freezers)
- Optional stamped stainless steel for food processing applications

MOTORS/ELECTRICAL

All standard fan motors supplied with A+ Series™ air coolers are premium efficiency, internal rotor, totally enclosed and VFD compatible. Motors are supplied with low temperature grease when appropriate.

Motor Speed Options

- 900 rpm (low noise)
- 1200 rpm (standard)
- 1800 rpm

Power Options

- 460/60/3
- 575/60/3
- 380/60/3
- 230/60/3
- 400/50/3
- 200/50/3

Wiring Options

- Common disconnect, fused or non-fused (standard)
- Individual disconnects, fused or non-fused
- Common fused disconnect with motor starters
- Custom UL508 listed control panels available

All wiring options use NEMA 4X boxes as standard. All panels are UL listed.

DEFROST

The following defrost methods are available for A+Series™ air coolers with CO_2 (R-744) as the refrigerant:

- Air
- Water
- Electric
- Interlaced glycol circuit
- Hot gas

Electric defrost is very effective and is widely used with CO_2, due to its simplicity and low first cost. Water is also popular because it defrosts quickly and provides rinsing of the evaporator. The use of hot gas is uncommon because of the high pressure of CO_2 at defrost temperatures. This defrost method is not available with copper tube evaporators and may require an increased wall thickness for stainless steel tubing and pipe, depending on the design pressure.

STANDARD FEATURES

All A+ Series™ air coolers come with the following features as standard:

CRADLE CRATING SYSTEM

The unique cradle crating system from Colmac Coil supports the full weight of the air cooler while withstanding the rigors of shipment. The cradle crate also safely supports the weight of the air cooler while it is lifted into position from below. Then after the air cooler is secured to the ceiling, the crate is easily removed from the unit by gravity allowing it to be safely lowered to the ground.

VERTICAL CONNECTIONS

Colmac Coil's vertical liquid and hot gas connections eliminate the need for field installed elbows and piping required to connect to horizontal connections. The result is time and money saved on the jobsite during installation.

FREE DRAINING LIQUID CONNECTIONS

With conventional coil designs, the liquid connection enters the liquid header in such a way that the bottom tubes in the coil stay flooded with condensed refrigerant during defrost. The result is slow, uneven (or incomplete) defrosting of the coil. Colmac Coil has solved this problem by extending the liquid header downward and placing the liquid connection below the level of the lowest tube in the coil. This design effectively traps all condensed liquid refrigerant and forces it out of the coil during defrost, resulting in a fast, complete and effective defrost of the entire coil.

REMOVABLE WATER DISTRIBUTION PANS (Water Defrost Units)

Fouling and plugging of spray nozzles is eliminated by the use of removable, cleanable water distribution pans. The distribution pans are designed to be easily removable for inspection and cleaning while the air cooler remains in place and undisturbed.

COLMAC COIL Manufacturing Inc.

AVAILABLE OPTIONS

AIR DISCHARGE ARRANGEMENTS (A+L only)

Long Throw Adapters
Fan guards are replaced with conical ducts which increase air throw distance approximately 30 - 40%. Consult your local Colmac representative.

45° Down Discharge
Fans are located in an optional, 45° down discharge duct. Fan capacities are calculated with an additional 1/4 iwg (62 Pa) of external static pressure.

Penthouse (90° down)
Fans are located in an optional, 90° down discharge duct (Penthouse). Access doors for inspection and motor removal are included. Fan capacities are calculated with an additional 1/2 iwg (124 Pa) of external static pressure.

Tube Axial Fans (external static pressure)
Fans are located in extended tubes that enhance the fan's ability to handle very large external static pressures. Consult your local Colmac representative.

WASHDOWN DUTY MOTORS

For applications where units are regularly washed down, these motors feature an epoxy coated finish and double sealed bearings.

REHEAT COIL SECTION

A condenser or hot fluid section can be added to the coil core to produce continuous dehumidification and reduce sweating by heating the air after it leaves the cooling coil section.

SEAL WELDED DRAINPAN

Fully welded seams on the drainpan cover improve hygiene and cleanability.

HINGED DRAINPAN

Drainpan hinges allow access for cleaning and maintenance.

FULL COVERAGE DRAINPAN (Standard on A+R)

Drainpan is extended to ensure that all water dripping off of the fans or casing is caught in the drainpan. This is not available on units with support legs.

ELECTRIC HEAT TRACE DRAINPAN COVER

Heat trace is added to the drainpan cover to keep it above the room dew point temperature, preventing condensate from forming on the cover and dripping. It is good for use in above freezing applications when the drainpan cover temperature may drop below the dew point temperature of the room air.

END COVERS

End covers enclose the header and/or return end of the unit to add protection from mechanical damage and hold in defrost heat. Covers are hinged to allow easy access for cleaning and maintenance. This is recommended for electric and water defrost units.

SUPPORT LEGS

Standard: Heights from 3 to 15 inches
Extended: Heights from 16 to 30 inches. Includes additional cross bracing for added stability.

SMART HANGER™ SYSTEM

This patented design was developed to make the process of mounting ceiling-hung air coolers faster and safer. Smart Hanger™ brackets and rails allow air cooler units to be hung from the ceiling without any personnel leaving the floor level. The time consuming process of aligning threaded rods into mounting holes while the unit is being lifted into position is eliminated, reducing suspended load time by as much as 75%. Side to side placement of the air cooler on the Smart Hanger™ rails is non-critical and therefore faster.

COIL INLET FILTER RACKS

Filters are added to inlet side of unit for applications with large amounts of airborne particulates.

COATED COIL CORE

Evaporator coils may be Heresite or Electrofin coated for added corrosion protection.

AIR DEFLECTORS (A+R only)

Air deflectors are added above fans to efficiently redirect air to the sides.

UNIT SELECTION

CAPACITY RATINGS

Evaporator ratings listed in the tables are given as gross capacity in Tons Refrigeration (TR). Ratings are based on the DT1 rating method for the following construction and conditions:

- 304L stainless steel tube/aluminum fin evaporator
- 5/8" tubes, inline pattern
- Configured (waffle) fins
- Pump recirculated CO_2, 2:1 overfeed
- 1200 rpm fan speed

Frosted Conditions	Wet Conditions
-10°F air on temperature	35°F air on temperature
-20°F saturated suction temperature	25°F saturated suction temperature
85% RH Air	85% RH Air
3 FPI fin spacing	4 FPI fin spacing

SELECTION PROCEDURE

1. Calculate the total Net cooling load required in TR per unit.
2. Add the estimated motor heat of the cooler to the Net cooling load, which can be calculated as 0.35 TR/HP. Examining the motor power of units in the tables will help to improve this estimate.
3. Select the A+ Series™ cooler type that best fits the application and capacity range.
4. Choose the desired construction materials based on the refrigerant and operating environment.
5. If using alternate materials or conditions, find the appropriate correction factors given in Tables 1, 2 and 3.
6. Determine the temperature difference (TD) by taking the difference between the room and evaporator temperatures.
7. If using a TD other than 10°F, determine the TD correction factor by dividing the actual TD by 10°F. Example: For a 12°F TD, this factor would be 12°F / 10°F = 1.20.
8. Divide the required capacity by all of the applicable correction factors to apply them.
9. Determine if the tables for Frosted or Wet Conditions should be used. If the room temperature is below 35°F, Frosted Conditions should be used. For 35°F and above, the Wet Conditions tables should be used.
10. Select a unit that meets or exceeds the required capacity from the tables.
11. Verify that the fan motor heat of the selected unit match the estimate made in Step 2. If not, recalculate the required cooling load with the actual motor heat to see if the selected unit will still meet capacity. If it does not, a new unit must be selected based on the recalculated cooling load.

Example Selection #1:

Three units are needed to refrigerate a 0°F room with a total cooling load of 60 tons (net). The evaporator temperature is -12°F, and it is a pump recirculated CO_2 (R-744) system. A+L coolers with two fans each will be used. The evaporator construction will be stainless steel tube, aluminum fins. Ratings required for sea level.

1. Determine the required load per unit: 60 TR / 3 units = 20 TR per unit

2. Add the estimated *fan motor heat* to the net capacity to get the *gross capacity*. In this example, it will be estimated as two 3 hp motors.
   Estimated *fan motor heat* = (number of fans) x (est. hp per motor) x (0.35 TR/hp)
   = 2 fans x 2 hp x 0.35 TR/hp = 1.4 TR

   The estimated *gross capacity* = 20 TR + 1.4 TR = 21.4 TR

3. The construction materials, feed method and elevation all match those used in the tables, so those correction factors are not required.

4. Determine the temperature difference (TD) for the evaporator.
   TD = (air on temp) - (evaporator temp) = 0°F – (-12)°F = 12°F
   Because the catalog ratings are based on a 10°F TD, a TD correction factor must be calculated.

   TD correction factor = (actual TD) / (10°F) = 12°F / 10°F = 1.2

5. Divide the *gross capacity* in Step 2 by all of the correction factors found in Steps 3 and 4.
   Adjusted gross capacity = 21.4 TR / 1.2 = 17.8 TR

6. Determine if the Frosted Condition or Wet Condition tables should be used.
   0°F Room Temp < 35°F, so use Frosted Condition tables

7. Select a unit that meets or exceeds the *adjusted gross capacity* (17.8TR) from the "A+L Two Fan Models" section. This results in selecting model A+L23T-32-144-63.0C-0300L, rated at 18 TR.

8. The selected unit has more motor horsepower than was estimated in Step 2. To verify that the selected unit will still meet capacity, we must recalculate Steps 2 and 5 with the actual motor horsepower.

   New *fan motor heat* = 2 fans x 3 hp ea x 0.35 TR/hp = 2.1 TR (Step 2)
   New *gross capacity* = 20 TR + 2.1 TR = 22.1 TR (Step 2)
   New *adjusted gross capacity* = 18.4 TR (Step 5)

   The selected unit's capacity does not meet the new *adjusted gross capacity*, so a different unit must be chosen.

9. Repeat Step 7 using the new *adjusted gross capacity* of 18.4 TR. The resulting unit selection is A+L23T-32-120-83.0C-0300L, which is rated at 20 TR.

10. Repeat Step 8. Both unit and calculations now have the same total motor horsepower, so no recalculations are required. This confirms the final selection is A+L23T-32-120-83.0C-0300L.

Example Selection #2:

Two units are required to refrigerate a 40°F room with a total cooling load of 18 tons (net). The evaporator temperature is 30°F, and it is a DX CO_2 system. A+S coolers will be used with copper tube, aluminum fin construction. The lowest first cost unit ($/TR) is desired and the number of fans per unit is flexible. The elevation is 3,000 ft.

1. Determine the required load per unit: 20 TR / 2 units = 9 TR per unit

2. Add the estimated *fan motor heat* to the *net capacity* to get the *gross capacity*. In this example, it will be estimated as two 3/4 hp motors.
   Estimated *fan motor heat* = (number of fans) x (est. hp per motor) x (0.35 TR/hp)
   = 2 fans x 0.75 hp x 0.35 TR/hp = 0.53 TR

   The estimated *gross capacity* = 9 TR + 0.53 TR = 9.53 TR

3. Select the appropriate material correction factor from Table 1.
   Correction factor for copper tube, aluminum fin = 1.11

4. Select the appropriate feed method correction factor from Table 2.
   Correction factor for DX = 0.83

5. Select the appropriate elevation correction factor from Table 3.
   Correction factor for 3,000 ft = 0.94

6. Determine the temperature difference (TD) for the evaporator.
   TD = (air on temp) - (evaporator temp) = 40°F – 30°F = 10°F
   This matches the catalog TD, so no TD correction factor is required.

7. Divide the *gross capacity* in Step 2 by all of the correction factors found in Steps 3-6.
   Adjusted gross capacity = 9.53 TR / 1.11 / 0.83 / 0.94 = 11.0 TR

8. Determine if the Frosted Condition or Wet Condition tables should be used.
   40°F Room Temp > 35°F, so use Wet Condition tables

9. Select a unit that meets or exceeds the *adjusted gross capacity* (11.0 TR) from the "A+S Lowest First Cost $/TR Models" section. This results in selecting model A+S23T-24-108-64.0C-0100L, rated at 12 TR.

10. The selected unit has more total motor horsepower than was estimated in Step 2. To verify that the selected unit will still meet capacity, we must recalculate Steps 2 and 7 with the actual motor horsepower.

    New *fan motor heat* = 2 fans x 1.0 hp ea x 0.35 TR/hp = 0.7 TR (Step 2)
    New *gross capacity* = 9.53 TR + 0.7 TR = 10.23 TR (Step 2)
    New *adjusted gross capacity* = 11.8 TR (Step 7)

    The selected unit's capacity still exceeds the new *adjusted gross capacity*, confirming that it will still meet the required capacity with the higher fan heat. The final selection is A+S23T-24-108-64.0C-0100L.

CORRECTION FACTORS

To select a cooler of alternate construction materials, divide the required capacity by the appropriate correction factor in the table below.

Table 1: Material Correction Factors

Coil Material	Correction Factor
Stainless steel tube/aluminum fin (standard)	-
Copper tube/aluminum fin	1.05
Stainless steel tube and fin	0.54
Stainless steel tube/anti-microbial fin	0.81
Copper tube and fin	1.11

For alternate refrigerants and feed methods, divide the required capacity by the appropriate factor in the table below.

Table 2: Refrigerant Feed Method Correction Factors

Feed Method	Correction Factors By Suspension Temperature				
	+40F	+20F	0F	-20F	-40F
Pump recirc. - Bottom	1.0	1.0	1.0	1.0	1.0
Pump recirc. - Top	1.0	1.0	1.0	1.0	1.0
DX	0.83*	0.83*	*	*	*
Brine					

*Consult your local CCM representative for selections

For ratings at an elevation other than sea level, divide the required capacity by the appropriate factor in the table below.

Table 3: Elevation Correction Factors

Elevation, ft Above Mean Sea Level	Correction Factor
0	1.00
1,000	0.98
2,000	0.96
3,000	0.94
4,000	0.91
5,000	0.89
6,000	0.87

ONLINE SELECTION SOFTWARE

Colmac's A+Pro online software offers custom unit ratings with an expanded library of refrigerants and additional construction options, such as 7/8" tube patterns. A+Pro also automates the generation of project schedules and engineering specifications in both IP and SI units.

SELECTION TABLES

The Selection Tables are divided according to cooler type. The first set of tables in each section show the lowest first cost unit for each capacity increment over the standard range. The remaining tables provide alternative options, arranged by the number of fans.

COLMAC COIL
Manufacturing Inc.

ELECTRICAL INFORMATION

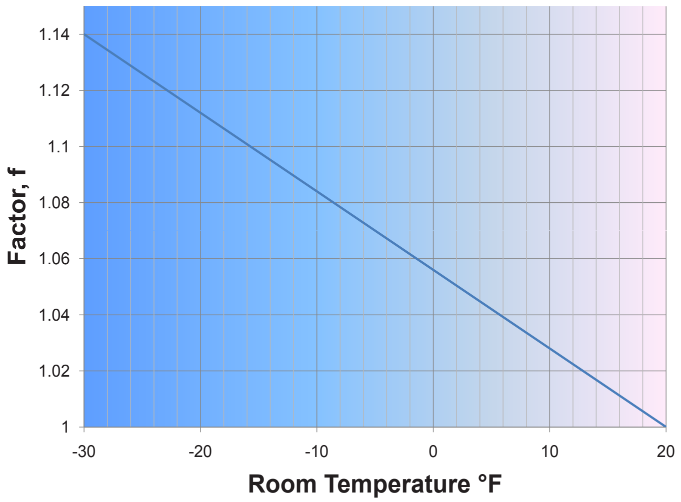
Table 4: Estimated Motor Full-Load Amps*

Motor Horsepower	208V (Amps)	230V (Amps)	460V (Amps)
0.33	1.7	1.5	0.8
0.5	2.4	2.2	1.1
0.75	3.5	3.2	1.6
1	4.6	4.2	2.1
1.5	6.6	6.0	3.0
2	7.5	6.8	3.4
3	10.7	9.6	4.8
5	16.7	15.2	7.6
7.5	24.2	22.0	11.0
10	30.8	28.0	14.0

*Based on 3 phase, 1200 rpm motors

When designing overload protection systems for temperatures below 20° F, apply the appropriate correction factor from the chart below to estimate the actual current draw.

Motor Amperage Correction vs. Temperature



SOUND PRESSURE ADJUSTMENT FOR DISTANCE

Sound data shown in the rating tables are in Sound Pressure Level (SPL) in dB(A). Sound Pressure is calculated based on 1/8 spherical field environment at a distance of 10 feet from the cooler. Sound Pressure at distances other than 10 ft can be determined by subtracting the reduction (dB) shown in the table below from the Sound Pressure Level shown in the rating tables.

Distance (ft)	10	15	20	25	30	40	50	60	70	80	90	100
Reduction (dB)	0	-3.5	-6	-8	-9.5	-12	-14	-15.5	-17	-18	-19	-20

A+ Series™ CO_2 Air Cooler Selection Tables

A+L HIGH PROFILE UNITS

Capacity Range: 5 - 100 TR

Featuring:

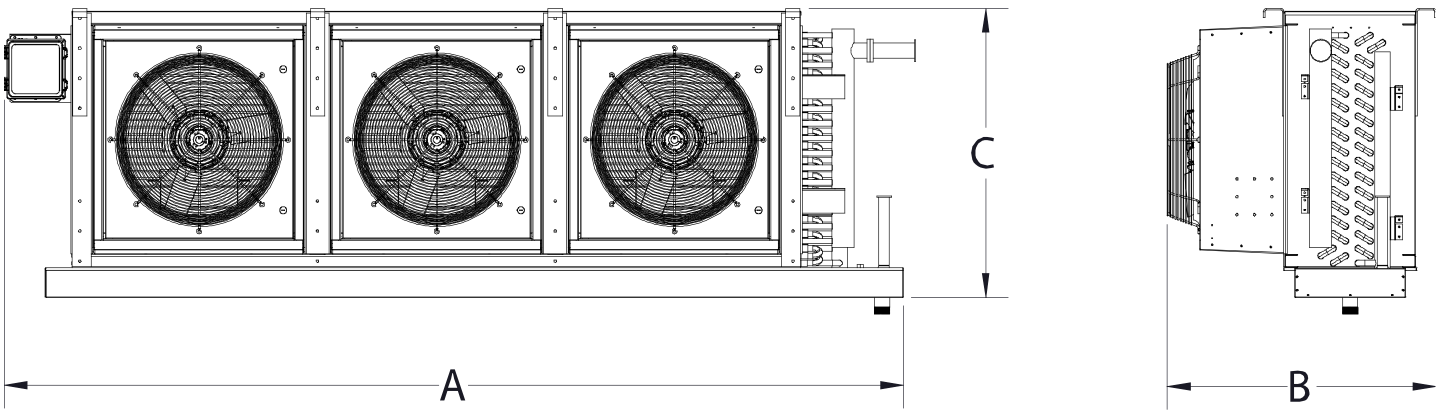
- 3/4 – 10 hp premium efficiency motors
- 26” – 48” diameter airfoil shaped fans
- 36” – 72” coil height
- 4 – 10 row deep coil
- Hinged fan panels
- Sloped fan boxes for water drainage

Options:

- Long air throw adapters
- 45° down air section
- Penthouse air section
- Tube Axial Fans (External Static Pressure)
- Reheat coil
- Seal welded drainpan
- Extended unit legs

A+L Unit Dimensions

Dimensions and weights provided in the tables may change based on the options and features selected. Do not use these for construction, refer to the factory submittal provided at time of order.



(3 fan unit shown)

A+L Lowest Cost ($/TR) Models

Table 4: Frosted Conditions*

Model Number	Capacity (TR)	Fans	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Air Throw (FT)	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+L13T-24-48-63.0C-0200L	5	1	12238	777	6	2	30	0.330	193	76	1111	1.29	69	56	44	812
A+L13T-32-60-43.0C-0300L	6	1	20839	794	4	3	42	0.371	235	82	1235	1.44	81	72	43	1004
A+L13T-32-60-63.0C-0300L	8	1	20393	777	6	3	42	0.301	230	83	1851	2.17	82	72	47	1183
A+L13T-32-60-83.0C-0300L	10	1	19487	742	8	3	42	0.246	220	83	2467	2.84	82	72	51	1356
A+L23T-24-96-83.0C-0200L	12	2	23707	753	8	2	30	0.283	187	79	2961	3.22	118	57	47	1735
A+L23T-24-120-83.0C-0300L	15	2	28301	719	8	3	30	0.337	224	82	3701	4.00	142	57	51	2198
A+L23T-32-144-63.0C-0300L	18	2	42478	674	6	3	42	0.277	240	86	4443	4.81	166	73	47	2543
A+L23T-32-120-83.0C-0300L	20	2	38974	742	8	3	42	0.246	220	86	4935	5.39	142	73	51	2617
A+L23T-32-144-83.0C-0300L	22	2	41003	651	8	3	42	0.220	231	86	5922	6.36	166	73	51	2972
A+L23T-32-120-103.0C-0500L	25	2	41942	799	10	5	42	0.287	237	87	6167	6.76	143	73	55	3097
A+L23T-32-144-103.0C-0500L	28	2	48178	765	10	5	42	0.285	272	86	7401	7.96	167	73	55	3538
A+L23T-36-132-103.0C-0750L	30	2	51858	798	10	7.5	48	0.312	256	95	7632	8.28	155	81	59	3754
A+L33T-32-180-83.0C-0500L	32	3	62859	798	8	5	42	0.367	236	90	7402	7.97	203	73	51	4132
A+L33T-28-198-103.0C-0500L	35	3	60517	799	10	5	36	0.354	266	86	8904	9.40	221	66	55	4492
A+L43T-32-288-63.0C-0500L	38	4	100317	796	6	5	42	0.422	283	90	8886	9.37	311	74	47	5323
A+L43T-32-240-83.0C-0300L	40	4	77947	742	8	3	42	0.246	220	89	9870	10.62	264	74	51	5101
A+L53T-32-300-63.0C-0300L	42	5	101964	777	6	3	42	0.294	230	90	9256	9.97	324	74	47	5519
A+L43T-32-288-83.0C-0300L	45	4	82005	651	8	3	42	0.220	231	89	11844	12.54	312	74	51	5836
A+L43T-32-240-103.0C-0500L	48	4	83884	799	10	5	42	0.286	237	90	12335	13.16	264	74	55	6033
A+L43T-32-240-103.0C-0500L	50	4	83884	799	10	5	42	0.286	237	90	12335	13.16	264	74	55	6033
A+L53T-32-300-83.0C-0300L	52	5	97433	742	8	3	42	0.246	220	90	12337	13.10	324	74	51	6329
A+L43T-36-288-83.0C-0750L	55	4	111584	787	8	7.5	48	0.416	276	95	13324	14.20	312	82	55	7014
A+L43T-32-288-103.0C-0500L	58	4	96355	765	10	5	42	0.285	272	89	14802	15.57	312	75	55	6937
A+L53T-32-300-103.0C-0500L	60	5	104855	799	10	5	42	0.292	237	91	15419	16.17	324	75	55	7471
A+L53T-32-300-103.0C-0500L	62	5	104855	799	10	5	42	0.292	237	91	15419	16.17	324	75	55	7479

*Ratings based on -10°F/85% rh air on temp, -20°F evaporating temp, 3 FPI fin spacing, 2:1 pumped CO_2 (bottom feed).

Table 5: Wet Conditions**

Model Number	Capacity (TR)	Fans	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Air Throw (FT)	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+L13T-24-60-44.0C-0100L	5	1	10745	546	4	1	30	0.184	170	72	1207	1.08	81	56	38	799
A+L13T-24-60-64.0C-0100L	6	1	10400	528	6	1	30	0.148	164	72	1809	1.56	81	56	42	934
A+L13T-32-72-44.0C-0200L	8	1	18877	599	4	2	42	0.201	213	82	1931	1.77	94	72	40	1116
A+L23T-28-108-44.0C-0075L	10	2	21805	528	4	0.75	36	0.144	144	82	2534	2.21	130	64	38	1471
A+L23T-24-120-64.0C-0100L	12	2	20801	528	6	1	30	0.148	164	75	3617	3.01	142	57	42	1774
A+L23T-28-108-64.0C-0150L	15	2	24735	598	6	1.5	36	0.130	163	80	3798	3.19	130	65	44	1888
A+L23T-28-132-64.0C-0200L	18	2	30133	596	6	2	36	0.155	198	80	4642	3.83	154	65	44	2222
A+L33T-28-198-44.0C-0150L	20	3	45441	600	4	1.5	36	0.189	199	82	4646	3.93	220	65	40	2687
A+L23T-32-144-64.0C-0200L	22	2	36423	578	6	2	42	0.155	206	85	5788	4.87	166	73	44	2566
A+L23T-28-132-104.0C-0200L	25	2	30160	597	10	2	36	0.133	199	81	7733	6.34	154	65	51	3002
A+L43T-28-216-64.0C-0100L	28	4	45038	545	6	1	36	0.117	148	84	7597	6.19	238	66	42	3544
A+L43T-28-216-64.0C-0150L	30	4	49470	598	6	1.5	36	0.130	163	83	7597	6.30	239	66	44	3715
A+L33T-32-216-64.0C-0200L	32	3	54634	578	6	2	42	0.155	206	87	8682	7.19	239	73	44	3876
A+L43T-28-264-64.0C-0150L	35	4	58591	580	6	1.5	36	0.147	193	83	9285	7.56	287	66	44	4309
A+L33T-32-216-84.0C-0200L	38	3	51669	547	8	2	42	0.123	194	85	11572	9.42	239	74	47	4578
A+L33T-32-216-84.0C-0300L	40	3	56314	596	8	3	42	0.156	212	87	11572	9.42	239	74	51	4795
A+L43T-32-288-64.0C-0200L	42	4	72845	578	6	2	42	0.154	206	88	11576	9.37	311	74	44	5098
A+L43T-32-288-64.0C-0300L	45	4	74843	594	6	3	42	0.181	211	91	11576	9.37	311	74	47	5392
A+L43T-28-264-104.0C-0200L	48	4	60321	597	10	2	36	0.133	199	84	15466	12.58	288	66	51	5859
A+L43T-28-264-104.0C-0200L	50	4	60321	597	10	2	36	0.133	199	84	15466	12.58	288	66	51	5859
A+L43T-32-288-84.0C-0500L	52	4	75422	599	8	5	42	0.237	213	91	15429	12.63	312	74	51	6604
A+L43T-36-288-84.0C-0500L	55	4	84390	595	8	5	48	0.185	208	89	17358	14.21	312	82	51	7131
A+L43T-36-288-84.0C-0500L	58	4	84390	595	8	5	48	0.185	208	89	17358	14.21	312	82	51	7125
A+L43T-32-288-104.0C-0500L	60	4	75205	597	10	5	42	0.191	212	91	19282	15.58	312	75	55	7514

**Ratings based on +35°F/85% rh air on temp, +25°F evaporating temp, 4 FPI fin spacing, 2:1 pumped CO_2 (bottom feed).

Additional models and custom selections available - contact your local Colmac Coil representative.

A+ Series™ CO_2 Air Cooler Selection Tables

A+L One Fan Models

Table 6: Frosted Conditions*

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Air Throw (FT)	Surface Area (FT^2)	Internal Volume (FT^3)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+L13T-24-48-63.0C-0200L	5	12238	777	6	2	30	0.330	76	193	1111	1.29	69	56	44	812
A+L13T-32-60-43.0C-0300L	6	20839	794	4	3	42	0.371	82	235	1235	1.44	81	72	43	1004
A+L13T-32-60-63.0C-0300L	8	20393	777	6	3	42	0.301	83	230	1851	2.17	82	72	47	1183
A+L13T-32-60-83.0C-0300L	10	19487	742	8	3	42	0.246	83	220	2467	2.84	82	72	51	1356
A+L13T-32-72-83.0C-0500L	12	24843	789	8	5	42	0.318	83	280	2961	3.32	94	72	51	1616
A+L13T-36-66-103.0C-0750L	15	25929	798	10	7.5	48	0.305	92	256	3816	4.35	88	80	59	1942

*Ratings based on -10°F/85% rh air on temp, -20°F evaporating temp, 3 FPI fin spacing, 2:1 pumped CO_2 (bottom feed).

Table 7: Wet Conditions**

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Air Throw (FT)	Surface Area (FT^2)	Internal Volume (FT^3)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+L13T-24-60-44.0C-0100L	5	10745	546	4	1	30	0.184	72	170	1207	1.08	81	56	38	799
A+L13T-24-60-64.0C-0100L	6	10400	528	6	1	30	0.148	72	164	1809	1.56	81	56	42	934
A+L13T-32-72-44.0C-0200L	8	18877	599	4	2	42	0.201	82	213	1931	1.77	94	72	40	1116
A+L13T-28-66-84.0C-0150L	10	14185	562	8	1.5	36	0.125	77	187	3094	2.70	88	65	47	1341
A+L13T-32-72-84.0C-0200L	12	17223	547	8	2	42	0.131	80	194	3857	3.33	94	72	47	1597
A+L13T-36-72-84.0C-0500L	15	21097	595	8	5	48	0.174	83	208	4339	3.74	94	80	51	1883

**Ratings based on +35°F/85% rh air on temp, +25°F evaporating temp, 4 FPI fin spacing, 2:1 pumped CO_2 (bottom feed).

Additional models and custom selections available - contact your local Colmac Coil representative.

A+L Two Fan Models

Table 8: Frosted Conditions*

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Air Throw (FT)	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+L23T-24-96-43.0C-0100L	6	20059	636.9	4	1	30	0.283	76	158	1482	1.63	117	56	38	1212
A+L23T-24-120-43.0C-0150L	8	23804	604.6	4	1.5	30	0.325	76	188	1853	2.06	142	57	40	1491
A+L23T-28-132-43.0C-0200L	10	32718	647.6	4	2	36	0.308	80	215	2377	2.63	154	65	40	1759
A+L23T-24-96-83.0C-0200L	12	23707	752.7	8	2	30	0.283	79	187	2961	3.22	118	57	47	1748
A+L23T-32-144-63.0C-0300L	15	42478	674.3	6	3	42	0.277	86	240	4443	4.81	166	73	47	2538
A+L23T-32-144-63.0C-0300L	18	42478	674.3	6	3	42	0.277	86	240	4443	4.81	166	73	47	2554
A+L23T-32-120-83.0C-0300L	20	38974	742.4	8	3	42	0.246	86	220	4935	5.39	142	73	51	2643
A+L23T-32-144-83.0C-0300L	22	41002	650.9	8	3	42	0.220	86	231	5922	6.36	166	73	51	2998
A+L23T-32-120-103.0C-0500L	25	41942	799	10	5	42	0.287	87	237	6167	6.76	143	73	55	3126
A+L23T-32-144-103.0C-0500L	28	48178	764.8	10	5	42	0.285	86	272	7401	7.96	167	73	55	3538
A+L23T-36-132-103.0C-0750L	30	51858	798.3	10	7.5	48	0.312	95	256	7632	8.28	155	81	59	3754
A+L23T-36-144-103.0C-0750L	32	56123	792	10	7.5	48	0.313	100	277	8326	8.96	167	81	59	4016

*Ratings based on -10°F/85% rh air on temp, -20°F evaporating temp, 3 FPI fin spacing, 2:1 pumped CO_2 (bottom feed).

Table 9: Wet Conditions**

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Air Throw (FT)	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+L23T-20-104-44.0C-0075L	6	13674	480.9	4	0.75	26	0.211	73	125	1743	1.46	125	49	38	1194
A+L23T-24-96-44.0C-0075L	8	18597	590.5	4	0.75	30	0.167	76	147	1931	1.69	118	56	38	1237
A+L23T-28-108-44.0C-0075L	10	21805	527.5	4	0.75	36	0.144	82	144	2534	2.21	130	64	38	1471
A+L23T-24-120-64.0C-0100L	12	20801	528.3	6	1	30	0.148	75	164	3617	3.01	142	57	42	1774
A+L23T-28-108-64.0C-0150L	15	24735	598.3	6	1.5	36	0.130	80	163	3798	3.19	130	65	44	1888
A+L23T-28-132-64.0C-0200L	18	30133	596.4	6	2	36	0.155	80	198	4642	3.83	154	65	44	2222
A+L23T-28-132-84.0C-0150L	20	28370	561.5	8	1.5	36	0.128	80	187	6188	5.14	154	65	47	2600
A+L23T-32-144-64.0C-0200L	22	36423	578.2	6	2	42	0.155	85	206	5788	4.87	166	73	44	2566
A+L23T-28-132-104.0C-0200L	25	30160	596.9	10	2	36	0.133	81	199	7733	6.34	154	65	51	3002
A+L23T-36-144-84.0C-0500L	28	42195	595.4	8	5	48	0.185	86	208	8679	7.15	166	81	51	3636
A+L23T-36-144-104.0C-0500L	30	40922	577.5	10	5	48	0.162	87	202	10846	8.96	167	81	55	4140
A+L23T-36-144-104.0C-0500L	32	40921	577.4	10	5	48	0.162	87	202	10846	8.96	167	81	55	4147

**Ratings based on +35°F/85% rh air on temp, +25°F evaporating temp, 4 FPI fin spacing, 2:1 pumped CO_2 (bottom feed).

Additional models and custom selections available - contact your local Colmac Coil representative.

A+ Series™ CO_2 Air Cooler Selection Tables

A+L Three Fan Models

Table 10: Frosted Conditions*

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Air Throw (FT)	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+L33T-24-144-43.0C-0150L	10	34544	731.2	4	1.5	30	0.359	78	182	2223	2.44	166	57	40	1874
A+L33T-24-180-43.0C-0150L	12	35706	604.6	4	1.5	30	0.324	78	188	2779	3.00	202	57	40	2196
A+L33T-24-144-83.0C-0300L	15	37707	798.1	8	3	30	0.358	81	199	4441	4.73	166	57	51	2786
A+L33T-24-144-83.0C-0300L	18	37707	798.1	8	3	30	0.358	81	199	4441	4.73	166	57	51	2805
A+L33T-28-162-63.0C-0300L	20	49358	796	6	3	36	0.309	83	217	4374	4.77	184	65	47	2930
A+L33T-24-180-83.0C-0300L	22	42451	718.8	8	3	30	0.337	84	224	5552	5.89	202	58	51	3301
A+L33T-32-180-63.0C-0300L	25	61178	777	6	3	42	0.300	88	230	5554	6.11	203	73	47	3388
A+L33T-32-216-63.0C-0500L	28	75238	796.3	6	5	42	0.422	89	283	6664	7.19	239	73	47	4059
A+L33T-32-180-83.0C-0300L	30	58460	742.4	8	3	42	0.250	88	220	7402	7.97	203	73	51	3879
A+L33T-32-180-83.0C-0500L	32	62859	798.3	8	5	42	0.367	90	236	7402	7.97	203	73	51	4132
A+L33T-28-198-103.0C-0500L	35	60517	798.5	10	5	36	0.354	86	266	8904	9.40	221	66	55	4507
A+L33T-36-216-83.0C-0750L	38	83688	787.3	8	7.5	48	0.416	94	276	9993	10.86	240	82	55	5321
A+L33T-36-216-83.0C-0750L	40	83688	787.3	8	7.5	48	0.416	94	276	9993	10.86	240	82	55	5321
A+L33T-32-216-103.0C-0500L	42	72266	764.8	10	5	42	0.294	87	272	11101	11.88	240	74	55	5272

*Ratings based on -10°F/85% rh air on temp, -20°F evaporating temp, 3 FPI fin spacing, 2:1 pumped CO_2 (bottom feed).

Table 11: Wet Conditions**

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Air Throw (FT)	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+L33T-20-156-44.0C-0075L	10	23599	553.3	4	0.75	26	0.205	75	143	2614	2.18	178	49	38	1759
A+L33T-24-144-44.0C-0075L	12	27896	590.5	4	0.75	30	0.169	78	147	2896	2.44	166	57	38	1816
A+L33T-20-156-64.0C-0100L	15	25072	587.8	6	1	26	0.183	75	152	3919	3.19	178	49	42	2125
A+L33T-20-156-84.0C-0100L	18	24443	573.1	8	1	26	0.153	75	149	5223	4.19	178	50	46	2448
A+L33T-28-198-44.0C-0150L	20	45441	599.6	4	1.5	36	0.189	82	199	4646	3.93	220	65	40	2687
A+L33T-24-144-104.0C-0100L	22	27144	574.6	10	1	30	0.119	79	143	7231	5.89	166	58	50	2933
A+L33T-32-216-44.0C-0200L	25	56632	599.4	4	2	42	0.204	87	213	5792	4.86	238	73	40	3195
A+L33T-24-180-104.0C-0200L	28	35395	599.4	10	2	30	0.158	81	186	9038	7.29	202	58	51	3727
A+L33T-28-198-84.0C-0150L	30	42555	561.5	8	1.5	36	0.123	82	187	9281	7.61	221	66	47	3824
A+L33T-32-216-64.0C-0200L	32	54634	578.2	6	2	42	0.155	87	206	8682	7.19	239	73	44	3876
A+L33T-32-216-84.0C-0150L	35	43316	458.4	8	1.5	42	0.103	89	163	11572	9.42	239	74	47	4482
A+L33T-32-216-84.0C-0200L	38	51669	546.8	8	2	42	0.123	85	194	11572	9.42	239	74	47	4578
A+L33T-32-216-84.0C-0300L	40	56314	596	8	3	42	0.156	87	212	11572	9.42	239	74	51	4795
A+L33T-36-216-84.0C-0500L	42	63292	595.4	8	5	48	0.177	88	208	13018	10.59	239	82	51	5383
A+L33T-36-216-84.0C-0500L	45	63292	595.4	8	5	48	0.177	88	208	13018	10.59	239	82	51	5383
A+L33T-36-216-104.0C-0500L	48	61382	577.4	10	5	48	0.162	88	202	16269	13.45	240	82	55	6162
A+L33T-36-216-104.0C-0500L	50	61382	577.4	10	5	48	0.162	88	202	16269	13.45	240	82	55	6162

**Ratings based on +35°F/85% rh air on temp, +25°F evaporating temp, 4 FPI fin spacing, 2:1 pumped CO_2 (bottom feed).

Additional models and custom selections available - contact your local Colmac Coil representative.

A+L Four Fan Models

Table 12: Frosted Conditions*

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Air Throw (FT)	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+L43T-24-192-43.0C-0100L	12	40118	636.9	4	1	30	0.282	79	158	2964	3.18	214	57	38	2366
A+L43T-28-216-43.0C-0200L	15	63534	768.5	4	2	36	0.362	84	209	3890	4.2	238	65	40	3027
A+L43T-28-216-43.0C-0200L	18	63534	768.5	4	2	36	0.362	84	209	3890	4.2	238	65	40	3040
A+L43T-28-264-43.0C-0200L	20	65435	647.6	4	2	36	0.308	83	215	4755	5.09	286	66	40	3489
A+L43T-28-264-43.0C-0200L	22	65435	647.6	4	2	36	0.308	83	215	4755	5.09	286	66	40	3489
A+L43T-32-240-43.0C-0300L	25	83356	794	4	3	42	0.371	88	235	4940	5.45	263	73	43	3802
A+L43T-32-288-43.0C-0300L	28	89499	710.4	4	3	42	0.355	89	253	5928	6.42	311	74	43	4291
A+L43T-24-240-83.0C-0300L	30	56601	718.8	8	3	30	0.337	85	224	7402	7.79	263	58	51	4346
A+L43T-24-240-83.0C-0500L	32	62980	799.8	8	5	30	0.429	85	249	7402	7.79	263	58	51	4608
A+L43T-32-288-63.0C-0300L	35	84956	674.3	6	3	42	0.276	89	240	8886	9.37	311	74	47	5051
A+L43T-32-288-63.0C-0500L	38	100317	796.3	6	5	42	0.422	90	283	8886	9.37	311	74	47	5333
A+L43T-32-240-83.0C-0300L	40	77947	742.4	8	3	42	0.246	89	220	9870	10.62	264	74	51	5108
A+L43T-32-240-83.0C-0500L	42	83812	798.3	8	5	42	0.359	92	236	9870	10.61	264	74	51	5479
A+L43T-32-288-83.0C-0300L	45	82005	650.9	8	3	42	0.220	89	231	11844	12.54	312	74	51	5836
A+L43T-32-240-103.0C-0500L	48	83884	799	10	5	42	0.286	90	237	12335	13.16	264	74	55	6041
A+L43T-32-240-103.0C-0500L	50	83884	799	10	5	42	0.286	90	237	12335	13.16	264	74	55	6041
A+L43T-32-288-83.0C-0500L	52	99371	788.8	8	5	42	0.317	89	280	11844	12.62	312	74	51	6181
A+L43T-36-288-83.0C-0750L	55	111584	787.3	8	7.5	48	0.416	95	276	13324	14.2	312	82	55	7014
A+L43T-32-288-103.0C-0500L	58	96355	764.8	10	5	42	0.285	89	272	14802	15.57	312	75	55	6945
A+L43T-36-264-103.0C-0750L	60	103716	798.3	10	7.5	48	0.312	98	256	15264	16.16	288	82	59	7343

*Ratings based on -10°F/85% rh air on temp, -20°F evaporating temp, 3 FPI fin spacing, 2:1 pumped CO_2 (bottom feed).

Table 13: Wet Conditions**

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Air Throw (FT)	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+L43T-20-152-64.0C-0075L	12	22506	541.6	6	0.75	26	0.171	81	103	3818	3.11	174	49	42	2225
A+L43T-20-152-84.0C-0075L	15	21998	529.3	8	0.75	26	0.149	82	100	5089	4.09	174	50	46	2559
A+L43T-20-152-84.0C-0075L	18	24904	599.3	8	0.75	26	0.145	79	114	5089	4.09	174	50	46	2559
A+L43T-28-216-44.0C-0075L	20	43610	527.5	4	0.75	36	0.146	85	144	5068	4.25	238	65	38	2908
A+L43T-24-192-64.0C-0100L	22	37715	598.7	6	1	30	0.160	83	149	5788	4.77	214	58	42	2940
A+L43T-24-240-64.0C-0100L	25	41601	528.3	6	1	30	0.147	78	164	7235	5.85	262	58	42	3495
A+L43T-28-216-64.0C-0100L	28	45038	544.7	6	1	36	0.117	84	148	7597	6.19	238	66	42	3544
A+L43T-28-216-64.0C-0150L	30	49470	598.3	6	1.5	36	0.130	83	163	7597	6.3	239	66	44	3715
A+L43T-32-288-44.0C-0200L	32	75510	599.4	4	2	42	0.201	88	213	7723	6.42	311	74	40	4220
A+L43T-28-264-64.0C-0150L	35	58591	579.8	6	1.5	36	0.147	83	193	9285	7.56	287	66	44	4309
A+L43T-28-264-84.0C-0150L	38	56739	561.5	8	1.5	36	0.128	83	187	12375	9.93	287	66	47	5028
A+L43T-28-264-84.0C-0150L	40	56740	561.5	8	1.5	36	0.128	83	187	12375	9.93	287	66	47	5028
A+L43T-32-288-64.0C-0200L	42	72845	578.2	6	2	42	0.154	88	206	11576	9.37	311	74	44	5098
A+L43T-32-288-64.0C-0300L	45	74843	594.1	6	3	42	0.181	91	211	11576	9.37	311	74	47	5392
A+L43T-28-264-104.0C-0200L	48	60321	596.9	10	2	36	0.133	84	199	15466	12.58	288	66	51	5859
A+L43T-32-288-84.0C-0500L	52	75422	598.7	8	5	42	0.237	91	213	15429	12.63	312	74	51	6604
A+L43T-36-288-84.0C-0500L	55	84390	595.4	8	5	48	0.185	89	208	17358	14.21	312	82	51	7131
A+L43T-36-288-84.0C-0500L	55	84390	595.4	8	5	48	0.185	89	208	17358	14.21	312	82	51	7131
A+L43T-36-288-84.0C-0500L	58	84390	595.4	8	5	48	0.185	89	208	17358	14.21	312	82	51	7125
A+L43T-32-288-104.0C-0500L	60	75205	596.9	10	5	42	0.191	91	212	19282	15.58	312	75	55	7514

**Ratings based on +35°F/85% rh air on temp, +25°F evaporating temp, 4 FPI fin spacing, 2:1 pumped CO_2 (bottom feed).

Additional models and custom selections available - contact your local Colmac Coil representative.

A+ Series™ CO_2 Air Cooler Selection Tables

A+L Five Fan Models

Table 14: Frosted Conditions*

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Air Throw (FT)	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+L53T-24-240-43.0C-0200L	15	62854	798.2	4	2	30	0.456	82	199	3705	3.96	262	58	40	3244
A+L53T-24-240-43.0C-0200L	18	62854	798.2	4	2	30	0.456	82	199	3705	3.96	262	58	40	3256
A+L53T-24-240-63.0C-0100L	20	47893	608.2	6	1	30	0.214	80	151	5554	5.85	262	58	42	3464
A+L53T-28-270-43.0C-0150L	22	69057	668.2	4	1.5	36	0.265	84	182	4863	5.2	292	66	40	3677
A+L53T-24-240-63.0C-0200L	25	61190	777.1	6	2	30	0.337	83	193	5554	5.94	263	58	44	3779
A+L53T-24-240-83.0C-0200L	28	59268	752.7	8	2	30	0.280	83	187	7402	7.79	263	58	47	4289
A+L53T-24-240-83.0C-0200L	30	59268	752.7	8	2	30	0.280	83	187	7402	7.79	263	58	47	4289
A+L53T-24-240-83.0C-0300L	32	62845	798.1	8	3	30	0.343	83	199	7402	7.79	263	58	51	4598
A+L53T-24-240-103.0C-0300L	35	62914	799	10	3	30	0.313	84	199	9251	9.64	263	58	55	5116
A+L53T-24-300-83.0C-0500L	38	78725	799.8	8	5	30	0.453	86	249	9253	9.6	323	59	51	5713
A+L53T-32-300-63.0C-0300L	40	101964	777	6	3	42	0.294	90	230	9256	9.97	324	74	47	5524
A+L53T-32-300-63.0C-0300L	42	101964	777	6	3	42	0.294	90	230	9256	9.97	324	74	47	5524
A+L53T-32-300-83.0C-0300L	45	97434	742.4	8	3	42	0.246	90	220	12337	13.1	324	74	51	6336
A+L53T-32-300-83.0C-0300L	48	97434	742.4	8	3	42	0.246	90	220	12337	13.1	324	74	51	6336
A+L53T-32-300-83.0C-0300L	50	97434	742.4	8	3	42	0.246	90	220	12337	13.1	324	74	51	6336
A+L53T-32-300-83.0C-0300L	52	97433	742.4	8	3	42	0.246	90	220	12337	13.1	324	74	51	6336
A+L53T-32-300-103.0C-0300L	55	93373	711.5	10	3	42	0.223	91	211	15419	16.17	324	75	55	7134
A+L53T-32-300-103.0C-0500L	58	104855	799	10	5	42	0.292	91	237	15419	16.17	324	75	55	7479
A+L53T-32-300-103.0C-0500L	60	104855	799	10	5	42	0.292	91	237	15419	16.17	324	75	55	7479

*Ratings based on -10°F/85% rh air on temp, -20°F evaporating temp, 3 FPI fin spacing, 2:1 pumped CO_2 (bottom feed).

Table 15: Wet Conditions**

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Air Throw (FT)	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+L53T-20-190-44.0C-0075L	12	29672	571.2	4	0.75	26	0.192	79	108	3184	2.62	212	49	38	2359
A+L53T-20-260-44.0C-0075L	15	34185	480.9	4	0.75	26	0.210	77	125	4357	3.5	282	50	38	2942
A+L53T-20-260-44.0C-0100L	18	42650	600	4	1	26	0.252	79	156	4357	3.5	282	50	38	2979
A+L53T-24-240-44.0C-0075L	20	46493	590.5	4	0.75	30	0.173	80	147	4827	4.01	262	58	38	3035
A+L53T-24-300-44.0C-0075L	22	47820	485.9	4	0.75	30	0.148	80	151	6033	4.91	322	58	38	3556
A+L53T-20-260-64.0C-0100L	25	41786	587.8	6	1	26	0.179	77	152	6531	5.26	282	50	42	3526
A+L53T-20-260-84.0C-0100L	28	40739	573.1	8	1	26	0.158	77	149	8706	6.92	282	50	46	4068
A+L53T-32-300-44.0C-0100L	30	59209	451.2	4	1	42	0.146	95	134	8044	6.66	323	74	38	4272
A+L53T-24-300-64.0C-0100L	32	52001	528.3	6	1	30	0.142	79	164	9044	7.3	323	58	42	4346
A+L53T-24-300-64.0C-0150L	35	58849	597.9	6	1.5	30	0.182	82	186	9044	7.3	323	58	44	4553
A+L53T-24-300-84.0C-0150L	38	57491	584.1	8	1.5	30	0.167	83	182	12054	9.6	323	59	47	5275
A+L53T-28-270-84.0C-0100L	40	54313	525.5	8	1	36	0.106	86	143	12657	10.14	293	66	46	5137
A+L53T-32-300-64.0C-0150L	42	71983	548.5	6	1.5	42	0.135	91	162	12058	9.73	323	74	44	5400
A+L53T-32-300-64.0C-0150L	45	71982	548.5	6	1.5	42	0.135	91	162	12058	9.73	323	74	44	5400
A+L53T-28-270-104.0C-0150L	48	61161	591.8	10	1.5	36	0.115	84	161	15817	12.84	294	67	51	6109
A+L53T-28-270-104.0C-0150L	50	61161	591.8	10	1.5	36	0.115	84	161	15817	12.84	294	67	51	6109
A+L53T-32-300-84.0C-0200L	52	75030	571.7	8	2	42	0.134	91	169	16072	13.11	324	74	47	6453
A+L53T-32-300-104.0C-0150L	55	67072	511.1	10	1.5	42	0.110	92	151	20086	16.18	324	75	51	7270
A+L53T-32-300-104.0C-0200L	58	76303	581.4	10	2	42	0.124	89	172	20086	16.18	324	75	51	7424
A+L53T-32-300-104.0C-0200L	60	76303	581.4	10	2	42	0.124	89	172	20086	16.18	324	75	51	7431

**Ratings based on +35°F/85% rh air on temp, +25°F evaporating temp, 4 FPI fin spacing, 2:1 pumped CO_2 (bottom feed).

Additional models and custom selections available - contact your local Colmac Coil representative.

A+L PENTHOUSE AND 45° DOWN UNITS

Capacity Range: 5 - 100 TR

Featuring:

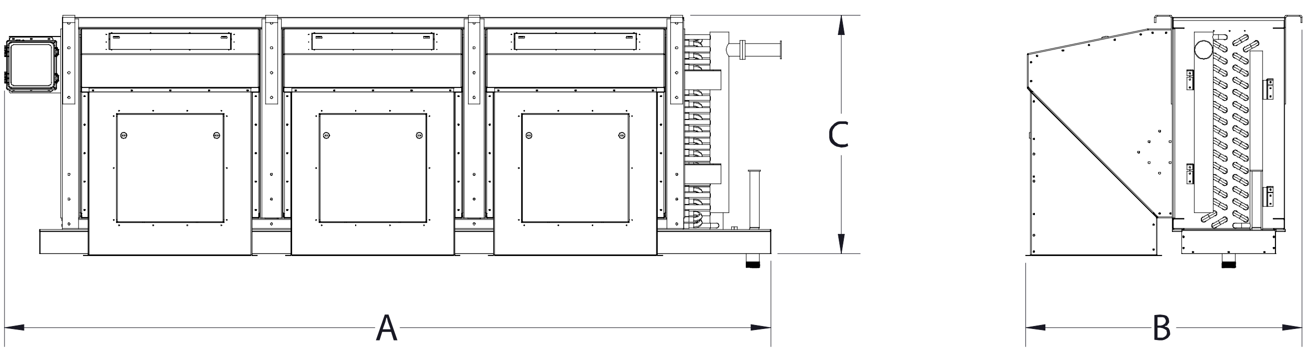
- 3/4 – 10 hp premium efficiency motors
- 26" – 48" diameter airfoil shaped fans
- 36" – 72" coil height
- 4 – 10 row deep coil
- Sloped fan boxes for water drainage
- 45 degree down versions include ¼" external static pressure

Options:

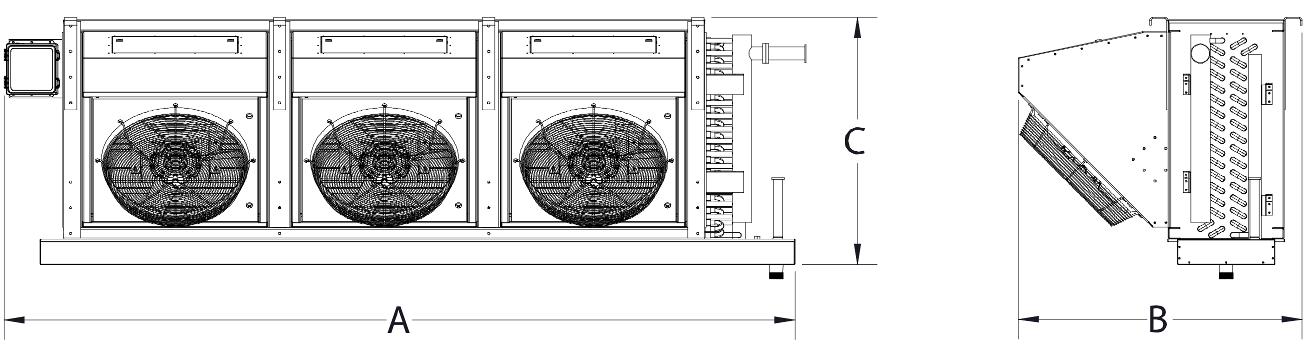
- Reheat coil
- Seal welded drainpan

A+L Penthouse and 45° Down Unit Dimensions

Dimensions and weights provided in the tables may change based on the options and features selected. Do not use these for construction, refer to the factory submittal provided at time of order.



(3 fan penhouse unit shown)



(3 fan 45° down unit shown)

A+ Series™ CO_2 Air Cooler Selection Tables

A+L Penthouse and 45° Down Lowest Cost ($/TR) Models

Table 16: Frosted Conditions*

Model Number	Capacity (TR)	Fans	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Surface Area (FT^2)	Internal Volume (FT^3)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+L13T-24-48-63.0C-0300L	5	1	12597	800	6	3	30	0.387	76	1111	1.29	69	56	60	1083
A+L13T-24-48-83.0C-0200L	6	1	11581	735	8	2	30	0.284	76	1480	1.68	69	56	64	1128
A+L13T-24-60-83.0C-0500L	8	1	15731	799	8	5	30	0.481	78	1851	2.11	82	57	64	1464
A+L13T-28-66-83.0C-0500L	10	1	20196	799	8	5	36	0.363	81	2375	2.70	88	65	70	1729
A+L23T-24-96-83.0C-0200L	12	2	23162	735	8	2	30	0.283	79	2961	3.22	118	57	64	2157
A+L23T-32-144-43.0C-0500L	15	2	50375	800	4	5	42	0.495	86	2964	3.32	166	73	67	3107
A+L23T-32-144-63.0C-0300L	18	2	41760	663	6	3	42	0.281	86	4443	4.81	166	73	71	3362
A+L23T-28-132-83.0C-0500L	20	2	40392	799	8	5	36	0.362	84	4750	5.14	154	65	70	3362
A+L23T-32-144-83.0C-0300L	22	2	40347	641	8	3	42	0.223	86	5922	6.36	166	73	75	3793
A+L23T-32-120-103.0C-0500L	25	2	41980	800	10	5	42	0.315	88	6167	6.76	143	73	79	3820
A+L23T-32-144-103.0C-0500L	28	2	47476	754	10	5	42	0.288	85	7401	7.96	167	73	79	4363
A+L23T-36-132-103.0C-0750L	30	2	51157	788	10	7.5	48	0.318	96	7632	8.28	155	81	85	4601
A+L23T-36-144-103.0C-0750L	32	2	56167	793	10	7.5	48	0.375	98	8326	8.96	167	81	85	4908
A+L33T-28-198-103.0C-0500L	35	3	60182	794	10	5	36	0.339	86	8904	9.40	221	66	74	5437
A+L43T-32-288-63.0C-0500L	38	4	98841	785	6	5	42	0.428	90	8886	9.37	311	74	71	6931
A+L43T-28-264-83.0C-0500L	40	4	80784	799	8	5	36	0.362	87	9500	10.14	288	66	70	6559
A+L43T-28-264-83.0C-0500L	42	4	80784	799	8	5	36	0.362	87	9500	10.14	288	66	70	6559
A+L43T-32-288-83.0C-0300L	45	4	80695	641	8	3	42	0.223	89	11844	12.54	312	74	75	7433
A+L43T-32-240-103.0C-0500L	48	4	83960	800	10	5	42	0.315	91	12335	13.16	264	74	79	7429
A+L43T-32-240-103.0C-0500L	50	4	83960	800	10	5	42	0.315	91	12335	13.16	264	74	79	7429
A+L43T-32-288-83.0C-0750L	52	4	100476	798	8	7.5	42	0.432	93	11844	12.62	312	74	75	8017
A+L43T-32-288-103.0C-0500L	55	4	94951	754	10	5	42	0.288	88	14802	15.57	312	75	79	8542
A+L53T-32-300-103.0C-0500L	58	5	104950	800	10	5	42	0.321	92	15419	16.17	324	75	79	9210
A+L53T-32-300-103.0C-0500L	60	5	104950	800	10	5	42	0.321	92	15419	16.17	324	75	79	9203

*Ratings based on -10°F/85% rh air on temp, -20°F evaporating temp, 3 FPI fin spacing, 2:1 pumped CO_2 (bottom feed).

Additional models and custom selections available - contact your local Colmac Coil representative.

A+L Penthouse and 45° Down Lowest Cost ($/TR) Models

Table 17: Wet Conditions**

Model Number	Capacity (TR)	Fans	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+L13T-24-60-44.0C-0100L	5	1	10595	538	4	1	30	0.186	72	1207	1.08	81	56	56	1048
A+L13T-24-60-64.0C-0100L	6	1	10263	521	6	1	30	0.150	72	1809	1.56	81	56	60	1200
A+L13T-32-72-44.0C-0200L	8	1	18879	599	4	2	42	0.205	80	1931	1.77	94	72	67	1564
A+L13T-32-72-64.0C-0200L	10	1	17942	570	6	2	42	0.157	82	2894	2.56	94	72	71	1785
A+L23T-20-104-84.0C-0150L	12	2	17008	598	8	1.5	26	0.172	76	3482	2.89	126	49	59	2085
A+L23T-28-108-64.0C-0200L	15	2	24717	598	6	2	36	0.219	84	3798	3.19	130	65	66	2512
A+L23T-28-132-64.0C-0200L	18	2	30295	600	6	2	36	0.160	81	4642	3.83	154	65	66	2880
A+L23T-32-144-64.0C-0200L	20	2	35884	570	6	2	42	0.157	85	5788	4.87	166	73	71	3432
A+L23T-32-144-64.0C-0200L	22	2	35884	570	6	2	42	0.157	85	5788	4.87	166	73	71	3432
A+L33T-32-216-44.0C-0200L	25	3	56637	599	4	2	42	0.208	85	5792	4.86	238	73	67	4503
A+L43T-28-216-64.0C-0100L	28	4	44344	536	6	1	36	0.120	85	7597	6.19	238	66	66	4697
A+L23T-32-144-104.0C-0300L	30	2	37688	598	10	3	42	0.146	86	9641	7.96	167	73	79	4478
A+L33T-32-216-64.0C-0200L	32	3	53826	570	6	2	42	0.157	87	8682	7.19	239	73	71	5144
A+L33T-28-198-104.0C-0200L	35	3	44600	589	10	2	36	0.136	83	11599	9.40	221	66	74	5410
A+L33T-32-216-84.0C-0200L	38	3	51091	541	8	2	42	0.125	86	11572	9.42	239	74	75	5846
A+L33T-32-216-84.0C-0300L	40	3	56078	594	8	3	42	0.145	87	11572	9.42	239	74	75	5996
A+L43T-28-264-84.0C-0200L	42	4	59917	593	8	2	36	0.147	84	12375	9.93	287	66	70	6411
A+L43T-32-288-64.0C-0300L	45	4	75080	596	6	3	42	0.200	88	11576	9.37	311	74	71	7039
A+L43T-28-264-104.0C-0200L	48	4	59467	589	10	2	36	0.135	84	15466	12.30	287	66	74	7130
A+L43T-32-288-84.0C-0300L	50	4	74771	594	8	3	42	0.154	88	15429	12.63	312	74	75	7943
A+L43T-32-288-84.0C-0500L	52	4	75580	600	8	5	42	0.211	92	15429	12.63	312	74	75	8178
A+L43T-32-288-104.0C-0200L	55	4	66416	527	10	2	42	0.118	87	19282	15.58	312	75	79	8621
A+L43T-32-288-104.0C-0300L	58	4	75377	598	10	3	42	0.146	89	19282	15.58	312	75	79	8772
A+L43T-32-288-104.0C-0300L	60	4	75377	598	10	3	42	0.146	89	19282	15.58	312	75	79	8772

**Ratings based on +35°F/85% rh air on temp, +25°F evaporating temp, 4 FPI fin spacing, 2:1 pumped CO_2 (bottom feed).

Additional models and custom selections available - contact your local Colmac Coil representative.

A+ Series™ CO_2 Air Cooler Selection Tables

A+L Penthouse and 45° Down One Fan Models

Table 18: Frosted Conditions*

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+L13T-24-48-63.0C-0300L	5	12597	800	6	3	30	0.387	76	1111	1.29	69	56	60	1083
A+L13T-24-48-83.0C-0200L	6	11581	735	8	2	30	0.284	76	1480	1.68	69	56	64	1128
A+L13T-24-60-83.0C-0500L	8	15731	799	8	5	30	0.481	78	1851	2.11	82	57	64	1464
A+L13T-28-66-83.0C-0500L	10	20196	799	8	5	36	0.363	81	2375	2.70	88	65	70	1729
A+L13T-32-72-83.0C-0500L	12	24462	777	8	5	42	0.322	83	2961	3.32	94	72	75	2037
A+L13T-36-66-103.0C-0750L	15	25579	788	10	7.5	48	0.311	93	3816	4.35	88	80	85	2384

*Ratings based on -10°F/85% rh air on temp, -20°F evaporating temp, 3 FPI fin spacing, 2:1 pumped CO_2 (bottom feed).

Table 19: Wet Conditions**

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+L13T-24-60-44.0C-0100L	5	10595	538	4	1	30	0.186	72	1207	1.08	81	56	56	1048
A+L13T-24-60-64.0C-0100L	6	10263	521	6	1	30	0.150	72	1809	1.56	81	56	60	1200
A+L13T-32-72-44.0C-0200L	8	18879	599	4	2	42	0.205	80	1931	1.77	94	72	67	1564
A+L13T-32-72-64.0C-0200L	10	17942	570	6	2	42	0.157	82	2894	2.56	94	72	71	1785
A+L13T-32-72-84.0C-0200L	12	17031	541	8	2	42	0.133	81	3857	3.33	94	72	75	2034
A+L13T-36-72-84.0C-0500L	15	20812	587	8	5	48	0.176	83	4339	3.74	94	80	81	2365

**Ratings based on +35°F/85% rh air on temp, +25°F evaporating temp, 4 FPI fin spacing, 2:1 pumped CO_2 (bottom feed).

Additional models and custom selections available - contact your local Colmac Coil representative.

A+L Penthouse and 45° Down Two Fan Models

Table 20: Frosted Conditions*

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+L23T-24-96-43.0C-0100L	6	19708	626	4	1	30	0.289	76	1482	1.63	117	56	56	1620
A+L23T-24-120-43.0C-0200L	8	26262	667	4	2	30	0.409	78	1853	2.06	142	57	56	2030
A+L23T-28-132-43.0C-0200L	10	32192	637	4	2	36	0.313	81	2377	2.63	154	65	62	2417
A+L23T-24-96-83.0C-0200L	12	23162	735	8	2	30	0.283	79	2961	3.22	118	57	64	2157
A+L23T-32-144-43.0C-0500L	15	50375	800	4	5	42	0.495	86	2964	3.32	166	73	67	3107
A+L23T-32-144-63.0C-0300L	18	41760	663	6	3	42	0.281	86	4443	4.81	166	73	71	3362
A+L23T-28-132-83.0C-0500L	20	40392	799	8	5	36	0.362	84	4750	5.14	154	65	70	3362
A+L23T-32-144-83.0C-0300L	22	40347	641	8	3	42	0.223	86	5922	6.36	166	73	75	3793
A+L23T-32-120-103.0C-0500L	25	41980	800	10	5	42	0.315	88	6167	6.76	143	73	79	3820
A+L23T-32-144-103.0C-0500L	28	47476	754	10	5	42	0.288	85	7401	7.96	167	73	79	4363
A+L23T-36-132-103.0C-0750L	30	51157	788	10	7.5	48	0.318	96	7632	8.28	155	81	85	4601
A+L23T-36-144-103.0C-0750L	32	56167	793	10	7.5	48	0.375	98	8326	8.96	167	81	85	4908

*Ratings based on -10°F/85% rh air on temp, -20°F evaporating temp, 3 FPI fin spacing, 2:1 pumped CO_2 (bottom feed).

Table 21: Wet Conditions**

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+L23T-20-76-44.0C-0075L	5	12418	598	4	0.75	26	0.220	75	1274	1.1	97	48	51	1252
A+L23T-20-104-44.0C-0075L	6	15437	543	4	0.75	26	0.218	73	1743	1.51	126	49	51	1551
A+L23T-24-96-44.0C-0075L	8	18260	580	4	0.75	30	0.170	76	1931	1.69	118	56	56	1667
A+L23T-24-120-44.0C-0150L	10	23517	597	4	1.5	30	0.240	78	2413	2.08	142	57	56	2060
A+L23T-20-104-84.0C-0150L	12	17008	598	8	1.5	26	0.172	76	3482	2.89	126	49	59	2085
A+L23T-28-108-64.0C-0200L	15	24717	598	6	2	36	0.219	84	3798	3.19	130	65	66	2512
A+L23T-28-132-64.0C-0200L	18	30295	600	6	2	36	0.160	81	4642	3.83	154	65	66	2880
A+L23T-32-144-64.0C-0200L	20	35884	570	6	2	42	0.157	85	5788	4.87	166	73	71	3432
A+L23T-32-144-64.0C-0200L	22	35884	570	6	2	42	0.157	85	5788	4.87	166	73	71	3432
A+L23T-28-132-104.0C-0300L	25	30163	597	10	3	36	0.138	82	7733	6.34	154	65	74	3767
A+L23T-36-144-84.0C-0500L	28	41624	587	8	5	48	0.187	86	8679	7.15	166	81	81	4583
A+L23T-32-144-104.0C-0300L	30	37688	598	10	3	42	0.146	86	9641	7.96	167	73	79	4478
A+L23T-36-144-104.0C-0500L	32	40404	570	10	5	48	0.164	87	10846	8.96	167	81	85	5094

**Ratings based on +35°F/85% rh air on temp, +25°F evaporating temp, 4 FPI fin spacing, 2:1 pumped CO_2 (bottom feed).

Additional models and custom selections available - contact your local Colmac Coil representative.

A+ Series™ CO_2 Air Cooler Selection Tables

A+L Penthouse and 45° Down Three Fan Models

Table 22: Frosted Conditions*

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+L33T-24-144-43.0C-0150L	10	33734	714	4	1.5	30	0.363	79	2223	2.44	166	57	56	2486
A+L33T-24-180-43.0C-0200L	12	39393	667	4	2	30	0.409	80	2779	3.00	202	57	56	3000
A+L33T-28-198-43.0C-0200L	15	48288	637	4	2	36	0.326	82	3566	3.88	220	65	62	3589
A+L33T-24-144-83.0C-0300L	18	37423	792	8	3	30	0.351	82	4441	4.73	166	57	64	3382
A+L33T-28-162-63.0C-0300L	20	49537	799	6	3	36	0.342	83	4374	4.77	184	65	66	3713
A+L33T-32-216-43.0C-0500L	22	75563	800	4	5	42	0.494	88	4446	4.85	238	73	67	4655
A+L33T-28-198-63.0C-0500L	25	60626	800	6	5	36	0.430	85	5345	5.82	221	65	66	4483
A+L33T-32-216-63.0C-0500L	28	74131	785	6	5	42	0.428	89	6664	7.19	239	73	71	5257
A+L33T-28-198-83.0C-0500L	30	60588	799	8	5	36	0.377	86	7125	7.61	221	66	70	4960
A+L33T-32-180-83.0C-0500L	32	62860	798	8	5	42	0.386	92	7402	7.97	203	73	75	5207
A+L33T-28-198-103.0C-0500L	35	60182	794	10	5	36	0.339	86	8904	9.40	221	66	74	5437
A+L33T-36-216-83.0C-0750L	38	84220	792	8	7.5	48	0.364	96	9993	10.86	240	82	81	6614
A+L33T-36-216-83.0C-0750L	40	84220	792	8	7.5	48	0.364	96	9993	10.86	240	82	81	6614
A+L33T-32-216-103.0C-0500L	42	71213	754	10	5	42	0.298	87	11101	11.88	240	74	79	6475
A+L33T-36-216-103.0C-0750L	45	84251	793	10	7.5	48	0.358	99	12489	13.45	240	82	85	7303
A+L33T-36-216-103.0C-0750L	48	84251	793	10	7.5	48	0.358	99	12489	13.45	240	82	85	7303
A+L33T-36-216-103.0C-0750L	50	84251	793	10	7.5	48	0.358	99	12489	13.45	240	82	85	7303

*Ratings based on -10°F/85% rh air on temp, -20°F evaporating temp, 3 FPI fin spacing, 2:1 pumped CO_2 (bottom feed).

Table 23: Wet Conditions**

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+L33T-20-114-44.0C-0075L	6	14161	454	4	0.75	26	0.251	82	1911	1.64	136	49	51	1850
A+L33T-20-114-44.0C-0075L	8	18628	598	4	0.75	26	0.220	76	1911	1.64	136	49	51	1843
A+L33T-20-156-44.0C-0075L	10	23156	543	4	0.75	26	0.206	75	2614	2.18	178	49	51	2288
A+L33T-24-144-44.0C-0075L	12	27390	580	4	0.75	30	0.172	78	2896	2.44	166	57	56	2456
A+L33T-20-156-64.0C-0150L	15	25578	600	6	1.5	26	0.205	78	3919	3.19	178	49	55	2743
A+L33T-20-156-84.0C-0100L	18	24181	567	8	1	26	0.155	75	5223	4.19	178	50	59	2975
A+L33T-28-198-44.0C-0150L	20	44772	591	4	1.5	36	0.192	82	4646	3.93	220	65	62	3667
A+L33T-24-144-104.0C-0100L	22	26686	565	10	1	30	0.120	79	7231	5.89	166	58	68	3598
A+L33T-32-216-44.0C-0200L	25	56637	599	4	2	42	0.208	85	5792	4.86	238	73	67	4503
A+L33T-24-180-104.0C-0200L	28	35341	598	10	2	30	0.164	82	9038	7.29	202	58	68	4466
A+L33T-32-216-64.0C-0200L	30	53826	570	6	2	42	0.157	87	8682	7.19	239	73	71	5144
A+L33T-32-216-64.0C-0200L	32	53826	570	6	2	42	0.157	87	8682	7.19	239	73	71	5144
A+L33T-28-198-104.0C-0200L	35	44600	589	10	2	36	0.136	83	11599	9.40	221	66	74	5410
A+L33T-32-216-84.0C-0200L	38	51091	541	8	2	42	0.125	86	11572	9.42	239	74	75	5846
A+L33T-32-216-84.0C-0300L	40	56078	594	8	3	42	0.145	87	11572	9.42	239	74	75	5996
A+L33T-36-216-84.0C-0500L	42	62436	587	8	5	48	0.179	88	13018	10.59	239	82	81	6804
A+L33T-36-216-84.0C-0500L	45	62435	587	8	5	48	0.179	88	13018	10.59	239	82	81	6804

**Ratings based on +35°F/85% rh air on temp, +25°F evaporating temp, 4 FPI fin spacing, 2:1 pumped CO_2 (bottom feed).

Additional models and custom selections available - contact your local Colmac Coil representative.

A+L Penthouse and 45° Down Four Fan Models

Table 24: Frosted Conditions*

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+L43T-24-192-43.0C-0100L	12	39415	626	4	1	30	0.288	79	2964	3.18	214	57	56	3212
A+L43T-24-240-43.0C-0200L	15	52524	667	4	2	30	0.408	81	3705	3.96	262	58	56	4013
A+L43T-24-192-63.0C-0150L	18	43112	684	6	1.5	30	0.286	80	4443	4.72	214	58	60	3762
A+L43T-28-264-43.0C-0200L	20	64384	637	4	2	36	0.313	84	4755	5.09	286	66	62	4788
A+L43T-24-240-63.0C-0200L	22	50048	636	6	2	30	0.292	81	5554	5.85	262	58	60	4526
A+L43T-24-192-83.0C-0300L	25	49897	792	8	3	30	0.341	83	5922	6.34	215	58	64	4475
A+L43T-32-288-43.0C-0300L	28	87860	697	4	3	42	0.362	89	5928	6.42	311	74	67	5884
A+L43T-32-288-43.0C-0500L	30	100750	800	4	5	42	0.495	89	5928	6.42	311	74	67	6155
A+L43T-24-240-83.0C-0500L	32	62926	799	8	5	30	0.479	84	7402	7.79	263	58	64	5518
A+L43T-24-240-103.0C-0500L	35	62809	798	10	5	30	0.426	85	9251	9.64	263	58	68	6033
A+L43T-32-288-63.0C-0500L	38	98841	785	6	5	42	0.428	90	8886	9.37	311	74	71	6931
A+L43T-28-264-83.0C-0500L	40	80784	799	8	5	36	0.362	87	9500	10.14	288	66	70	6559
A+L43T-28-264-83.0C-0500L	42	80784	799	8	5	36	0.362	87	9500	10.14	288	66	70	6559
A+L43T-32-288-83.0C-0300L	45	80695	641	8	3	42	0.223	89	11844	12.54	312	74	75	7433
A+L43T-32-240-103.0C-0500L	48	83960	800	10	5	42	0.315	91	12335	13.16	264	74	79	7429
A+L43T-32-240-103.0C-0500L	50	83960	800	10	5	42	0.315	91	12335	13.16	264	74	79	7429
A+L43T-32-288-83.0C-0750L	52	100476	798	8	7.5	42	0.432	93	11844	12.62	312	74	75	8017
A+L43T-32-288-103.0C-0500L	55	94951	754	10	5	42	0.288	88	14802	15.57	312	75	79	8542
A+L43T-36-264-103.0C-0750L	58	102314	788	10	7.5	48	0.318	99	15264	16.16	288	82	85	8976
A+L43T-36-264-103.0C-0750L	60	102314	788	10	7.5	48	0.318	99	15264	16.16	288	82	85	8969
A+L43T-36-288-103.0C-1000L	62	112911	797	10	10	48	0.402	96	16652	17.52	312	82	85	9738

*Ratings based on -10°F/85% rh air on temp, -20°F evaporating temp, 3 FPI fin spacing, 2:1 pumped CO_2 (bottom feed).

Table 25: Wet Conditions**

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+L43T-20-152-44.0C-0075L	10	24837	598	4	0.75	26	0.220	78	2547	2.13	174	49	51	2413
A+L43T-20-208-44.0C-0075L	12	29562	520	4	0.75	26	0.202	79	3486	2.85	230	50	51	3029
A+L43T-24-192-44.0C-0075L	15	36520	580	4	0.75	30	0.170	79	3861	3.18	214	57	56	3285
A+L43T-20-152-84.0C-0075L	18	24848	598	8	0.75	26	0.139	74	5089	4.09	174	50	59	3094
A+L43T-24-240-44.0C-0150L	20	47034	597	4	1.5	30	0.240	81	4827	4.01	262	58	56	4066
A+L43T-24-192-64.0C-0100L	22	37788	600	6	1	30	0.153	79	5788	4.77	214	58	60	3809
A+L43T-24-240-64.0C-0100L	25	41050	521	6	1	30	0.149	78	7235	5.85	262	58	60	4514
A+L43T-28-216-64.0C-0100L	28	44344	536	6	1	36	0.120	85	7597	6.19	238	66	66	4697
A+L43T-28-216-64.0C-0150L	30	49524	599	6	1.5	36	0.169	86	7597	6.30	239	66	66	4841
A+L43T-32-288-44.0C-0200L	32	75516	599	4	2	42	0.205	86	7723	6.42	311	74	67	5951
A+L43T-28-264-64.0C-0150L	35	57771	572	6	1.5	36	0.149	83	9285	7.56	287	66	66	5612
A+L43T-32-288-64.0C-0200L	38	71768	570	6	2	42	0.168	88	11576	9.37	311	74	71	6780
A+L43T-32-288-64.0C-0200L	40	71768	570	6	2	42	0.168	88	11576	9.37	311	74	71	6780
A+L43T-28-264-84.0C-0200L	42	59917	593	8	2	36	0.147	84	12375	9.93	287	66	70	6411
A+L43T-32-288-64.0C-0300L	45	75080	596	6	3	42	0.200	88	11576	9.37	311	74	71	7039
A+L43T-28-264-104.0C-0200L	48	59467	589	10	2	36	0.135	84	15466	12.30	287	66	74	7130
A+L43T-32-288-84.0C-0300L	50	74771	594	8	3	42	0.154	88	15429	12.63	312	74	75	7943
A+L43T-32-288-84.0C-0500L	52	75580	600	8	5	42	0.211	92	15429	12.63	312	74	75	8178
A+L43T-32-288-104.0C-0200L	55	66416	527	10	2	42	0.118	87	19282	15.58	312	75	79	8621
A+L43T-32-288-104.0C-0300L	58	75377	598	10	3	42	0.146	89	19282	15.58	312	75	79	8772
A+L43T-32-288-104.0C-0300L	60	75377	598	10	3	42	0.146	89	19282	15.58	312	75	79	8772

**Ratings based on +35°F/85% rh air on temp, +25°F evaporating temp, 4 FPI fin spacing, 2:1 pumped CO_2 (bottom feed).

Additional models and custom selections available - contact your local Colmac Coil representative.

A+ Series™ CO_2 Air Cooler Selection Tables

A+L Penthouse and 45° Down Five Fan Models

Table 26: Frosted Conditions*

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+L53T-24-240-43.0C-0100L	15	49269	626	4	1	30	0.285	80	3705	3.96	262	58	56	4002
A+L53T-24-240-43.0C-0200L	18	62206	790	4	2	30	0.462	83	3705	3.96	262	58	56	4267
A+L53T-24-300-43.0C-0200L	20	65655	667	4	2	30	0.400	82	4631	4.91	322	58	56	4991
A+L53T-24-240-63.0C-0150L	22	53890	684	6	1.5	30	0.275	81	5554	5.85	262	58	60	4668
A+L53T-24-240-63.0C-0200L	25	60229	765	6	2	30	0.342	83	5554	5.94	263	58	60	4789
A+L53T-24-240-83.0C-0200L	28	57905	735	8	2	30	0.280	83	7402	7.79	263	58	64	5296
A+L53T-24-240-83.0C-0200L	30	57905	735	8	2	30	0.280	83	7402	7.79	263	58	64	5296
A+L53T-24-300-63.0C-0500L	32	78441	797	6	5	30	0.539	84	6942	7.30	323	58	60	6223
A+L53T-24-240-103.0C-0300L	35	62887	799	10	3	30	0.330	84	9251	9.64	263	58	68	6056
A+L53T-24-300-83.0C-0500L	38	78657	799	8	5	30	0.506	85	9253	9.60	323	59	64	6849
A+L53T-32-300-63.0C-0300L	40	99672	760	6	3	42	0.299	90	9256	9.97	324	74	71	7246
A+L53T-32-300-63.0C-0300L	42	99672	760	6	3	42	0.299	90	9256	9.97	324	74	71	7246
A+L53T-32-300-83.0C-0300L	45	95400	727	8	3	42	0.250	91	12337	13.10	324	74	75	8057
A+L53T-32-300-83.0C-0300L	48	95400	727	8	3	42	0.250	91	12337	13.10	324	74	75	8057
A+L53T-32-300-83.0C-0300L	50	95400	727	8	3	42	0.250	91	12337	13.10	324	74	75	8057
A+L53T-32-300-83.0C-0500L	52	104767	798	8	5	42	0.380	95	12337	13.10	324	74	75	8537
A+L53T-32-300-103.0C-0300L	55	91555	698	10	3	42	0.225	91	15419	16.17	324	75	79	8856
A+L53T-32-300-103.0C-0500L	58	104950	800	10	5	42	0.321	92	15419	16.17	324	75	79	9210
A+L53T-32-300-103.0C-0500L	60	104950	800	10	5	42	0.321	92	15419	16.17	324	75	79	9203

*Ratings based on -10°F/85% rh air on temp, -20°F evaporating temp, 3 FPI fin spacing, 2:1 pumped CO_2 (bottom feed).

Table 27: Wet Conditions**

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+L53T-20-190-44.0C-0075L	12	31046	598	4	0.75	26	0.227	79	3184	2.62	212	49	51	3043
A+L53T-20-260-44.0C-0075L	15	36952	520	4	0.75	26	0.202	80	4357	3.50	282	50	51	3805
A+L53T-20-190-64.0C-0075L	18	31128	599	6	0.75	26	0.150	75	4773	3.85	212	50	55	3439
A+L53T-24-240-44.0C-0075L	20	45650	580	4	0.75	30	0.175	80	4827	4.01	262	58	56	4091
A+L53T-20-190-84.0C-0075L	22	31060	598	8	0.75	26	0.141	75	6362	5.16	212	50	59	3855
A+L53T-20-260-64.0C-0100L	25	41323	581	6	1	26	0.182	77	6531	5.26	282	50	55	4407
A+L53T-20-260-84.0C-0100L	28	40302	567	8	1	26	0.160	77	8706	6.92	282	50	59	4943
A+L53T-20-260-84.0C-0150L	30	42519	598	8	1.5	26	0.171	80	8706	7.00	283	50	59	5108
A+L53T-24-300-64.0C-0100L	32	51312	521	6	1	30	0.143	79	9044	7.30	323	58	60	5611
A+L53T-24-300-64.0C-0150L	35	58180	591	6	1.5	30	0.186	83	9044	7.30	323	58	60	5779
A+L53T-24-300-84.0C-0150L	38	56612	575	8	1.5	30	0.167	83	12054	9.60	323	59	64	6486
A+L53T-24-300-84.0C-0200L	40	59001	600	8	2	30	0.201	84	12054	9.60	323	59	64	6588
A+L53T-32-300-64.0C-0150L	42	70849	540	6	1.5	42	0.137	92	12058	9.73	323	74	71	7217
A+L53T-32-300-64.0C-0200L	45	76665	584	6	2	42	0.149	91	12058	9.73	323	74	71	7317
A+L53T-28-270-104.0C-0150L	48	61897	599	10	1.5	36	0.123	85	15817	12.84	294	67	74	7501
A+L53T-28-270-104.0C-0150L	50	61897	599	10	1.5	36	0.123	85	15817	12.84	294	67	74	7501
A+L53T-32-300-84.0C-0200L	52	77646	592	8	2	42	0.141	88	16072	13.11	324	74	75	8331
A+L53T-32-300-104.0C-0150L	55	66162	504	10	1.5	42	0.111	92	20086	16.18	324	75	79	9087
A+L53T-32-300-104.0C-0200L	58	77699	592	10	2	42	0.139	90	20086	16.18	324	75	79	9187
A+L53T-32-300-104.0C-0200L	60	77699	592	10	2	42	0.139	90	20086	16.18	324	75	79	9187

**Ratings based on +35°F/85% rh air on temp, +25°F evaporating temp, 4 FPI fin spacing, 2:1 pumped CO_2 (bottom feed).

Additional models and custom selections available - contact your local Colmac Coil representative.

A+M MEDIUM PROFILE UNITS

Capacity Range: 2 - 50 TR

Featuring:

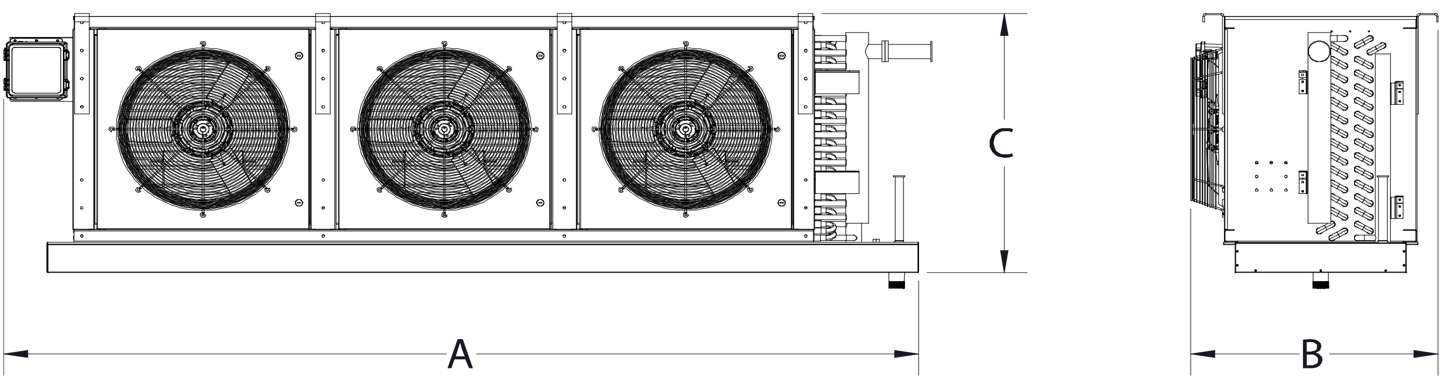
- 1/3 – 5 hp premium efficiency motors
- 16” – 42” diameter airfoil shaped fans
- 33.75” – 63” coil height
- 4 – 8 row deep coil
- Hinged fan panels
- Sloped fan boxes for water drainage

Options:

- Reheat coil
- Seal welded drainpan
- Full coverage drainpan

A+M Unit Dimensions

Dimensions and weights provided in the tables may change based on the options and features selected. Do not use these for construction, refer to the factory submittal provided at time of order.



(3 fan unit shown)

A+ Series™ CO_2 Air Cooler Selection Tables

A+M Lowest Cost ($/TR) Models

Table 28: Frosted Conditions*

Model Number	Capacity (TR)	Fans	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Air Throw (FT)	Sound @10FT (dB(A))	Surface Area (FT^2)	Internal Volume (FT^3)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+M13T-24-40-43.0C-0100L	3	1	9671	737	4	1	30	0.291	153	73	618	0.76	61	57	38	597
A+M13T-24-54-43.0C-0200L	4	1	13152	742	4	2	30	0.426	208	75	834	0.97	75	57	40	764
A+M13T-24-54-63.0C-0150L	5	1	11273	636	6	1.5	30	0.252	178	74	1250	1.43	75	57	44	876
A+M13T-20-54-83.0C-0200L	6	1	11580	784	8	2	30	0.283	183	76	1388	1.55	75	49	47	942
A+M13T-32-58-63.0C-0300L	8	1	20213	797	6	3	42	0.306	228	83	1790	2.11	80	73	47	1212
A+M13T-32-58-83.0C-0300L	10	1	19275	760	8	3	42	0.252	218	84	2385	2.76	80	73	51	1398
A+M23T-32-116-43.0C-0300L	12	2	40421	797	4	3	42	0.413	228	85	2388	2.68	138	73	43	1967
A+M23T-32-116-63.0C-0300L	15	2	40426	797	6	3	42	0.306	228	86	3579	3.97	138	74	47	2267
A+M23T-32-132-63.0C-0500L	18	2	46000	797	6	5	42	0.407	260	88	4073	4.45	154	74	47	2623
A+M23T-32-116-83.0C-0300L	20	2	38550	760	8	3	42	0.252	218	87	4770	5.23	138	74	51	2606
A+M23T-32-132-83.0C-0500L	22	2	45934	796	8	5	42	0.317	259	88	5428	5.87	154	74	51	3017
A+M33T-32-174-63.0C-0300L	25	3	60640	797	6	3	42	0.305	228	88	5369	5.93	197	74	47	3312
A+M43T-28-184-83.0C-0200L	28	4	54773	778	8	2	36	0.243	180	85	6621	7.12	207	66	47	3634
A+M33T-32-174-83.0C-0300L	30	3	57825	760	8	3	42	0.255	218	88	7156	7.73	197	74	51	3788
A+M43T-32-232-63.0C-0300L	32	4	80853	797	6	3	42	0.305	228	89	7158	7.68	255	75	47	4322
A+M43T-32-264-63.0C-0300L	35	4	83439	723	6	3	42	0.286	235	89	8145	8.64	287	75	47	4728
A+M53T-32-290-63.0C-0300L	38	5	101066	797	6	3	42	0.322	228	90	8948	9.43	313	75	47	5324
A+M33T-32-198-103.0C-0500L	40	3	69237	799	10	5	42	0.314	260	90	10176	10.97	222	75	55	4966
A+M63T-28-276-83.0C-0200L	42	6	82159	778	8	2	36	0.237	180	87	9932	10.56	300	67	47	5331
A+M43T-32-264-83.0C-0500L	45	4	91867	796	8	5	42	0.317	259	91	10857	11.58	288	75	51	5785
A+M53T-32-290-83.0C-0300L	48	5	96376	760	8	3	42	0.251	218	90	11926	12.70	314	75	51	6144
A+M53T-32-290-83.0C-0300L	50	5	96376	760	8	3	42	0.251	218	90	11926	12.70	314	75	51	6144
A+M43T-32-264-103.0C-0500L	52	4	92316	799	10	5	42	0.306	260	91	13568	14.36	288	75	55	6515
A+M43T-32-264-103.0C-0500L	55	4	92316	799	10	5	42	0.306	260	91	13568	14.36	288	75	55	6527
A+M53T-32-290-103.0C-0500L	58	5	100918	796	10	5	42	0.295	228	91	14905	15.67	314	76	55	7341
A+M53T-32-290-103.0C-0500L	60	5	100918	796	10	5	42	0.295	228	91	14905	15.67	314	76	55	7341

*Ratings based on -10°F/85% rh air on temp, -20°F evaporating temp, 3 FPI fin spacing, 2:1 pumped CO_2 (bottom feed).

Table 29: Wet Conditions**

Model Number	Capacity (TR)	Fans	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Air Throw (FT)	Sound @10FT (dB(A))	Surface Area (FT^2)	Internal Volume (FT^3)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+M13T-24-40-44.0C-0050L	3	1	7666	584	4	0.5	30	0.145	121	74	804	0.74	61	57	38	599
A+M13T-24-54-44.0C-0050L	4	1	7969	450	4	0.5	30	0.114	126	74	1086	0.95	75	57	38	701
A+M13T-20-54-64.0C-0075L	5	1	8795	596	6	0.75	30	0.134	139	73	1357	1.19	75	49	42	791
A+M13T-24-54-64.0C-0100L	6	1	10111	571	6	1	30	0.148	160	73	1628	1.43	75	57	42	881
A+M13T-28-60-64.0C-0200L	8	1	13705	597	6	2	36	0.192	180	81	2110	1.90	82	65	44	1110
A+M23T-20-108-64.0C-0075L	10	2	17591	596	6	0.75	30	0.141	139	76	2713	2.28	130	50	42	1480
A+M23T-24-108-64.0C-0100L	12	2	20223	571	6	1	30	0.147	160	76	3256	2.74	130	57	42	1688
A+M23T-28-120-64.0C-0100L	15	2	22946	500	6	1	36	0.110	151	81	4220	3.51	142	65	42	1997
A+M33T-24-162-64.0C-0100L	18	3	30334	571	6	1	30	0.147	160	78	4884	3.99	184	58	42	2466
A+M33T-32-174-44.0C-0150L	20	3	44695	587	4	1.5	42	0.176	168	89	4666	4.01	196	74	40	2677
A+M23T-32-116-84.0C-0300L	22	2	30252	596	8	3	42	0.190	171	93	6214	5.23	138	74	51	2808
A+M43T-24-216-64.0C-0150L	25	4	42505	600	6	1.5	30	0.157	168	80	6511	5.31	238	59	44	3399
A+M23T-32-132-104.0C-0300L	28	2	34499	598	10	3	42	0.161	195	90	8838	7.24	154	74	55	3471
A+M33T-32-198-64.0C-0200L	30	3	49678	574	6	2	42	0.139	187	84	7958	6.65	221	74	44	3640
A+M43T-28-240-64.0C-0200L	32	4	54819	597	6	2	36	0.191	180	87	8441	6.93	263	67	44	4093
A+M43T-32-232-64.0C-0150L	35	4	57194	564	6	1.5	42	0.138	161	91	9325	7.68	255	74	44	4215
A+M33T-32-198-84.0C-0300L	38	3	51711	597	8	3	42	0.136	195	87	10607	8.69	221	75	51	4457
A+M43T-32-264-64.0C-0300L	40	4	69291	600	6	3	42	0.254	196	91	10611	8.64	287	75	47	5069
A+M43T-32-232-84.0C-0200L	42	4	59482	586	8	2	42	0.129	168	90	12429	10.06	255	75	47	5022
A+M43T-32-264-84.0C-0200L	45	4	67724	586	8	2	42	0.135	191	87	14143	11.35	287	75	47	5600
A+M43T-32-264-84.0C-0200L	48	4	67724	586	8	2	42	0.135	191	87	14143	11.35	287	75	47	5600
A+M53T-32-290-84.0C-0200L	50	5	74352	586	8	2	42	0.136	168	91	15536	12.71	314	75	47	6241
A+M53T-32-290-84.0C-0300L	52	5	75629	596	8	3	42	0.201	171	97	15536	12.71	314	75	51	6619
A+M43T-32-264-104.0C-0300L	55	4	68998	598	10	3	42	0.161	195	93	17675	14.37	288	75	55	6696
A+M53T-32-290-104.0C-0200L	58	5	75605	596	10	2	42	0.126	171	89	19416	15.68	314	75	51	7192
A+M53T-32-290-104.0C-0200L	60	5	75605	596	10	2	42	0.126	171	89	19416	15.68	314	75	51	7181

**Ratings based on +35°F/85% rh air on temp, +25°F evaporating temp, 4 FPI fin spacing, 2:1 pumped CO_2 (bottom feed).

Additional models and custom selections available - contact your local Colmac Coil representative.

A+M One Fan Models

Table 30: Frosted Conditions*

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Air Throw (FT)	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+M13T-24-40-43.0C-0100L	3	9671	737	4	1	30	0.291	153	73	618	0.76	61	57	38	597
A+M13T-24-54-43.0C-0200L	4	13152	742	4	2	30	0.426	208	75	834	0.97	75	57	40	764
A+M13T-24-54-63.0C-0150L	5	11273	636	6	1.5	30	0.252	178	74	1250	1.43	75	57	44	876
A+M13T-20-54-83.0C-0200L	6	11580	784	8	2	30	0.283	183	76	1388	1.55	75	49	47	942
A+M13T-32-58-63.0C-0300L	8	20213	797	6	3	42	0.306	228	83	1790	2.11	80	73	47	1212
A+M13T-32-58-83.0C-0300L	10	19275	760	8	3	42	0.252	218	84	2385	2.76	80	73	51	1398
A+M13T-32-66-103.0C-0300L	12	19301	669	10	3	42	0.208	218	83	3392	3.79	88	74	55	1734
A+M23T-32-116-63.0C-0300L	15	40426	797	6	3	42	0.306	228	86	3579	3.97	138	74	47	2267

*Ratings based on -10°F/85% rh air on temp, -20°F evaporating temp, 3 FPI fin spacing, 2:1 pumped CO_2 (bottom feed).

Table 31: Wet Conditions**

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Air Throw (FT)	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+M13T-24-40-44.0C-0050L	3	7666	584	4	0.5	30	0.145	121	74	804	0.74	61	57	38	599
A+M13T-24-54-44.0C-0050L	4	7969	450	4	0.5	30	0.114	126	74	1086	0.95	75	57	38	701
A+M13T-20-54-64.0C-0075L	5	8795	596	6	0.75	30	0.134	139	73	1357	1.19	75	49	42	791
A+M13T-24-54-64.0C-0100L	6	10111	571	6	1	30	0.148	160	73	1628	1.43	75	57	42	881
A+M13T-28-60-64.0C-0200L	8	13705	597	6	2	36	0.192	180	81	2110	1.90	82	65	44	1110
A+M13T-28-60-84.0C-0150L	10	13665	595	8	1.5	36	0.127	180	78	2813	2.49	82	65	47	1310
A+M13T-32-66-84.0C-0300L	12	17237	597	8	3	42	0.142	195	82	3536	3.08	88	73	51	1634

**Ratings based on +35°F/85% rh air on temp, +25°F evaporating temp, 4 FPI fin spacing, 2:1 pumped CO_2 (bottom feed).

Additional models and custom selections available - contact your local Colmac Coil representative.

A+M Two Fan Models

Table 32: Frosted Conditions*

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Air Throw (FT)	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+M23T-20-80-43.0C-0050L	4	13928	637	4	0.5	30	0.210	110	77	1029	1.14	101	49	38	918
A+M23T-24-80-43.0C-0075L	5	17588	670	4	0.75	30	0.253	139	77	1235	1.38	101	57	38	1067
A+M23T-24-80-43.0C-0100L	6	19342	737	4	1	30	0.295	153	76	1235	1.38	101	57	38	1087
A+M23T-24-80-63.0C-0100L	8	18303	697	6	1	30	0.223	145	77	1851	2.09	102	57	42	1274
A+M23T-24-108-63.0C-0150L	10	22547	636	6	1.5	30	0.251	178	77	2499	2.74	130	58	44	1667
A+M23T-32-116-43.0C-0300L	12	40421	797	4	3	42	0.413	228	85	2388	2.68	138	73	43	1967
A+M23T-32-116-63.0C-0300L	15	40426	797	6	3	42	0.306	228	86	3579	3.97	138	74	47	2267
A+M23T-32-132-63.0C-0500L	18	46000	797	6	5	42	0.407	260	88	4073	4.45	154	74	47	2623
A+M23T-32-116-83.0C-0300L	20	38550	760	8	3	42	0.252	218	87	4770	5.23	138	74	51	2606
A+M23T-32-132-83.0C-0500L	22	45934	796	8	5	42	0.317	259	88	5428	5.87	154	74	51	3017
A+M23T-32-132-103.0C-0500L	25	46158	799	10	5	42	0.306	260	88	6784	7.36	155	74	55	3393

*Ratings based on -10°F/85% rh air on temp, -20°F evaporating temp, 3 FPI fin spacing, 2:1 pumped CO_2 (bottom feed).

Table 33: Wet Conditions**

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Air Throw (FT)	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+M23T-20-80-44.0C-0033L	5	11554	528	4	0.333	30	0.109	91	77	1341	1.15	101	49	38	960
A+M23T-24-80-44.0C-0050L	6	15333	584	4	0.5	30	0.144	121	77	1609	1.45	102	57	38	1088
A+M23T-24-108-44.0C-0050L	8	15939	450	4	0.5	30	0.115	126	77	2172	1.88	130	57	38	1346
A+M23T-20-108-64.0C-0075L	10	17591	596	6	0.75	30	0.141	139	76	2713	2.28	130	50	42	1480
A+M23T-24-108-64.0C-0100L	12	20223	571	6	1	30	0.147	160	76	3256	2.74	130	57	42	1688
A+M23T-28-120-64.0C-0100L	15	22946	500	6	1	36	0.110	151	81	4220	3.51	142	65	42	1997
A+M23T-32-132-64.0C-0150L	18	29305	508	6	1.5	42	0.131	165	87	5306	4.37	154	74	44	2430
A+M23T-32-116-84.0C-0150L	20	27529	543	8	1.5	42	0.118	155	88	6214	5.23	138	74	47	2590
A+M23T-32-116-84.0C-0300L	22	30252	596	8	3	42	0.190	171	93	6214	5.23	138	74	51	2808
A+M23T-32-132-104.0C-0300L	25	34499	598	10	3	42	0.161	195	90	8838	7.24	154	74	55	3482
A+M23T-32-132-104.0C-0300L	28	34499	598	10	3	42	0.161	195	90	8838	7.24	154	74	55	3471

**Ratings based on +35°F/85% rh air on temp, +25°F evaporating temp, 4 FPI fin spacing, 2:1 pumped CO_2 (bottom feed).

Additional models and custom selections available - contact your local Colmac Coil representative.

A+M Three Fan Models

Table 34: Frosted Conditions*

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Air Throw (FT)	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+M33T-24-120-43.0C-0075L	8	26382	670	4	0.75	30	0.257	139	78	1853	2.06	142	57	38	1542
A+M33T-20-120-63.0C-0075L	10	23821	726	6	0.75	30	0.218	125	78	2314	2.51	142	50	42	1673
A+M33T-24-120-63.0C-0100L	12	27455	697	6	1	30	0.223	145	78	2777	3.01	142	58	42	1864
A+M33T-24-120-83.0C-0150L	15	29876	759	8	1.5	30	0.254	157	79	3701	4.00	142	58	47	2255
A+M33T-32-174-43.0C-0300L	18	60632	797	4	3	42	0.424	228	87	3582	3.95	196	74	43	2875
A+M33T-28-138-83.0C-0150L	20	36680	694	8	1.5	36	0.192	161	82	4966	5.35	160	66	47	2710
A+M33T-28-180-63.0C-0300L	22	53247	773	6	3	36	0.341	234	84	4860	5.24	202	66	47	3146
A+M33T-32-174-63.0C-0300L	25	60640	797	6	3	42	0.305	228	88	5369	5.93	197	74	47	3312
A+M33T-28-180-83.0C-0500L	28	55115	800	8	5	36	0.433	242	87	6477	6.97	203	66	51	3832
A+M33T-32-174-83.0C-0300L	30	57825	760	8	3	42	0.255	218	88	7156	7.73	197	74	51	3788
A+M33T-32-198-83.0C-0300L	32	60130	694	8	3	42	0.239	226	88	8143	8.69	221	75	51	4151
A+M33T-32-198-103.0C-0500L	35	68411	790	10	5	42	0.308	257	90	10176	10.97	222	75	55	4919
A+M33T-32-198-103.0C-0500L	38	69237	799	10	5	42	0.314	260	90	10176	10.97	222	75	55	4953
A+M33T-32-198-103.0C-0500L	40	69237	799	10	5	42	0.314	260	90	10176	10.97	222	75	55	4966

*Ratings based on -10°F/85% rh air on temp, -20°F evaporating temp, 3 FPI fin spacing, 2:1 pumped CO_2 (bottom feed).

Table 35: Wet Conditions**

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Air Throw (FT)	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+M33T-20-120-44.0C-0050L	8	19613	598	4	0.5	30	0.137	103	79	2011	1.71	142	50	38	1446
A+M33T-24-120-44.0C-0050L	10	22999	584	4	0.5	30	0.144	121	79	2413	2.08	142	57	38	1576
A+M33T-24-162-44.0C-0050L	12	23908	450	4	0.5	30	0.117	126	79	3258	2.73	184	58	38	1972
A+M33T-20-162-64.0C-0075L	15	26386	596	6	0.75	30	0.137	139	78	4070	3.32	184	50	42	2219
A+M33T-24-162-64.0C-0100L	18	30334	571	6	1	30	0.147	160	78	4884	3.99	184	58	42	2466
A+M33T-32-174-44.0C-0150L	20	44695	587	4	1.5	42	0.176	168	89	4666	4.01	196	74	40	2677
A+M33T-20-162-104.0C-0100L	22	26520	599	10	1	30	0.119	140	79	6779	5.51	184	51	50	2957
A+M33T-32-174-64.0C-0150L	25	42896	564	6	1.5	42	0.142	161	89	6994	5.81	196	74	44	3231
A+M33T-32-198-64.0C-0200L	28	49679	574	6	2	42	0.139	187	84	7958	6.65	221	74	44	3612
A+M33T-32-198-64.0C-0200L	30	49678	574	6	2	42	0.139	187	84	7958	6.65	221	74	44	3640
A+M33T-32-174-84.0C-0200L	32	44611	586	8	2	42	0.127	168	88	9322	7.73	197	74	47	3840
A+M33T-32-198-84.0C-0200L	35	50793	586	8	2	42	0.130	191	86	10607	8.69	221	74	47	4263
A+M33T-32-198-84.0C-0300L	38	51711	597	8	3	42	0.136	195	87	10607	8.69	221	75	51	4457
A+M33T-32-198-104.0C-0200L	40	49339	570	10	2	42	0.120	186	86	13256	10.73	221	75	51	4887
A+M33T-32-198-104.0C-0300L	42	51749	598	10	3	42	0.159	195	91	13256	10.73	221	75	55	5079

**Ratings based on +35°F/85% rh air on temp, +25°F evaporating temp, 4 FPI fin spacing, 2:1 pumped CO_2 (bottom feed).

Additional models and custom selections available - contact your local Colmac Coil representative.

A+ Series™ CO_2 Air Cooler Selection Tables

A+M Four Fan Models

Table 36: Frosted Conditions*

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Air Throw (FT)	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+M43T-20-160-43.0C-0100L	10	34977	800	4	1	30	0.319	138	79	2058	2.25	182	50	38	1920
A+M43T-24-160-43.0C-0100L	12	38684	737	4	1	30	0.294	153	79	2470	2.69	182	58	38	2072
A+M43T-24-160-63.0C-0075L	15	33478	638	6	0.75	30	0.193	132	80	3702	4.00	182	58	42	2392
A+M43T-20-216-63.0C-0150L	18	43311	733	6	1.5	30	0.279	171	80	4165	4.39	238	51	44	2962
A+M43T-24-160-83.0C-0150L	20	39835	759	8	1.5	30	0.251	157	80	4935	5.29	182	58	47	2944
A+M43T-28-184-63.0C-0150L	22	51232	727	6	1.5	36	0.228	169	83	4968	5.35	206	66	44	3091
A+M43T-32-264-43.0C-0300L	25	88334	765	4	3	42	0.374	249	89	5434	5.93	287	75	43	4024
A+M43T-28-184-83.0C-0200L	28	54773	778	8	2	36	0.243	180	85	6621	7.12	207	66	47	3634
A+M43T-32-232-63.0C-0300L	30	80853	797	6	3	42	0.305	228	89	7158	7.68	255	75	47	4322
A+M43T-32-232-63.0C-0300L	32	80853	797	6	3	42	0.305	228	89	7158	7.68	255	75	47	4322
A+M43T-32-264-63.0C-0300L	35	83439	723	6	3	42	0.286	235	89	8145	8.64	287	75	47	4728
A+M53T-32-290-63.0C-0300L	38	101066	797	6	3	42	0.322	228	90	8948	9.43	313	75	47	5324
A+M43T-32-264-83.0C-0300L	40	80173	694	8	3	42	0.232	226	89	10857	11.58	288	75	51	5455
A+M43T-32-264-83.0C-0300L	42	80173	694	8	3	42	0.232	226	89	10857	11.58	288	75	51	5444
A+M43T-32-264-83.0C-0500L	45	91867	796	8	5	42	0.317	259	91	10857	11.58	288	75	51	5785
A+M43T-32-264-103.0C-0300L	48	77203	669	10	3	42	0.207	218	90	13568	14.29	288	75	55	6160
A+M43T-32-264-103.0C-0500L	50	92316	799	10	5	42	0.306	260	91	13568	14.36	288	75	55	6515
A+M43T-32-264-103.0C-0500L	52	92316	799	10	5	42	0.306	260	91	13568	14.36	288	75	55	6515
A+M43T-32-264-103.0C-0500L	55	92316	799	10	5	42	0.306	260	91	13568	14.36	288	75	55	6527

*Ratings based on -10°F/85% rh air on temp, -20°F evaporating temp, 3 FPI fin spacing, 2:1 pumped CO_2 (bottom feed).

Table 37: Wet Conditions**

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Air Throw (FT)	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+M43T-20-160-44.0C-0050L	10	26151	598	4	0.5	30	0.137	103	80	2681	2.25	182	50	38	1891
A+M43T-24-160-44.0C-0050L	12	30666	584	4	0.5	30	0.143	121	80	3218	2.70	182	58	38	2055
A+M43T-20-216-44.0C-0075L	15	35155	595	4	0.75	30	0.162	139	80	3620	2.95	238	50	38	2449
A+M43T-24-216-44.0C-0100L	18	42407	598	4	1	30	0.198	168	78	4344	3.54	238	58	38	2696
A+M43T-20-216-64.0C-0075L	20	35182	596	6	0.75	30	0.141	139	79	5426	4.43	238	51	42	2910
A+M43T-28-240-44.0C-0100L	22	47406	516	4	1	36	0.145	156	84	5631	4.67	262	66	38	3168
A+M43T-24-216-64.0C-0150L	25	42505	600	6	1.5	30	0.157	168	80	6511	5.31	238	59	44	3399
A+M33T-32-198-64.0C-0200L	28	49679	574	6	2	42	0.139	187	84	7958	6.65	221	74	44	3612
A+M43T-24-216-84.0C-0100L	30	38993	550	8	1	30	0.126	154	79	8679	6.98	238	59	46	3703
A+M43T-28-240-64.0C-0200L	32	54819	597	6	2	36	0.191	180	87	8441	6.93	263	67	44	4093
A+M43T-32-232-64.0C-0150L	35	57194	564	6	1.5	42	0.138	161	91	9325	7.68	255	74	44	4215
A+M43T-32-264-64.0C-0200L	38	66238	574	6	2	42	0.146	187	85	10611	8.64	287	75	44	4791
A+M43T-32-264-64.0C-0300L	40	69291	600	6	3	42	0.254	196	91	10611	8.64	287	75	47	5069
A+M43T-32-232-84.0C-0200L	42	59482	586	8	2	42	0.129	168	90	12429	10.06	255	75	47	5022
A+M43T-32-264-84.0C-0200L	45	67724	586	8	2	42	0.135	191	87	14143	11.35	287	75	47	5600
A+M43T-32-264-84.0C-0200L	48	67724	586	8	2	42	0.135	191	87	14143	11.35	287	75	47	5600
A+M43T-32-264-104.0C-0200L	50	65787	570	10	2	42	0.122	186	88	17675	14.37	288	75	51	6446
A+M43T-32-264-104.0C-0200L	52	65786	570	10	2	42	0.122	186	88	17675	14.37	288	75	51	6446
A+M43T-32-264-104.0C-0300L	55	68998	598	10	3	42	0.161	195	93	17675	14.37	288	75	55	6696

**Ratings based on +35°F/85% rh air on temp, +25°F evaporating temp, 4 FPI fin spacing, 2:1 pumped CO_2 (bottom feed).

Additional models and custom selections available - contact your local Colmac Coil representative.

A+M Five Fan Models

Table 38: Frosted Conditions*

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Air Throw (FT)	Sound @10FT (dB(A))	Surface Area (FT^2)	Internal Volume (FT^3)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+M53T-20-200-43.0C-0075L	12	42305	774	4	0.75	30	0.298	134	81	2573	2.75	222	50	38	2331
A+M53T-20-270-43.0C-0075L	15	44846	608	4	0.75	30	0.236	142	80	3473	3.68	292	51	38	2899
A+M53T-20-200-63.0C-0100L	18	43308	792	6	1	30	0.257	137	80	3857	4.09	222	50	42	2770
A+M53T-20-200-83.0C-0075L	20	37464	685	8	0.75	30	0.186	118	81	5141	5.42	222	51	46	3096
A+M53T-20-270-63.0C-0150L	22	54139	733	6	1.5	30	0.289	171	81	5207	5.45	292	51	44	3656
A+M53T-24-200-83.0C-0150L	25	49794	759	8	1.5	30	0.259	157	81	6169	6.58	223	59	47	3634
A+M53T-20-270-83.0C-0150L	28	51887	703	8	1.5	30	0.232	164	83	6940	7.25	293	51	47	4166
A+M53T-20-270-83.0C-0200L	30	57901	784	8	2	30	0.285	183	83	6940	7.25	293	51	47	4265
A+M53T-24-270-83.0C-0200L	32	60719	686	8	2	30	0.265	192	83	8328	8.69	293	59	47	4647
A+M53T-28-300-63.0C-0300L	35	88746	773	6	3	36	0.339	234	86	8099	8.51	323	67	47	5090
A+M53T-32-290-63.0C-0300L	38	101066	797	6	3	42	0.322	228	90	8948	9.43	313	75	47	5324
A+M53T-28-300-83.0C-0200L	40	74819	652	8	2	36	0.206	197	85	10795	11.40	324	67	47	5473
A+M53T-28-300-83.0C-0200L	42	74819	652	8	2	36	0.206	197	85	10795	11.40	324	67	47	5463
A+M53T-28-300-83.0C-0300L	45	84789	738	8	3	36	0.283	223	86	10795	11.40	324	68	51	5811
A+M53T-32-290-83.0C-0300L	48	96376	760	8	3	42	0.251	218	90	11926	12.70	314	75	51	6144
A+M53T-32-290-83.0C-0300L	50	96376	760	8	3	42	0.251	218	90	11926	12.70	314	75	51	6144
A+M53T-28-300-103.0C-0500L	52	91581	798	10	5	36	0.321	241	88	13491	14.16	324	68	55	6888
A+M53T-32-290-103.0C-0300L	55	92192	727	10	3	42	0.226	208	91	14905	15.67	314	76	55	6932
53T-32-290-103.0C-0500L-CRB-WW	58	100918	796	10	5	42	0.295	228	91	14905	15.67	314	76	55	7341
53T-32-290-103.0C-0500L-CRB-WW	60	100918	796	10	5	42	0.295	228	91	14905	15.67	314	76	55	7341

*Ratings based on -10°F/85% rh air on temp, -20°F evaporating temp, 3 FPI fin spacing, 2:1 pumped CO_2 (bottom feed).

Table 39: Wet Conditions**

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Air Throw (FT)	Sound @10FT (dB(A))	Surface Area (FT^2)	Internal Volume (FT^3)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+M53T-24-200-44.0C-0033L	15	29718	453	4	0.333	30	0.097	94	80	4022	3.30	222	58	38	2541
A+M53T-20-270-44.0C-0075L	18	43944	595	4	0.75	30	0.159	139	81	4525	3.72	292	51	38	3043
A+M53T-24-270-44.0C-0075L	20	47249	533	4	0.75	30	0.166	149	80	5430	4.46	292	59	38	3284
A+M53T-24-270-44.0C-0100L	22	53009	598	4	1	30	0.197	168	79	5430	4.46	292	59	38	3341
A+M53T-20-270-64.0C-0075L	25	43977	596	6	0.75	30	0.133	139	80	6783	5.45	292	51	42	3601
A+M53T-24-270-64.0C-0075L	28	45634	515	6	0.75	30	0.125	144	80	8139	6.53	292	59	42	3888
A+M53T-28-230-64.0C-0100L	30	50854	578	6	1	36	0.118	134	86	8089	6.67	253	66	42	3836
A+M53T-32-290-44.0C-0150L	32	74492	587	4	1.5	42	0.177	168	91	7776	6.46	313	75	40	4326
A+M53T-24-270-84.0C-0100L	35	48741	550	8	1	30	0.131	154	80	10848	8.70	293	59	46	4633
A+M53T-28-230-84.0C-0100L	38	52008	591	8	1	36	0.115	137	86	10781	8.73	253	67	46	4492
A+M53T-32-290-64.0C-0150L	40	71493	564	6	1.5	42	0.147	161	91	11656	9.43	313	75	44	5216
A+M53T-24-270-104.0C-0150L	42	53015	599	10	1.5	30	0.143	168	82	13558	10.77	293	59	51	5498
A+M53T-28-300-84.0C-0150L	45	68323	595	8	1.5	36	0.138	180	85	14063	11.20	323	67	47	5757
A+M53T-32-290-84.0C-0150L	48	68822	543	8	1.5	42	0.124	155	92	15536	12.39	313	75	47	6105
A+M53T-32-290-84.0C-0200L	50	74352	586	8	2	42	0.136	168	91	15536	12.71	314	75	47	6241
A+M53T-32-290-84.0C-0300L	52	75629	596	8	3	42	0.201	171	97	15536	12.71	314	75	51	6619
A+M53T-28-300-104.0C-0200L	55	68793	599	10	2	36	0.143	181	87	17575	14.16	324	68	51	6718
A+M53T-32-290-104.0C-0200L	58	75605	596	10	2	42	0.126	171	89	19416	15.68	314	75	51	7192
A+M53T-32-290-104.0C-0200L	60	75605	596	10	2	42	0.126	171	89	19416	15.68	314	75	51	7181

**Ratings based on +35°F/85% rh air on temp, +25°F evaporating temp, 4 FPI fin spacing, 2:1 pumped CO_2 (bottom feed).

Additional models and custom selections available - contact your local Colmac Coil representative.

A+ Series™ CO_2 Air Cooler Selection Tables

A+M Six Fan Models

Table 40: Frosted Conditions*

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Air Throw (FT)	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+M63T-20-240-43.0C-0075L	15	50766	774	4	0.75	30	0.283	134	81	3088	3.30	262	51	38	2780
A+M63T-20-240-63.0C-0050L	18	39626	604	6	0.5	30	0.157	104	83	4628	4.84	262	51	42	3135
A+M63T-20-240-63.0C-0075L	20	47643	726	6	0.75	30	0.218	125	81	4628	4.88	262	51	42	3234
A+M63T-24-240-63.0C-0075L	22	50217	638	6	0.75	30	0.193	132	81	5554	5.85	262	59	42	3511
A+M63T-20-240-83.0C-0100L	25	49607	756	8	1	30	0.214	131	82	6169	6.50	263	51	46	3745
A+M63T-20-240-103.0C-0100L	28	46787	713	10	1	30	0.190	123	83	7709	8.03	263	51	50	4188
A+M63T-24-240-83.0C-0150L	30	59753	759	8	1.5	30	0.254	157	82	7402	7.79	263	59	47	4316
A+M63T-24-240-83.0C-0200L	32	62880	799	8	2	30	0.294	166	83	7402	7.79	263	59	47	4460
A+M63T-28-276-83.0C-0150L	35	73358	694	8	1.5	36	0.192	161	85	9932	10.56	300	67	47	5222
A+M63T-28-276-83.0C-0150L	38	73359	694	8	1.5	36	0.192	161	85	9932	10.56	300	67	47	5211
A+M63T-28-276-83.0C-0150L	40	73359	694	8	1.5	36	0.192	161	85	9932	10.56	300	67	47	5222
A+M63T-28-276-83.0C-0200L	42	82159	778	8	2	36	0.237	180	87	9932	10.56	300	67	47	5331
A+M63T-28-276-103.0C-0300L	45	84396	799	10	3	36	0.264	185	89	12412	13.10	300	68	55	6430
A+M63T-28-276-103.0C-0300L	48	84396	799	10	3	36	0.264	185	89	12412	13.10	300	68	55	6443
A+M63T-28-276-103.0C-0300L	50	84396	799	10	3	36	0.264	185	89	12412	13.10	300	68	55	6443

*Ratings based on -10°F/85% rh air on temp, -20°F evaporating temp, 3 FPI fin spacing, 2:1 pumped CO_2 (bottom feed).

Table 41: Wet Conditions**

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Air Throw (FT)	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+M63T-20-240-44.0C-0050L	15	39226	598	4	0.5	30	0.142	103	82	4022	3.25	262	51	38	2793
A+M63T-24-240-44.0C-0050L	18	45999	584	4	0.5	30	0.143	121	82	4827	4.01	262	58	38	3043
A+M63T-24-240-44.0C-0050L	20	45999	584	4	0.5	30	0.143	121	82	4827	4.01	262	58	38	3035
A+M63T-20-240-64.0C-0050L	22	39285	599	6	0.5	30	0.110	103	83	6029	4.88	262	51	42	3316
A+M63T-24-240-64.0C-0050L	25	43981	559	6	0.5	30	0.114	116	82	7235	5.85	262	59	42	3628
A+M63T-24-240-84.0C-0050L	28	40666	517	8	0.5	30	0.094	107	82	9643	7.79	263	59	45	4162
A+M63T-24-240-84.0C-0050L	30	40668	517	8	0.5	30	0.094	107	82	9643	7.79	263	59	45	4192
A+M63T-24-240-84.0C-0075L	32	46815	595	8	0.75	30	0.115	123	82	9643	7.79	263	59	46	4310
A+M63T-28-276-64.0C-0100L	35	61026	578	6	1	36	0.121	134	87	9707	7.88	299	67	42	4572
A+M63T-28-276-84.0C-0075L	38	48867	463	8	0.75	36	0.086	107	90	12938	10.35	299	67	46	5281
A+M63T-28-276-84.0C-0100L	40	62410	591	8	1	36	0.120	137	87	12938	10.35	299	67	46	5341
A+M63T-28-276-84.0C-0100L	42	62410	591	8	1	36	0.120	137	87	12938	10.35	299	67	46	5341
A+M63T-28-276-104.0C-0100L	45	59914	567	10	1	36	0.108	131	86	16169	13.10	300	67	50	6133
A+M63T-28-276-104.0C-0100L	48	59914	567	10	1	36	0.108	131	86	16169	13.10	300	67	50	6133
A+M63T-28-276-104.0C-0100L	50	59913	567	10	1	36	0.108	131	86	16169	13.10	300	67	50	6133
A+M63T-28-276-104.0C-0150L	52	63007	596	10	1.5	36	0.131	138	91	16169	13.10	300	67	51	6389

**Ratings based on +35°F/85% rh air on temp, +25°F evaporating temp, 4 FPI fin spacing, 2:1 pumped CO_2 (bottom feed).

Additional models and custom selections available - contact your local Colmac Coil representative.

A+S LOW PROFILE UNITS

Capacity Range: 5 - 35 TR

Featuring:

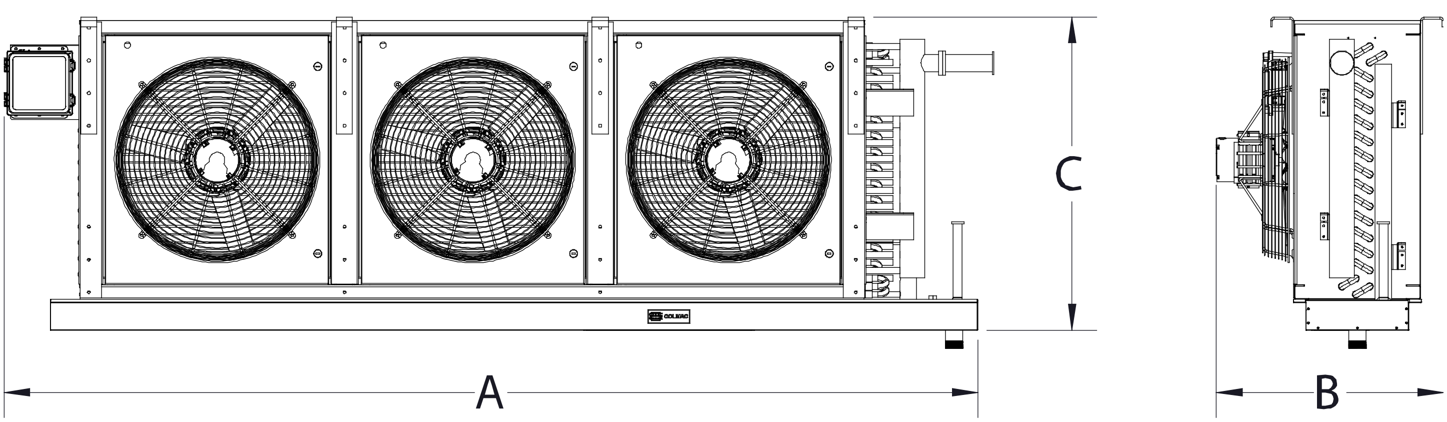
- 1/3 – 1 hp premium efficiency motors
- 16” – 30” diameter airfoil shaped fans
- 33.75” – 45” coil height
- 4 – 10 row deep coil
- Hinged fan panels
- Guard mounted motors
- Sloped fan boxes for water drainage

Options:

- Reheat coil
- Seal welded drainpan
- Full coverage drainpan

A+S Unit Dimensions

Dimensions and weights provided in the tables may change based on the options and features selected. Do not use these for construction, refer to the factory submittal provided at time of order.



(3 fan unit shown)

A+ Series™ CO_2 Air Cooler Selection Tables

A+S Lowest Cost ($/TR) Models

Table 42: Frosted Conditions*

Model Number	Capacity (TR)	Fans	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Air Throw (FT)	Sound @10FT (dB(A))	Surface Area (FT^2)	Internal Volume (FT^3)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+S13T-20-38-43.0C-0050L	2	1	6892	663	4	0.5	30	0.217	109	74	489	0.61	59	48	28	413
A+S13T-20-54-43.0C-0075L	3	1	8969	608	4	0.75	30	0.233	142	73	695	0.81	75	48	28	519
A+S13T-20-54-63.0C-0100L	4	1	9438	639	6	1	30	0.227	149	73	1041	1.18	75	49	32	625
A+S13T-20-54-83.0C-0100L	5	1	9041	612	8	1	30	0.191	143	73	1388	1.55	75	49	36	741
A+S23T-20-108-43.0C-0075L	6	2	17939	608	4	0.75	30	0.233	142	77	1389	1.51	129	49	28	959
A+S23T-24-76-63.0C-0100L	7	2	18047	724	6	1	30	0.254	143	76	1759	2.00	98	57	32	973
A+S23T-20-76-83.0C-0100L	8	2	16156	778	8	1	30	0.242	128	78	1953	2.17	98	49	36	1046
A+S33T-20-114-63.0C-0075L	9	3	23413	751	6	0.75	30	0.236	123	78	2198	2.38	136	49	32	1300
A+S23T-20-108-83.0C-0100L	10	2	18082	612	8	1	30	0.199	143	76	2776	2.99	130	49	36	1359
A+S33T-20-162-63.0C-0100L	12	3	28314	639	6	1	30	0.226	149	78	3124	3.32	184	49	32	1718
A+S43T-24-152-63.0C-0100L	15	4	36094	724	6	1	30	0.254	143	79	3517	3.79	174	57	32	1918
A+S43T-20-152-103.0C-0100L	18	4	30385	731	10	1	30	0.213	120	81	4883	5.12	174	50	40	2325
A+S43T-20-216-83.0C-0100L	20	4	36164	612	8	1	30	0.198	143	79	5552	5.82	238	50	36	2702
A+S63T-24-228-63.0C-0100L	22	6	54140	724	6	1	30	0.254	143	81	5276	5.58	250	58	32	2825
A+S53T-20-270-83.0C-0100L	25	5	45205	612	8	1	30	0.191	143	80	6940	7.25	293	51	36	3336
A+S63T-20-228-103.0C-0100L	28	6	45577	731	10	1	30	0.209	120	83	7324	7.65	251	50	40	3426
A+S63T-24-228-103.0C-0100L	30	6	49733	665	10	1	30	0.197	131	82	8789	9.19	251	58	40	3816

*Ratings based on -10°F/85% rh air on temp, -20°F evaporating temp, 3 FPI fin spacing, 2:1 pumped CO_2 (bottom feed).

Table 43: Wet Conditions**

Model Number	Capacity (TR)	Fans	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Air Throw (FT)	Sound @10FT (dB(A))	Surface Area (FT^2)	Internal Volume (FT^3)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+S13T-20-38-44.0C-0033L	2	1	4564	439	4	0.333	30	0.080	72	73	637	0.59	59	48	28	447
A+S13T-24-38-44.0C-0050L	3	1	7301	586	4	0.5	30	0.146	115	73	764	0.71	59	56	28	465
A+S13T-24-54-44.0C-0050L	4	1	7969	450	4	0.5	30	0.114	126	74	1086	0.95	75	56	28	592
A+S13T-20-54-64.0C-0075L	5	1	8795	596	6	0.75	30	0.134	139	73	1357	1.19	75	49	32	678
A+S13T-24-54-64.0C-0100L	6	1	10111	571	6	1	30	0.158	160	73	1628	1.43	75	56	32	748
A+S23T-20-108-44.0C-0075L	7	2	17578	595	4	0.75	30	0.160	139	77	1810	1.56	130	49	28	1024
A+S23T-24-108-44.0C-0050L	8	2	15939	450	4	0.5	30	0.115	126	77	2172	1.88	130	57	28	1120
A+S23T-24-108-44.0C-0100L	9	2	21204	598	4	1	30	0.212	168	75	2172	1.88	130	57	28	1125
A+S23T-20-108-64.0C-0075L	10	2	17591	596	6	0.75	30	0.141	139	76	2713	2.28	130	49	32	1256
A+S23T-24-108-64.0C-0100L	12	2	20223	571	6	1	30	0.157	160	76	3256	2.74	130	57	32	1400
A+S33T-20-162-64.0C-0075L	15	3	26386	596	6	0.75	30	0.137	139	78	4070	3.32	184	49	32	1833
A+S33T-24-162-64.0C-0100L	18	3	30334	571	6	1	30	0.157	160	78	4884	3.99	184	57	32	2075
A+S43T-20-216-64.0C-0075L	20	4	35182	596	6	0.75	30	0.141	139	79	5426	4.43	238	50	32	2460
A+S53T-24-270-44.0C-0100L	22	5	53009	598	4	1	30	0.210	168	79	5430	4.46	292	58	28	2718
A+S53T-20-270-64.0C-0075L	25	5	43977	596	6	0.75	30	0.133	139	80	6783	5.45	292	50	32	3038
A+S53T-24-270-64.0C-0075L	28	5	45635	515	6	0.75	30	0.125	144	80	8139	6.53	292	58	32	3368
A+S53T-20-270-84.0C-0075L	30	5	42142	571	8	0.75	30	0.118	133	80	9040	7.25	293	51	36	3604
A+S63T-24-228-84.0C-0075L	32	6	44553	596	8	0.75	30	0.117	117	81	9161	7.43	251	58	36	3586
A+S53T-24-270-84.0C-0100L	35	5	48741	550	8	1	30	0.139	154	80	10848	8.70	293	59	36	4021
A+S53T-24-270-104.0C-0100L	38	5	46994	531	10	1	30	0.119	149	81	13558	10.77	293	59	40	4676
A+S53T-24-270-104.0C-0100L	40	5	46993	531	10	1	30	0.119	149	81	13558	10.77	293	59	40	4668

**Ratings based on +35°F/85% rh air on temp, +25°F evaporating temp, 4 FPI fin spacing, 2:1 pumped CO_2 (bottom feed).

Additional models and custom selections available - contact your local Colmac Coil representative.

A+S One Fan Models

Table 44: Frosted Conditions*

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Air Throw (FT)	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+S13T-20-38-43.0C-0050L	2	6892	663	4	0.5	30	0.217	74	109	489	0.61	59	48	28	413
A+S13T-20-54-43.0C-0075L	3	8969	608	4	0.75	30	0.233	73	142	695	0.81	75	48	28	519
A+S13T-20-54-63.0C-0100L	4	9438	639	6	1	30	0.227	73	149	1041	1.18	75	49	32	625
A+S13T-20-54-83.0C-0100L	5	9041	612	8	1	30	0.191	73	143	1388	1.55	75	49	36	741

*Ratings based on -10°F/85% rh air on temp, -20°F evaporating temp, 3 FPI fin spacing, 2:1 pumped CO_2 (bottom feed).

Table 45: Wet Conditions**

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Air Throw (FT)	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+S13T-20-38-44.0C-0033L	2	4564	439	4	0.333	30	0.080	73	72	637	0.59	59	48	28	447
A+S13T-24-38-44.0C-0050L	3	7301	586	4	0.5	30	0.146	73	115	764	0.71	59	56	28	465
A+S13T-24-54-44.0C-0050L	4	7969	450	4	0.5	30	0.114	74	126	1086	0.95	75	56	28	592
A+S13T-20-54-64.0C-0075L	5	8795	596	6	0.75	30	0.134	73	139	1357	1.19	75	49	32	678
A+S13T-24-54-64.0C-0100L	6	10111	571	6	1	30	0.158	73	160	1628	1.43	75	56	32	748
A+S13T-24-54-84.0C-0100L	7	9748	550	8	1	30	0.135	73	154	2170	1.93	76	57	36	902

**Ratings based on +35°F/85% rh air on temp, +25°F evaporating temp, 4 FPI fin spacing, 2:1 pumped CO_2 (bottom feed).

A+S Two Fan Models

Table 46: Frosted Conditions*

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Air Throw (FT)	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+S23T-20-76-43.0C-0050L	4	13783	663	4	0.5	30	0.215	77	109	978	1.09	97	49	28	735
A+S23T-24-76-43.0C-0075L	5	17416	699	4	0.75	30	0.260	77	138	1173	1.32	97	56	28	805
A+S23T-20-108-43.0C-0075L	6	17939	608	4	0.75	30	0.233	77	142	1389	1.51	129	49	28	959
A+S23T-24-76-63.0C-0100L	7	18047	724	6	1	30	0.254	76	143	1759	2.00	98	57	32	973
A+S23T-20-76-83.0C-0100L	8	16156	778	8	1	30	0.242	78	128	1953	2.17	98	49	36	1046
A+S23T-20-108-83.0C-0100L	9	18082	612	8	1	30	0.199	76	143	2776	2.99	130	49	36	1380
A+S23T-20-108-83.0C-0100L	10	18082	612	8	1	30	0.199	76	143	2776	2.99	130	49	36	1359

*Ratings based on -10°F/85% rh air on temp, -20°F evaporating temp, 3 FPI fin spacing, 2:1 pumped CO_2 (bottom feed).

Table 47: Wet Conditions**

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Air Throw (FT)	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+S23T-12-48-44.0C-0033L	2	4709	598	4	0.333	16	0.180	67	70	483	0.43	69	33	28	468
A+S23T-12-64-64.0C-0033L	3	5516	525	6	0.333	16	0.174	65	82	965	0.81	85	33	32	641
A+S23T-12-64-84.0C-0033L	4	5318	507	8	0.333	16	0.136	66	79	1286	1.06	85	33	36	730
A+S23T-16-96-44.0C-0033L	5	10080	480	4	0.333	24	0.127	68	100	1287	1.08	117	41	28	828
A+S23T-24-76-44.0C-0050L	6	14602	586	4	0.5	30	0.146	76	115	1528	1.32	97	56	28	852
A+S23T-20-108-44.0C-0075L	7	17578	595	4	0.75	30	0.160	77	139	1810	1.56	130	49	28	1024
A+S23T-24-108-44.0C-0050L	8	15939	450	4	0.5	30	0.115	77	126	2172	1.88	130	57	28	1120
A+S23T-24-108-44.0C-0100L	9	21204	598	4	1	30	0.212	75	168	2172	1.88	130	57	28	1125
A+S23T-20-108-64.0C-0075L	10	17591	596	6	0.75	30	0.141	76	139	2713	2.28	130	49	32	1256
A+S23T-24-108-64.0C-0100L	12	20223	571	6	1	30	0.157	76	160	3256	2.74	130	57	32	1400
A+S23T-24-108-104.0C-0100L	15	18798	531	10	1	30	0.126	77	149	5423	4.43	130	57	40	1966

**Ratings based on +35°F/85% rh air on temp, +25°F evaporating temp, 4 FPI fin spacing, 2:1 pumped CO_2 (bottom feed).

Additional models and custom selections available - contact your local Colmac Coil representative.

A+ Series™ CO_2 Air Cooler Selection Tables

A+S Three Fan Models

Table 48: Frosted Conditions*

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Air Throw (FT)	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+S33T-20-114-43.0C-0050L	6	20675	663	4	0.5	30	0.207	79	109	1467	1.64	136	49	28	1077
A+S33T-20-114-43.0C-0075L	7	24699	793	4	0.75	30	0.284	79	130	1467	1.64	136	49	28	1072
A+S33T-24-114-43.0C-0075L	8	26125	699	4	0.75	30	0.263	78	138	1760	1.97	136	57	28	1173
A+S33T-20-114-63.0C-0075L	9	23413	751	6	0.75	30	0.236	78	123	2198	2.38	136	49	32	1300
A+S33T-24-114-63.0C-0075L	10	24772	662	6	0.75	30	0.199	78	130	2638	2.87	136	57	32	1449
A+S33T-20-162-63.0C-0100L	12	28314	639	6	1	30	0.226	78	149	3124	3.32	184	49	32	1718
A+S33T-20-162-83.0C-0100L	15	27123	612	8	1	30	0.196	77	143	4164	4.42	184	50	36	2062

*Ratings based on -10°F/85% rh air on temp, -20°F evaporating temp, 3 FPI fin spacing, 2:1 pumped CO_2 (bottom feed).

Table 49: Wet Conditions**

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Air Throw (FT)	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+S33T-16-96-64.0C-0033L	7	12386	590	6	0.333	24	0.118	71	82	1929	1.63	118	41	32	1076
A+S33T-20-114-44.0C-0033L	8	17167	551	4	0.333	30	0.113	79	90	1911	1.64	136	49	28	1138
A+S33T-24-114-44.0C-0050L	9	21903	586	4	0.5	30	0.145	78	115	2293	1.98	136	57	28	1248
A+S33T-20-162-44.0C-0050L	10	23405	528	4	0.5	30	0.128	79	123	2715	2.27	184	49	28	1491
A+S33T-24-162-44.0C-0050L	12	23908	450	4	0.5	30	0.117	79	126	3258	2.73	184	57	28	1642
A+S33T-20-162-64.0C-0075L	15	26386	596	6	0.75	30	0.137	78	139	4070	3.32	184	49	32	1833
A+S33T-24-162-64.0C-0100L	18	30334	571	6	1	30	0.157	78	160	4884	3.99	184	57	32	2075
A+S33T-24-162-84.0C-0075L	20	26487	498	8	0.75	30	0.104	78	140	6509	5.35	184	58	36	2488
A+S33T-20-162-104.0C-0100L	22	26520	599	10	1	30	0.127	79	140	6779	5.51	184	50	40	2572

**Ratings based on +35°F/85% rh air on temp, +25°F evaporating temp, 4 FPI fin spacing, 2:1 pumped CO_2 (bottom feed).

A+S Four Fan Models

Table 50: Frosted Conditions*

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Air Throw (FT)	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+S43T-20-152-43.0C-0050L	8	27566	663	4	0.5	30	0.214	80	109	1955	2.12	174	49	28	1403
A+S43T-20-152-43.0C-0075L	9	32932	793	4	0.75	30	0.296	80	130	1955	2.13	174	49	28	1411
A+S43T-24-152-43.0C-0075L	10	34833	699	4	0.75	30	0.260	80	138	2347	2.56	174	57	28	1557
A+S43T-20-152-63.0C-0075L	12	31217	751	6	0.75	30	0.228	80	123	2931	3.11	174	49	32	1737
A+S43T-24-152-63.0C-0100L	15	36094	724	6	1	30	0.254	79	143	3517	3.79	174	57	32	1918
A+S43T-20-152-103.0C-0100L	18	30385	731	10	1	30	0.213	81	120	4883	5.12	174	50	40	2325
A+S43T-20-216-83.0C-0100L	20	36164	612	8	1	30	0.198	79	143	5552	5.82	238	50	36	2702

*Ratings based on -10°F/85% rh air on temp, -20°F evaporating temp, 3 FPI fin spacing, 2:1 pumped CO_2 (bottom feed).

Table 51: Wet Conditions**

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Air Throw (FT)	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+S43T-20-152-44.0C-0033L	10	22890	551	4	0.333	30	0.112	80	90	2547	2.13	174	49	28	1480
A+S43T-24-152-44.0C-0050L	12	29205	586	4	0.5	30	0.145	79	115	3057	2.56	174	57	28	1665
A+S43T-20-216-44.0C-0075L	15	35155	595	4	0.75	30	0.162	80	139	3620	2.95	238	50	28	1957
A+S43T-24-216-44.0C-0100L	18	42407	598	4	1	30	0.212	78	168	4344	3.54	238	58	28	2189
A+S43T-20-216-64.0C-0075L	20	35182	596	6	0.75	30	0.141	79	139	5426	4.43	238	50	32	2460
A+S43T-24-216-64.0C-0075L	22	36508	515	6	0.75	30	0.122	79	144	6511	5.31	238	58	32	2728
A+S43T-24-216-84.0C-0075L	25	35316	498	8	0.75	30	0.102	79	140	8679	6.98	238	58	36	3252
A+S43T-24-216-84.0C-0100L	28	38993	550	8	1	30	0.134	79	154	8679	6.98	238	58	36	3253
A+S43T-24-216-104.0C-0100L	30	37596	531	10	1	30	0.126	80	149	10846	8.74	239	58	40	3786

**Ratings based on +35°F/85% rh air on temp, +25°F evaporating temp, 4 FPI fin spacing, 2:1 pumped CO_2 (bottom feed).

Additional models and custom selections available - contact your local Colmac Coil representative.

A+S Five Fan Models

Table 52: Frosted Conditions*

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Air Throw (FT)	Surface Area (FT^2)	Internal Volume (FT^3)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+S53T-20-190-43.0C-0050L	10	34458	663	4	0.5	30	0.214	81	109	2444	2.62	212	50	28	1773
A+S53T-24-190-43.0C-0075L	12	43541	699	4	0.75	30	0.268	81	138	2933	3.15	212	57	28	1948
A+S53T-20-270-43.0C-0075L	15	44846	608	4	0.75	30	0.236	80	142	3473	3.68	292	50	28	2347
A+S53T-24-190-63.0C-0100L	18	45117	724	6	1	30	0.266	80	143	4397	4.68	212	58	32	2375
A+S53T-20-190-83.0C-0100L	20	40390	778	8	1	30	0.242	82	128	4884	5.16	212	50	36	2521
A+S53T-24-190-83.0C-0075L	22	39299	630	8	0.75	30	0.169	81	124	5860	6.19	212	58	36	2791
A+S53T-20-270-83.0C-0100L	25	45205	612	8	1	30	0.191	80	143	6940	7.25	293	51	36	3336

*Ratings based on -10°F/85% rh air on temp, -20°F evaporating temp, 3 FPI fin spacing, 2:1 pumped CO_2 (bottom feed).

Table 53: Wet Conditions**

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Air Throw (FT)	Surface Area (FT^2)	Internal Volume (FT^3)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+S53T-24-190-44.0C-0050L	15	36506	586	4	0.5	30	0.142	80	115	3821	3.15	212	57	28	2052
A+S53T-20-270-44.0C-0075L	18	43944	595	4	0.75	30	0.159	81	139	4525	3.72	292	50	28	2480
A+S53T-24-270-44.0C-0075L	20	47249	533	4	0.75	30	0.166	80	149	5430	4.46	292	58	28	2719
A+S53T-24-270-44.0C-0100L	22	53009	598	4	1	30	0.210	79	168	5430	4.46	292	58	28	2718
A+S53T-20-270-64.0C-0075L	25	43977	596	6	0.75	30	0.133	80	139	6783	5.45	292	50	32	3038
A+S53T-24-270-64.0C-0075L	28	45635	515	6	0.75	30	0.125	80	144	8139	6.53	292	58	32	3368
A+S53T-20-270-84.0C-0075L	30	42142	571	8	0.75	30	0.118	80	133	9040	7.25	293	51	36	3604
A+S53T-24-270-84.0C-0075L	32	44145	498	8	0.75	30	0.105	80	140	10848	8.70	293	59	36	4027
A+S53T-24-270-84.0C-0100L	35	48741	550	8	1	30	0.139	80	154	10848	8.70	293	59	36	4021
A+S53T-24-270-104.0C-0100L	38	46994	531	10	1	30	0.119	81	149	13558	10.77	293	59	40	4676
A+S53T-24-270-104.0C-0100L	40	46993	531	10	1	30	0.119	81	149	13558	10.77	293	59	40	4668

**Ratings based on +35°F/85% rh air on temp, +25°F evaporating temp, 4 FPI fin spacing, 2:1 pumped CO_2 (bottom feed).

Additional models and custom selections available - contact your local Colmac Coil representative.

A+S Six Fan Models

Table 54: Frosted Conditions*

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Air Throw (FT)	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+S63T-24-228-43.0C-0075L	15	52249	699	4	0.75	30	0.263	81	138	3520	3.78	250	58	28	2327
A+S63T-20-228-63.0C-0050L	18	39063	627	6	0.5	30	0.161	83	103	4397	4.61	250	50	32	2569
A+S63T-20-228-63.0C-0100L	20	49698	797	6	1	30	0.257	81	131	4397	4.65	250	50	32	2571
A+S63T-24-228-63.0C-0100L	22	54140	724	6	1	30	0.254	81	143	5276	5.58	250	58	32	2825
A+S63T-24-228-83.0C-0075L	25	47159	630	8	0.75	30	0.176	81	124	7032	7.43	251	58	36	3318
A+S63T-20-228-103.0C-0100L	28	45577	731	10	1	30	0.209	83	120	7324	7.65	251	50	40	3426
A+S63T-24-228-103.0C-0100L	30	49733	665	10	1	30	0.197	82	131	8789	9.19	251	58	40	3816

*Ratings based on -10°F/85% rh air on temp, -20°F evaporating temp, 3 FPI fin spacing, 2:1 pumped CO_2 (bottom feed).

Table 55: Wet Conditions**

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Air Throw (FT)	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+S63T-16-192-64.0C-0033L	15	24771	590	6	0.333	24	0.118	74	82	3859	3.11	214	42	32	2109
A+S63T-24-228-44.0C-0050L	18	43807	586	4	0.5	30	0.145	81	115	4585	3.72	250	58	28	2446
A+S63T-16-288-64.0C-0050L	20	33991	540	6	0.5	24	0.149	76	112	5788	4.63	310	43	32	2902
A+S63T-20-228-64.0C-0075L	22	37373	600	6	0.75	30	0.174	88	98	5728	4.66	250	50	32	2744
A+S63T-24-228-64.0C-0050L	25	43449	581	6	0.5	30	0.116	83	114	6873	5.58	250	58	32	3019
A+S63T-24-228-84.0C-0050L	28	40090	536	8	0.5	30	0.097	82	106	9161	7.43	251	58	36	3586
A+S63T-24-228-84.0C-0050L	30	40090	536	8	0.5	30	0.097	82	106	9161	7.43	251	58	36	3586
A+S63T-24-228-84.0C-0075L	32	44553	596	8	0.75	30	0.117	81	117	9161	7.43	251	58	36	3586
A+S63T-24-228-104.0C-0075L	35	44458	594	10	0.75	30	0.114	81	117	11449	9.19	251	58	40	4137

**Ratings based on +35°F/85% rh air on temp, +25°F evaporating temp, 4 FPI fin spacing, 2:1 pumped CO_2 (bottom feed).

Additional models and custom selections available - contact your local Colmac Coil representative.

A+R PROCESS ROOM UNITS

Capacity Range: 3 - 25 TR

Featuring:

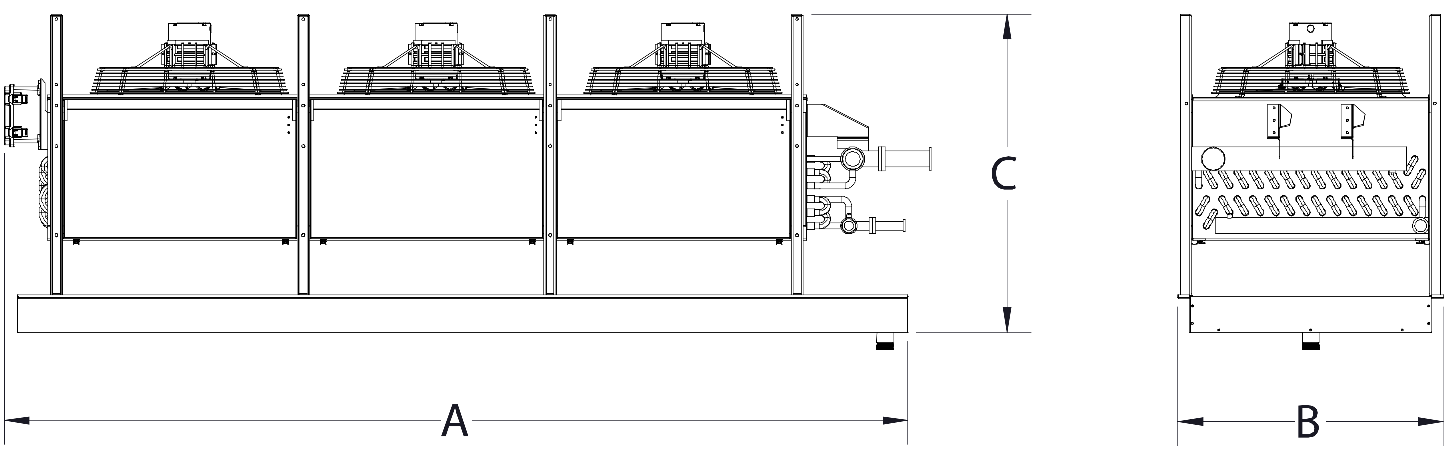
- 1/3 – 1 hp premium efficiency motors
- 16” – 30” diameter airfoil shaped fans
- 4 – 12 row coil
- Hinged side access panels
- Full coverage drainpan

Options:

- Air deflectors
- CIP piping
- Seal welded drainpan
- Reheat coil

A+R Unit Dimensions

Dimensions and weights provided in the tables may change based on the options and features selected. Do not use these for construction, refer to the factory submittal provided at time of order.



(3 fan unit shown)

A+R Lowest Cost ($/TR) Models

Table 56: Frosted Conditions*

Model Number	Capacity (TR)	Fans	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Surface Area (FT^2)	Internal Volume (FT^3)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+R13T-20-54-43.0C-0075L	3	1	8969	608	4	0.75	30	0.233	73	695	0.81	75	37	45	602
A+R13T-20-54-63.0C-0100L	4	1	9438	639	6	1	30	0.227	73	1041	1.18	75	41	45	686
A+R13T-20-54-83.0C-0100L	5	1	9041	612	8	1	30	0.191	73	1388	1.55	75	45	45	799
A+R23T-20-108-43.0C-0075L	6	2	17939	608	4	0.75	30	0.233	77	1389	1.51	129	37	45	1047
A+R23T-20-76-83.0C-0100L	8	2	16156	778	8	1	30	0.242	78	1953	2.17	98	45	45	1116
A+R23T-20-108-83.0C-0100L	10	2	18082	612	8	1	30	0.199	76	2776	2.99	130	45	45	1465
A+R33T-20-162-63.0C-0100L	12	3	28314	639	6	1	30	0.226	78	3124	3.32	184	41	45	1834
A+R43T-20-152-83.0C-0075L	15	4	29352	706	8	0.75	30	0.191	80	3907	4.14	174	45	45	2148
A+R43T-20-152-103.0C-0100L	18	4	30385	731	10	1	30	0.213	81	4883	5.12	174	49	45	2439
A+R53T-20-190-83.0C-0100L	20	5	40390	778	8	1	30	0.242	82	4884	5.16	212	45	45	2668
A+R53T-20-190-103.0C-0100L	22	5	37981	731	10	1	30	0.225	82	6103	6.39	212	49	45	3023
A+R53T-20-270-83.0C-0100L	25	5	45205	612	8	1	30	0.191	80	6940	7.25	293	45	45	3509
A+R63T-20-228-103.0C-0100L	28	6	45577	731	10	1	30	0.209	83	7324	7.65	251	49	45	3605
A+R73T-20-266-103.0C-0075L	30	7	48548	668	10	0.75	30	0.168	82	8544	8.85	289	49	45	4157
A+R73T-20-266-103.0C-0100L	32	7	53174	731	10	1	30	0.210	84	8544	8.85	289	49	45	4157

*Ratings based on -10°F/85% rh air on temp, -20°F evaporating temp, 3 FPI fin spacing, 2:1 pumped CO_2 (bottom feed).

Table 57: Wet Conditions**

Model Number	Capacity (TR)	Fans	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Surface Area (FT^2)	Internal Volume (FT^3)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+R13T-20-54-44.0C-0033L	3	1	6031	409	4	0.333	30	0.095	72	905	0.79	75	37	45	634
A+R13T-16-48-84.0C-0050L	4	1	5453	519	8	0.5	24	0.118	68	1286	1.10	69	45	37	672
A+R13T-20-54-64.0C-0075L	5	1	8795	596	6	0.75	30	0.134	73	1357	1.19	75	41	45	739
A+R13T-20-54-84.0C-0075L	6	1	8428	571	8	0.75	30	0.119	73	1808	1.56	75	45	45	864
A+R33T-20-114-44.0C-0033L	8	3	17167	551	4	0.333	30	0.113	79	1911	1.64	136	37	45	1248
A+R23T-20-108-64.0C-0075L	10	2	17591	596	6	0.75	30	0.141	76	2713	2.28	130	41	45	1350
A+R23T-20-108-84.0C-0075L	12	2	16857	571	8	0.75	30	0.119	76	3616	2.99	130	45	45	1576
A+R33T-20-162-64.0C-0075L	15	3	26386	596	6	0.75	30	0.137	78	4070	3.32	184	41	45	1955
A+R43T-20-152-84.0C-0050L	18	4	24427	588	8	0.5	30	0.099	82	5089	4.09	174	45	45	2302
A+R43T-20-216-64.0C-0075L	20	4	35182	596	6	0.75	30	0.141	79	5426	4.43	238	41	45	2608
A+R33T-20-162-104.0C-0100L	22	3	26520	599	10	1	30	0.127	79	6779	5.51	184	49	45	2687
A+R53T-20-270-64.0C-0075L	25	5	43977	596	6	0.75	30	0.133	80	6783	5.45	292	41	45	3213
A+R43T-20-216-104.0C-0100L	28	4	35360	599	10	1	30	0.132	81	9038	7.21	238	49	45	3504
A+R53T-20-270-84.0C-0075L	30	5	42142	571	8	0.75	30	0.118	80	9040	7.25	293	45	45	3776
A+R53T-20-270-104.0C-0075L	32	5	40480	548	10	0.75	30	0.102	80	11298	8.98	293	49	45	4331
A+R53T-20-270-104.0C-0075L	35	5	40479	548	10	0.75	30	0.102	80	11298	8.98	293	49	45	4331

**Ratings based on +35°F/85% rh air on temp, +25°F evaporating temp, 4 FPI fin spacing, 2:1 pumped CO_2 (bottom feed).

Additional models and custom selections available - contact your local Colmac Coil representative.

A+R One Fan Models

Table 58: Frosted Conditions*

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+R13T-20-54-43.0C-0075L	3	8969	608	4	0.75	30	0.233	73	695	0.81	75	37	45	602
A+R13T-20-54-63.0C-0100L	4	9438	639	6	1	30	0.227	73	1041	1.18	75	41	45	686
A+R13T-20-54-83.0C-0100L	5	9041	612	8	1	30	0.191	73	1388	1.55	75	45	45	799

*Ratings based on -10°F/85% rh air on temp, -20°F evaporating temp, 3 FPI fin spacing, 2:1 pumped CO_2 (bottom feed).

Table 59: Wet Conditions**

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+R13T-20-54-44.0C-0033L	3	6031	409	4	0.333	30	0.095	72	905	0.79	75	37	45	634
A+R13T-16-48-84.0C-0050L	4	5453	519	8	0.5	24	0.118	68	1286	1.10	69	45	37	672
A+R13T-20-54-64.0C-0075L	5	8795	596	6	0.75	30	0.134	73	1357	1.19	75	41	45	739
A+R13T-20-54-84.0C-0075L	6	8428	571	8	0.75	30	0.119	73	1808	1.56	75	45	45	864

**Ratings based on +35°F/85% rh air on temp, +25°F evaporating temp, 4 FPI fin spacing, 2:1 pumped CO_2 (bottom feed).

A+R Two Fan Models

Table 60: Frosted Conditions*

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+R23T-20-76-43.0C-0050L	4	13783	663	4	0.5	30	0.215	77	978	1.09	97	37	45	816
A+R23T-20-76-63.0C-0050L	5	13021	627	6	0.5	30	0.164	78	1466	1.61	97	41	45	967
A+R23T-20-108-43.0C-0075L	6	17939	608	4	0.75	30	0.233	77	1389	1.51	129	37	45	1047
A+R23T-20-76-83.0C-0100L	8	16156	778	8	1	30	0.242	78	1953	2.17	98	45	45	1116
A+R23T-20-108-83.0C-0100L	10	18082	612	8	1	30	0.199	76	2776	2.99	130	45	45	1465

*Ratings based on -10°F/85% rh air on temp, -20°F evaporating temp, 3 FPI fin spacing, 2:1 pumped CO_2 (bottom feed).

Table 61: Wet Conditions**

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+R23T-12-64-64.0C-0033L	3	5516	525	6	0.333	16	0.174	65	965	0.81	85	41	29	702
A+R23T-12-64-84.0C-0033L	4	5318	507	8	0.333	16	0.136	66	1286	1.06	85	45	29	776
A+R23T-16-96-44.0C-0033L	5	10080	480	4	0.333	24	0.127	68	1287	1.08	117	37	37	886
A+R23T-20-108-44.0C-0033L	6	12061	409	4	0.333	30	0.094	75	1810	1.51	129	37	45	1111
A+R23T-16-96-84.0C-0050L	8	10906	519	8	0.5	24	0.118	71	2571	2.14	118	45	37	1240
A+R23T-20-108-64.0C-0075L	10	17591	596	6	0.75	30	0.141	76	2713	2.28	130	41	45	1350
A+R23T-20-108-84.0C-0075L	12	16857	571	8	0.75	30	0.119	76	3616	2.99	130	45	45	1576

**Ratings based on +35°F/85% rh air on temp, +25°F evaporating temp, 4 FPI fin spacing, 2:1 pumped CO_2 (bottom feed).

Additional models and custom selections available - contact your local Colmac Coil representative.

A+ Series™ CO_2 Air Cooler Selection Tables

A+R Three Fan Models

Table 62: Frosted Conditions*

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+R33T-20-114-43.0C-0050L	6	20675	663	4	0.5	30	0.207	79	1467	1.64	136	37	45	1178
A+R33T-20-114-63.0C-0050L	8	19532	627	6	0.5	30	0.168	80	2198	2.38	136	41	45	1392
A+R33T-20-114-83.0C-0075L	10	22013	706	8	0.75	30	0.200	78	2930	3.14	136	45	45	1655
A+R33T-20-162-63.0C-0100L	12	28314	639	6	1	30	0.226	78	3124	3.32	184	41	45	1834
A+R33T-20-162-83.0C-0100L	15	27123	612	8	1	30	0.196	77	4164	4.42	184	45	45	2167

*Ratings based on -10°F/85% rh air on temp, -20°F evaporating temp, 3 FPI fin spacing, 2:1 pumped CO_2 (bottom feed).

Table 63: Wet Conditions**

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+R33T-12-72-44.0C-0033L	3	7063	598	4	0.333	16	0.182	68	724	0.61	93	37	29	711
A+R33T-12-96-44.0C-0033L	4	8595	546	4	0.333	16	0.212	67	965	0.79	117	37	29	823
A+R33T-12-96-64.0C-0033L	5	8274	525	6	0.333	16	0.162	67	1447	1.19	117	41	29	966
A+R33T-12-96-84.0C-0050L	6	8152	518	8	0.5	16	0.171	67	1929	1.57	117	45	29	1115
A+R33T-20-114-44.0C-0033L	8	17167	551	4	0.333	30	0.113	79	1911	1.64	136	37	45	1248
A+R33T-16-144-64.0C-0050L	10	16996	540	6	0.5	24	0.149	73	2894	2.37	166	41	37	1542
A+R33T-16-144-84.0C-0050L	12	16358	519	8	0.5	24	0.125	73	3857	3.11	166	45	37	1791
A+R33T-20-162-64.0C-0075L	15	26386	596	6	0.75	30	0.137	78	4070	3.32	184	41	45	1955
A+R33T-20-162-84.0C-0075L	18	25285	571	8	0.75	30	0.113	78	5424	4.37	184	45	45	2334
A+R33T-20-162-104.0C-0075L	20	24288	548	10	0.75	30	0.102	78	6779	5.51	184	49	45	2687
A+R33T-20-162-104.0C-0100L	22	26520	599	10	1	30	0.127	79	6779	5.51	184	49	45	2687

**Ratings based on +35°F/85% rh air on temp, +25°F evaporating temp, 4 FPI fin spacing, 2:1 pumped CO_2 (bottom feed).

A+R Four Fan Models

Table 64: Frosted Conditions*

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+R43T-20-152-43.0C-0050L	8	27566	663	4	0.5	30	0.214	80	1955	2.12	174	37	45	1524
A+R43T-20-152-63.0C-0050L	10	26042	627	6	0.5	30	0.171	81	2931	3.11	174	41	45	1854
A+R43T-20-152-63.0C-0075L	12	31217	751	6	0.75	30	0.228	80	2931	3.11	174	41	45	1860
A+R43T-20-152-83.0C-0075L	15	29352	706	8	0.75	30	0.191	80	3907	4.14	174	45	45	2148
A+R43T-20-216-83.0C-0100L	18	36164	612	8	1	30	0.198	79	5552	5.82	238	45	45	2841

*Ratings based on -10°F/85% rh air on temp, -20°F evaporating temp, 3 FPI fin spacing, 2:1 pumped CO_2 (bottom feed).

Table 65: Wet Conditions**

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+R43T-12-128-84.0C-0033L	8	10637	507	8	0.333	16	0.140	69	2571	2.09	150	45	29	1454
A+R43T-20-152-44.0C-0033L	10	22890	551	4	0.333	30	0.112	80	2547	2.13	174	37	45	1610
A+R43T-20-152-64.0C-0033L	12	21716	523	6	0.333	30	0.094	81	3818	3.11	174	41	45	1966
A+R43T-20-216-44.0C-0075L	15	35155	595	4	0.75	30	0.162	80	3620	2.95	238	37	45	2110
A+R43T-20-152-84.0C-0050L	18	24427	588	8	0.5	30	0.099	82	5089	4.09	174	45	45	2302
A+R43T-20-216-64.0C-0075L	20	35182	596	6	0.75	30	0.141	79	5426	4.43	238	41	45	2608
A+R43T-20-216-84.0C-0050L	22	28989	491	8	0.5	30	0.089	81	7232	5.82	238	45	45	3056
A+R43T-20-216-104.0C-0075L	25	32384	548	10	0.75	30	0.106	79	9038	7.21	238	49	45	3504
A+R43T-20-216-104.0C-0100L	28	35360	599	10	1	30	0.132	81	9038	7.21	238	49	45	3504

**Ratings based on +35°F/85% rh air on temp, +25°F evaporating temp, 4 FPI fin spacing, 2:1 pumped CO_2 (bottom feed).

Additional models and custom selections available - contact your local Colmac Coil representative.

A+R Five Fan Models

Table 66: Frosted Conditions*

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+R53T-20-190-63.0C-0075L	15	39021	751	6	0.75	30	0.221	81	3664	3.90	212	41	45	2299
A+R53T-20-190-83.0C-0075L	18	36690	706	8	0.75	30	0.202	81	4884	5.13	212	45	45	2659
A+R53T-20-190-83.0C-0100L	20	40390	778	8	1	30	0.242	82	4884	5.16	212	45	45	2668
A+R53T-20-190-103.0C-0100L	22	37981	731	10	1	30	0.225	82	6103	6.39	212	49	45	3023
A+R53T-20-270-83.0C-0100L	25	45205	612	8	1	30	0.191	80	6940	7.25	293	45	45	3509

*Ratings based on -10°F/85% rh air on temp, -20°F evaporating temp, 3 FPI fin spacing, 2:1 pumped CO_2 (bottom feed).

Table 67: Wet Conditions**

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+R53T-16-160-64.0C-0033L	12	20643	590	6	0.333	24	0.121	73	3215	2.63	182	41	37	1874
A+R53T-16-160-84.0C-0050L	15	20971	599	8	0.5	24	0.111	73	4286	3.46	182	45	37	2168
A+R53T-20-190-64.0C-0075L	18	31144	600	6	0.75	30	0.179	88	4773	3.85	212	41	45	2449
A+R53T-20-190-84.0C-0033L	20	25862	498	8	0.333	30	0.077	84	6362	5.16	212	45	45	2855
A+R53T-20-190-84.0C-0050L	22	30534	588	8	0.5	30	0.101	83	6362	5.16	212	45	45	2855
A+R53T-20-270-64.0C-0075L	25	43977	596	6	0.75	30	0.133	80	6783	5.45	292	41	45	3213
A+R53T-20-270-84.0C-0075L	28	42142	571	8	0.75	30	0.118	80	9040	7.25	293	45	45	3776
A+R53T-20-270-84.0C-0075L	30	42142	571	8	0.75	30	0.118	80	9040	7.25	293	45	45	3776
A+R53T-20-270-104.0C-0075L	32	40480	548	10	0.75	30	0.102	80	11298	8.98	293	49	45	4331
A+R53T-20-270-104.0C-0075L	35	40479	548	10	0.75	30	0.102	80	11298	8.98	293	49	45	4331

**Ratings based on +35°F/85% rh air on temp, +25°F evaporating temp, 4 FPI fin spacing, 2:1 pumped CO_2 (bottom feed).

Additional models and custom selections available - contact your local Colmac Coil representative.

A+ Series™ CO_2 Air Cooler Selection Tables

A+R Six Fan Models

Table 68: Frosted Conditions*

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+R63T-20-228-63.0C-0050L	18	39063	627	6	0.5	30	0.161	83	4397	4.61	250	41	45	2735
A+R63T-20-228-63.0C-0100L	20	49698	797	6	1	30	0.257	81	4397	4.65	250	41	45	2743
A+R63T-20-228-83.0C-0075L	22	44028	706	8	0.75	30	0.199	81	5860	6.12	250	45	45	3166
A+R63T-20-228-103.0C-0075L	25	41613	668	10	0.75	30	0.167	82	7324	7.65	251	49	45	3597
A+R63T-20-228-103.0C-0100L	28	45577	731	10	1	30	0.209	83	7324	7.65	251	49	45	3605

*Ratings based on -10°F/85% rh air on temp, -20°F evaporating temp, 3 FPI fin spacing, 2:1 pumped CO_2 (bottom feed).

Table 69: Wet Conditions**

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+R63T-16-192-64.0C-0033L	15	24771	590	6	0.333	24	0.118	74	3859	3.11	214	41	37	2231
A+R63T-16-192-84.0C-0050L	18	25165	599	8	0.5	24	0.111	74	5143	4.10	214	45	37	2581
A+R63T-16-288-64.0C-0050L	20	33991	540	6	0.5	24	0.149	76	5788	4.63	310	41	37	3030
A+R63T-20-228-64.0C-0075L	22	37373	600	6	0.75	30	0.174	88	5728	4.66	250	41	45	2921
A+R63T-20-228-84.0C-0050L	25	36641	588	8	0.5	30	0.105	84	7634	6.12	250	45	45	3389
A+R63T-20-228-104.0C-0050L	28	34830	559	10	0.5	30	0.094	85	9541	7.58	250	49	45	3870
A+R63T-16-288-104.0C-0100L	30	37781	600	10	1	24	0.170	79	9641	7.64	311	49	37	4041

**Ratings based on +35°F/85% rh air on temp, +25°F evaporating temp, 4 FPI fin spacing, 2:1 pumped CO_2 (bottom feed).

A+R Seven Fan Models

Table 70: Frosted Conditions*

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+R73T-20-266-63.0C-0075L	22	54630	751	6	0.75	30	0.230	82	5129	5.37	288	41	45	3161
A+R73T-20-266-83.0C-0075L	25	51365	706	8	0.75	30	0.188	82	6837	7.15	289	45	45	3660
A+R73T-20-266-83.0C-0100L	28	56546	778	8	1	30	0.237	83	6837	7.15	289	45	45	3666
A+R73T-20-266-103.0C-0075L	30	48548	668	10	0.75	30	0.168	82	8544	8.85	289	49	45	4157
A+R73T-20-266-103.0C-0100L	32	53174	731	10	1	30	0.210	84	8544	8.85	289	49	45	4157

*Ratings based on -10°F/85% rh air on temp, -20°F evaporating temp, 3 FPI fin spacing, 2:1 pumped CO_2 (bottom feed).

Table 71: Wet Conditions**

Model Number	Capacity (TR)	Air Volume (CFM)	Face Velocity (FPM)	Rows	Motor HP (EA)	Fan Diameter (IN)	Fan kW/TR	Sound @10FT (dB(A))	Surface Area (FT²)	Internal Volume (FT³)	"A" Length (IN)	"B" Depth (IN)	"C" Height (IN)	Unit Weight (LB)
A+R73T-20-266-44.0C-0050L	18	43462	598	4	0.5	30	0.136	83	4458	3.58	288	37	45	2785
A+R73T-16-224-84.0C-0050L	20	29359	599	8	0.5	24	0.112	74	6000	4.82	246	45	37	2997
A+R73T-20-266-64.0C-0033L	22	38003	523	6	0.333	30	0.088	84	6682	5.37	288	41	45	3354
A+R73T-20-266-64.0C-0050L	25	43007	591	6	0.5	30	0.111	81	6682	5.37	288	41	45	3356
A+R73T-20-266-84.0C-0050L	28	42748	588	8	0.5	30	0.103	85	8906	7.15	289	45	45	3919
A+R73T-20-266-84.0C-0050L	30	42748	588	8	0.5	30	0.103	85	8906	7.15	289	45	45	3919
A+R73T-20-266-104.0C-0050L	32	40635	559	10	0.5	30	0.090	85	11131	8.85	289	49	45	4476
A+R73T-20-266-104.0C-0050L	35	40634	559	10	0.5	30	0.090	85	11131	8.85	289	49	45	4476

**Ratings based on +35°F/85% rh air on temp, +25°F evaporating temp, 4 FPI fin spacing, 2:1 pumped CO_2 (bottom feed).

Additional models and custom selections available - contact your local Colmac Coil representative.

Notes:

Additional models and custom selections available - contact your local Colmac Coil representative.

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Manufacturing Inc.

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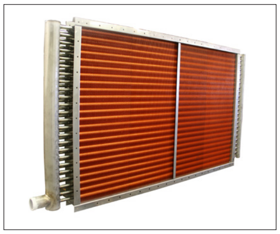
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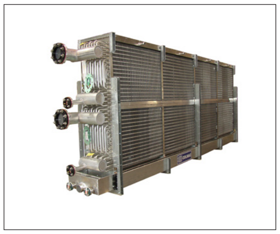
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North American Headquarters
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"The Heat Transfer Experts"

When you want Quality, specify COLMAC!

Installation, Operation, and Maintenance

A+ Series™ Air Coolers

ENG00019601

Contents

1. SAFETY INSTRUCTIONS

To avoid serious personal injury, accidental death, or major property damage, read and follow all safety instructions in the manual and on the equipment. Maintain all safety labels in good condition. If necessary, replace labels using the provided part numbers.

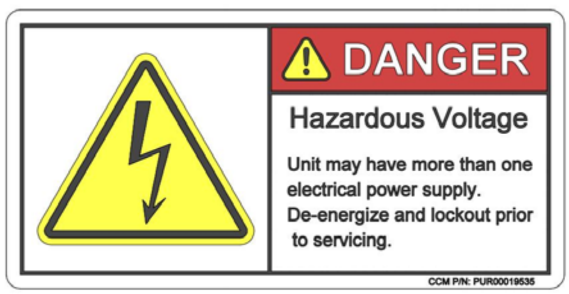
This is the safety alert symbol. It is used to alert you to potential personal injury hazards. Obey all safety messages that follow this symbol to avoid possible injury or death.

DANGER indicates a hazardous situation which, if not avoided, will result in death or serious injury.

WARNING indicates a hazardous situation which, if not avoided, could result in death or serious injury.

CAUTION indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.

NOTICE indicates instructions that pertain to safe equipment operation. Failure to follow these instructions could result in equipment damage.



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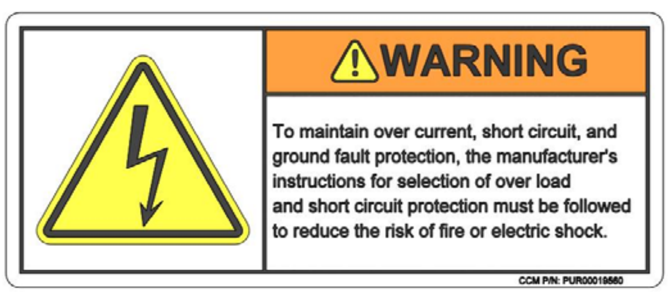

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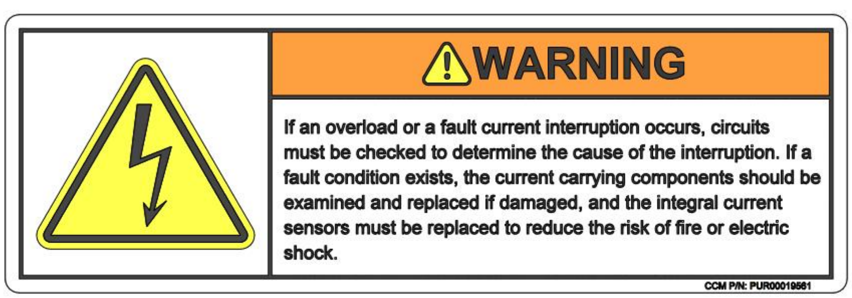

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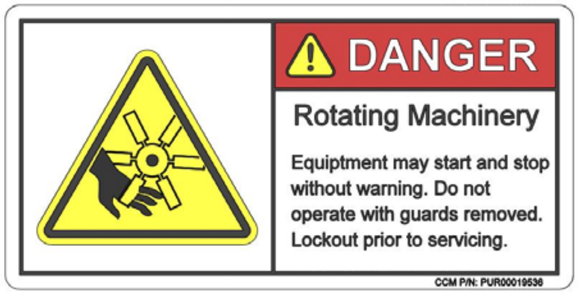

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1.1. **Refrigerant Warning**

1.1.1. A+ Series™ Evaporators may contain liquid refrigerant such as ammonia, R-22, R-507, etc. For this reason, A+ Series™ Evaporators should be installed, operated and serviced by qualified refrigeration technicians only.

1.1.2. Liquid refrigerant causes burns, which may be fatal, if it leaks and comes in contact with a person.

1.1.3. Refrigerant vapor can cause asphyxiation and or tissue burns if released to the atmosphere in the vicinity of people.

1.1.4. Liquid refrigerant that is isolated in a pipe or equipment without an adequate means of pressure relief can rupture pipe or equipment if it is allowed to warm.

1.1.5. Hot refrigerant vapor, when injected into an evaporator containing cold refrigerant, will rapidly condense. This rapid condensation can accelerate liquid slugs to dangerously high energy levels that can rupture pipes, valves and other components.

1.1.6. Please refer to various manuals from organizations such as IIAR, ASHRAE, and RETA for more information concerning the safe operation of refrigeration equipment.

2. INSTALLATION

2.1. **Inspection**

2.1.1. Damage or Shortage – Upon receipt of equipment, inspect for shortages and damage. Any shortage or damage found during initial inspection should be noted on delivery receipt. This action notifies the carrier that you intend to file a claim. Any damaged equipment is the responsibility of the carrier, and should not be returned to Colmac Coil without prior notification. If any shortage or damage is discovered after unpacking the unit, call the deliverer for a concealed damage or shortage inspection. The inspector will need related paperwork, delivery receipt, and any information indicating his liability for the damage.

2.1.2. While Colmac will gladly provide information to assist with the process, the responsibility for filing such a claim is that of the purchaser or the purchaser's consignee.

2.1.3. Specified Equipment – Check unit nameplate for: Electrical specifications to ensure compatibility with electrical power supply. Model Nomenclature and other information to match original order.

2.1.4. Each Colmac A+ Series™ Evaporator coil is shipped with a low-pressure nitrogen charge. Slightly open the Schrader valve located on the coil connection cap to detect the presence of the charge by listening for the nitrogen escaping through the valve. After this brief test, close the valve to maintain the nitrogen charge until the unit is ready to be connected to the system piping.

2.1.5. If the unit has lost its nitrogen charge, it may have been compromised during shipment. Before installation, pressure test the coil with dry nitrogen to ensure there is not a coil leak and report the loss of the shipping charge to Colmac. If the unit will not hold pressure, please obtain the unit's serial number, then contact your Colmac Representative for a resolution.

2.2. **Transporting and Storing**

2.2.1. Colmac A+ Series™ Evaporators are designed to facilitate safe handling with fork trucks or cranes. Use caution when handling to prevent damage to exposed components. The shipping skid should remain affixed to the unit to enable handling and to prevent damage to the pan and other components.

2.2.2. Lifting forks should be placed under appropriate areas of the wooden shipping skid for proper handling. The lifting skid may be used to lift the unit into place for either ceiling-hung or foot-mounted applications.

2.2.3. **NOTICE:** Use shipping container, or use hangers to lift unit into mounting position. Never lift unit by placing forklift in direct contact with drainpan.

2.2.4. **CAUTION:** Where the finned surface of the coil is exposed, extreme care should be taken to avoid contact with the sharp edges of the fins to minimize the chance of injury.

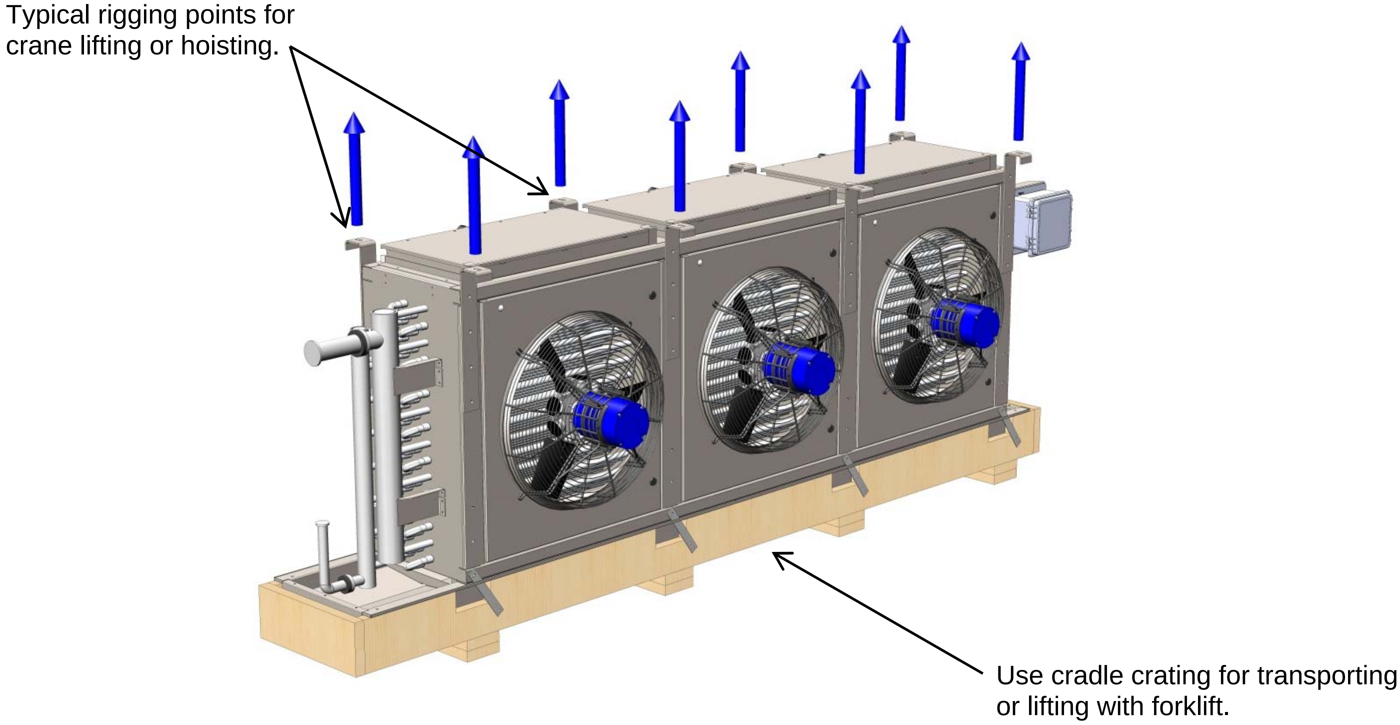
2.2.5. Store unit in a clean, dry area protected from adverse ambient conditions, and away from traffic and congestion that could cause damage.

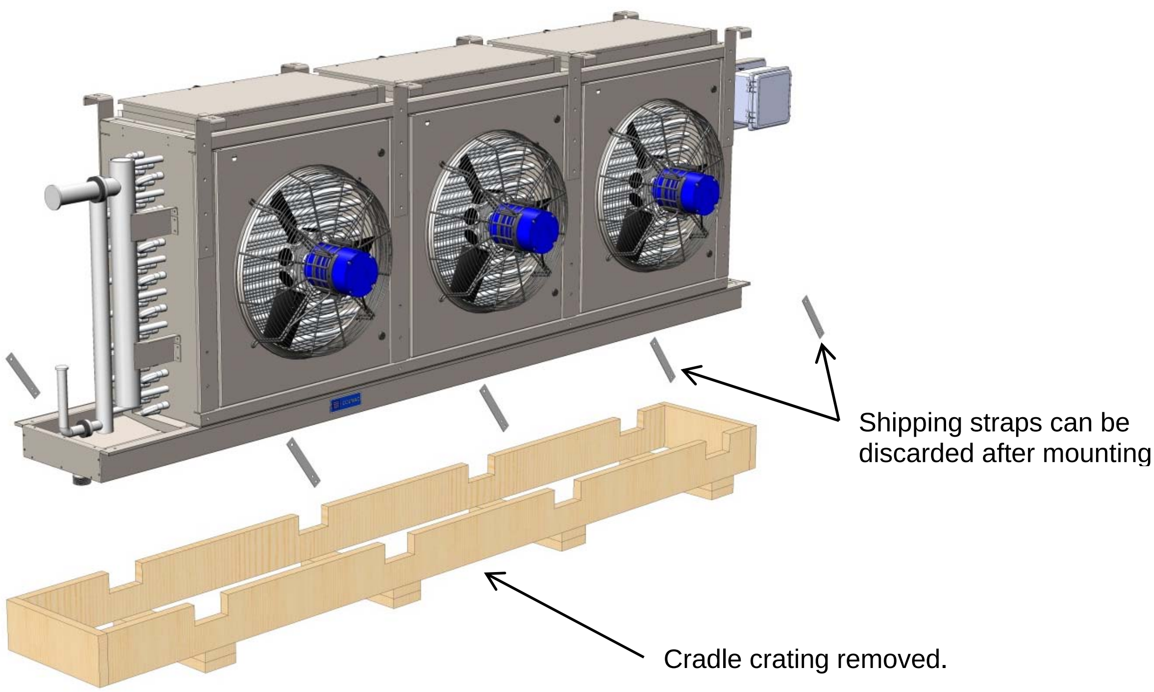
2.2.6. Units stored for long periods of time should have the fan motor shaft turned several revolutions on a monthly basis to prevent the motor bearings from seizing.

2.2.7. Use shipping container and forklift to transport unit from truck to storage area and from storage area to installation area. See Submittal drawing for weight of unit. Center of gravity is for all practical purposes the same as the physical center of the unit.

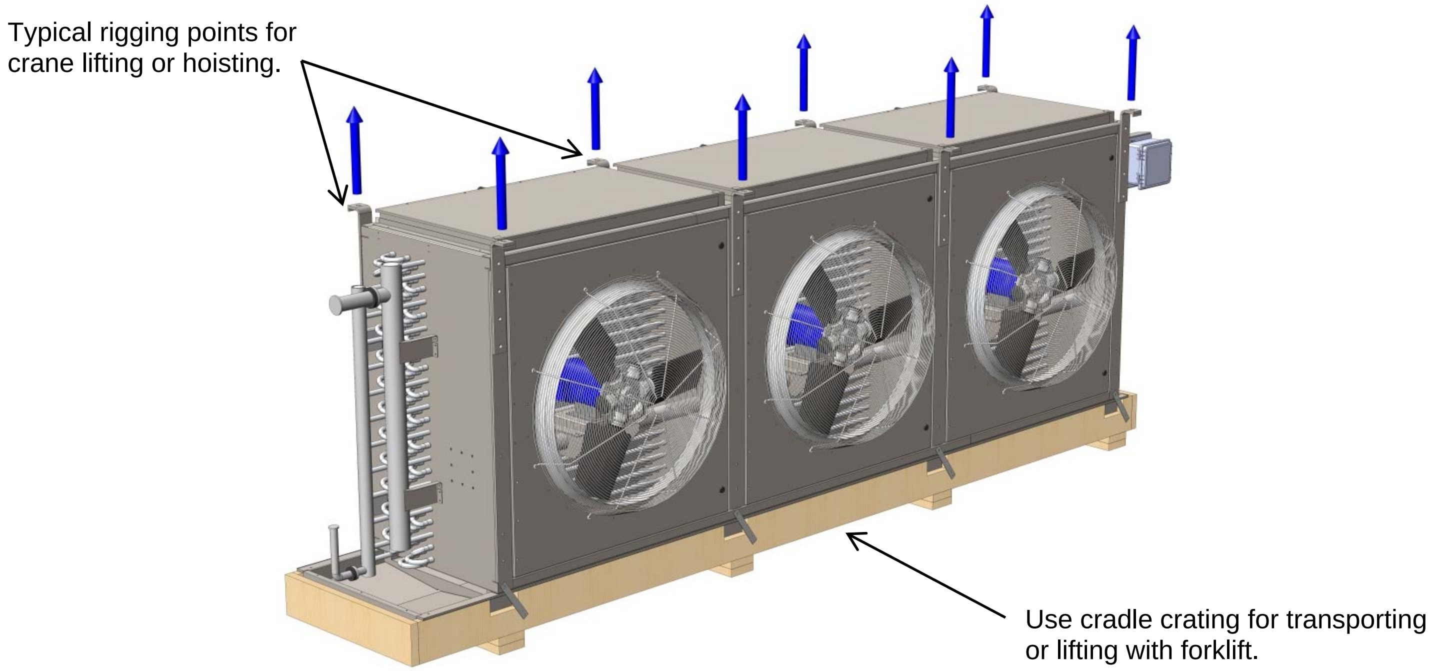
2.2.8. Shipping crating and lifting points for the A+S, A+M, A+L standard, A+L 45°, A+L penthouse and A+R are shown in graphics that follow.

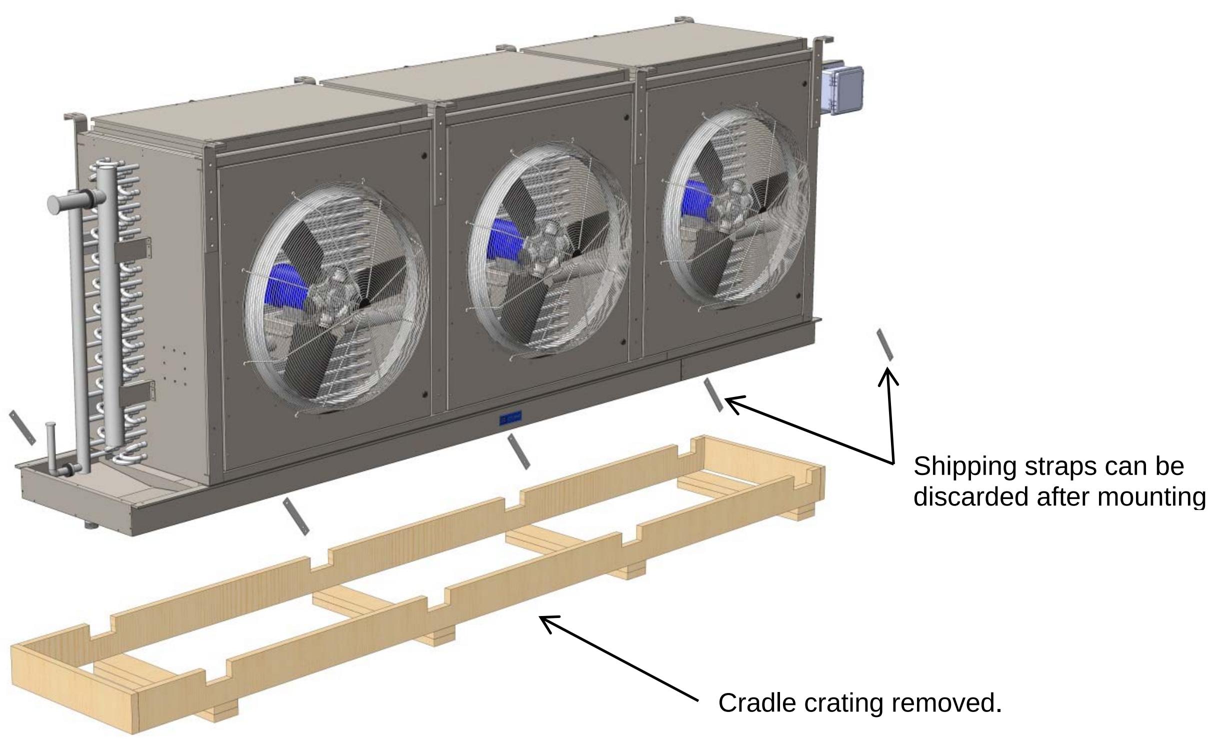
A+S Unit


Typical rigging points for
crane lifting or hoisting.
Use cradle crating for transporting
or lifting with forklift.

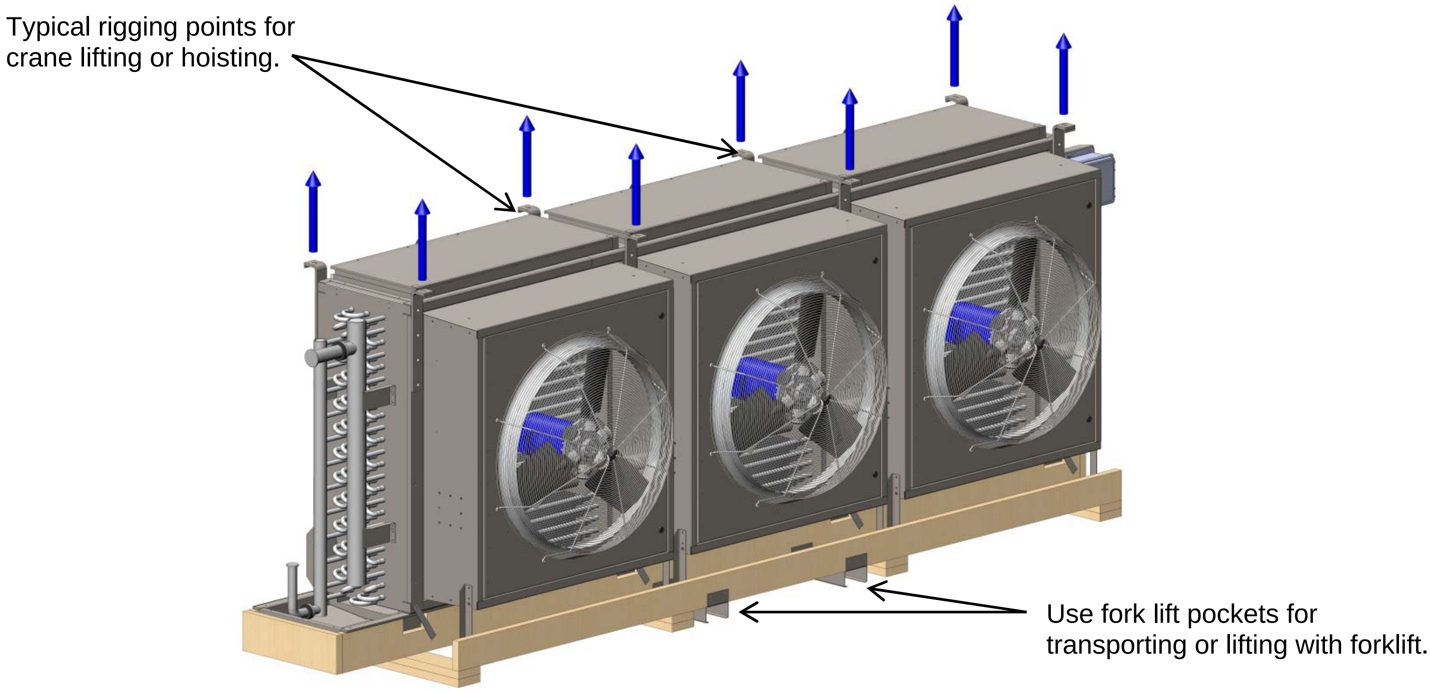

Shipping straps can be
discarded after mounting.
Cradle crating removed.

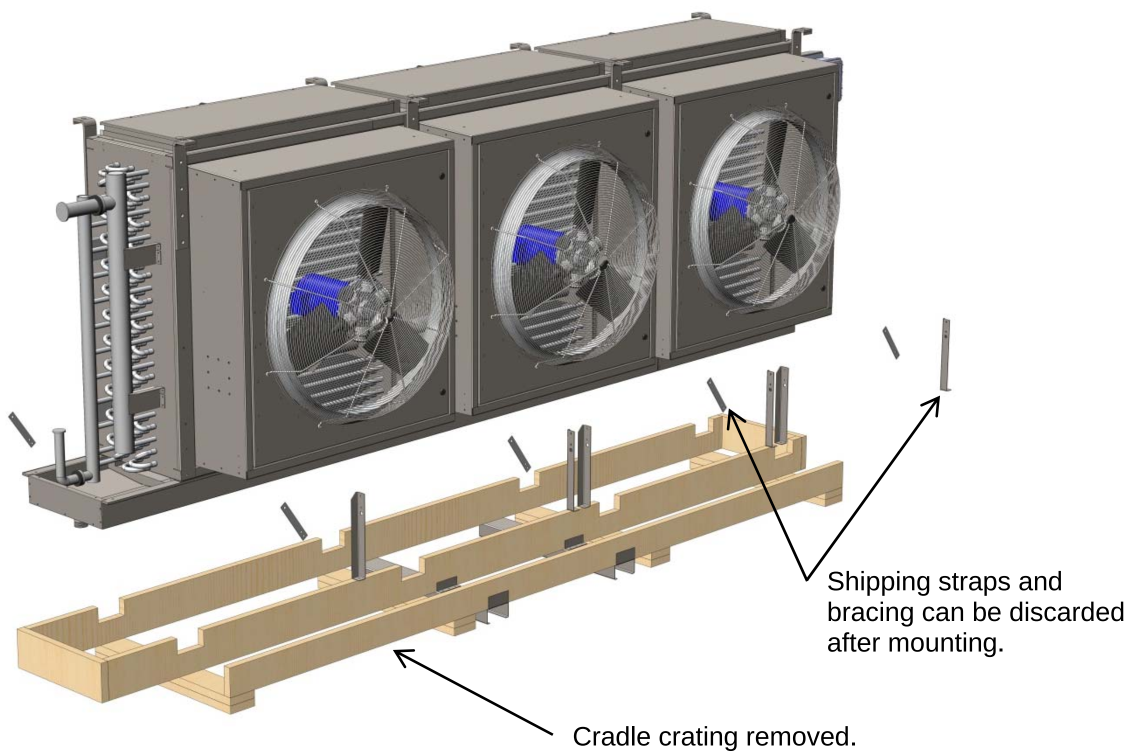
A+M Unit


Typical rigging points for crane lifting or hoisting.
Use cradle crating for transporting or lifting with forklift.

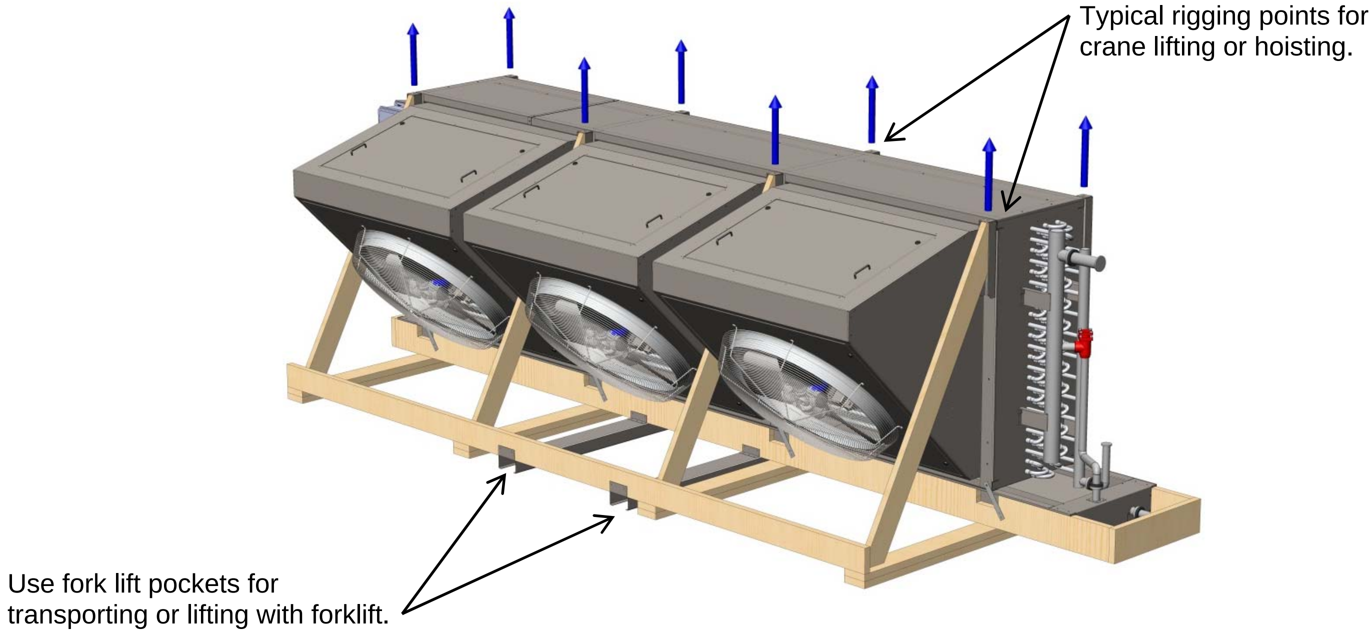

Shipping straps can be discarded after mounting.
Cradle crating removed.

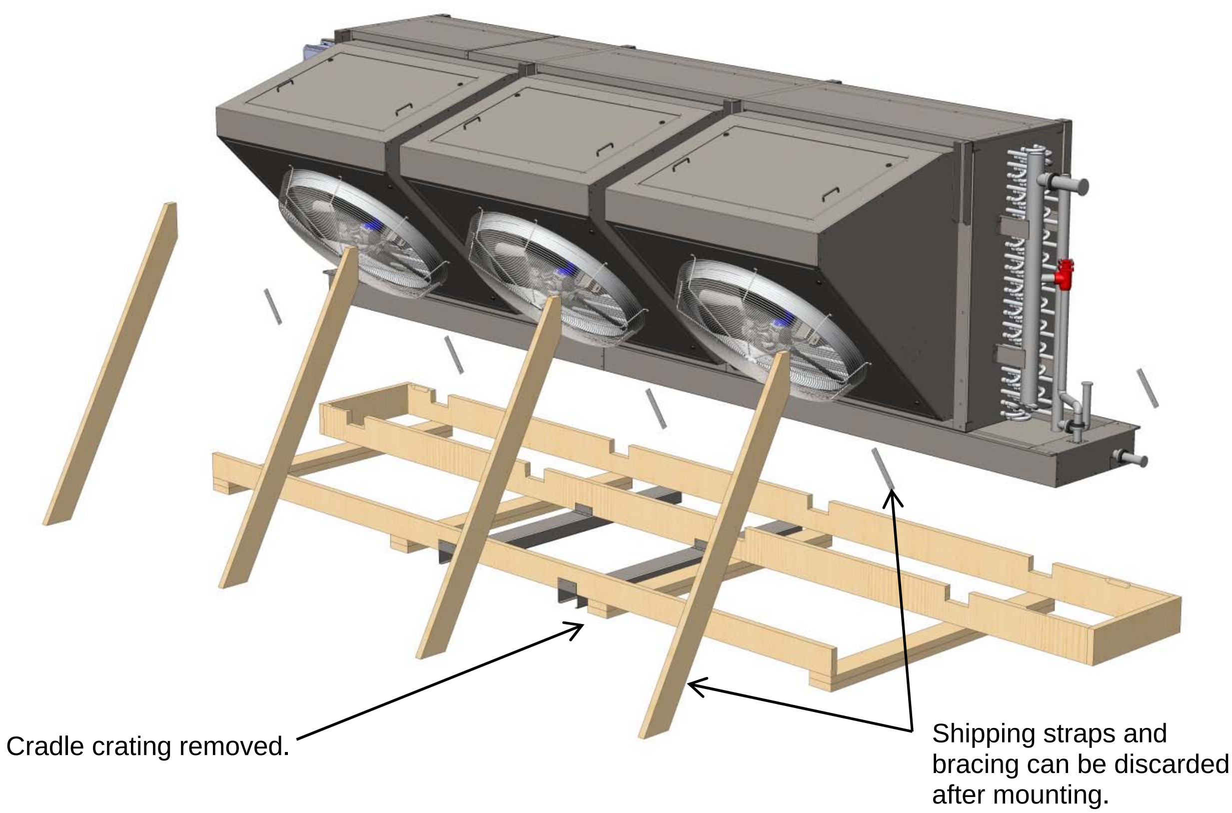
A+L Unit


Typical rigging points for
crane lifting or hoisting.
Use fork lift pockets for
transporting or lifting with forklift.

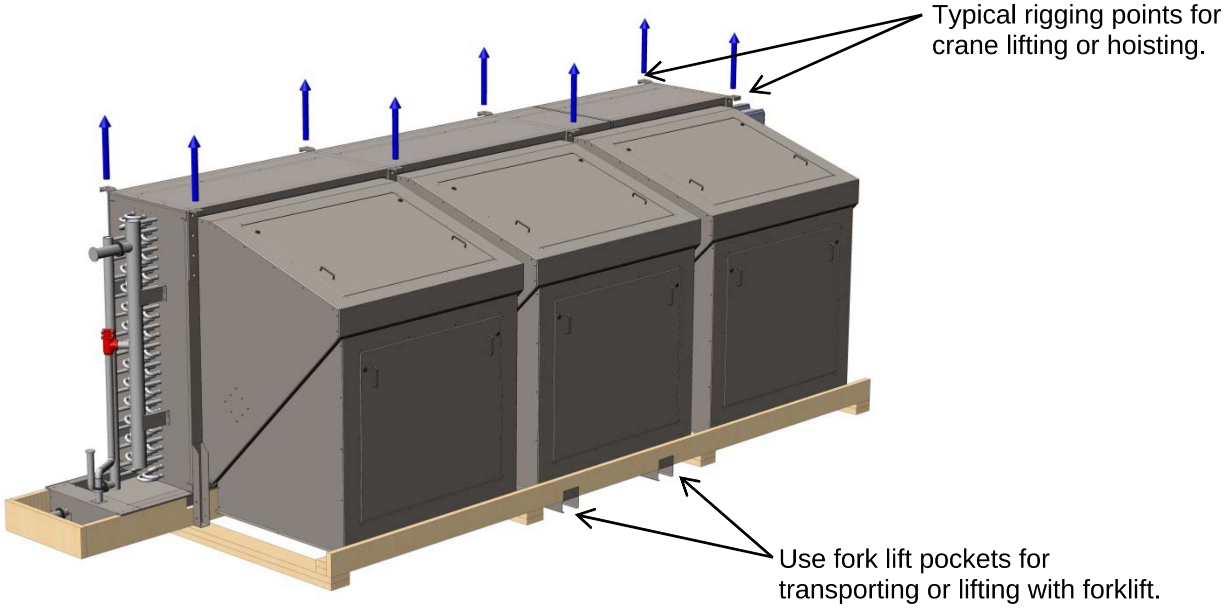

Shipping straps and
bracing can be discarded
after mounting.
Cradle crating removed.

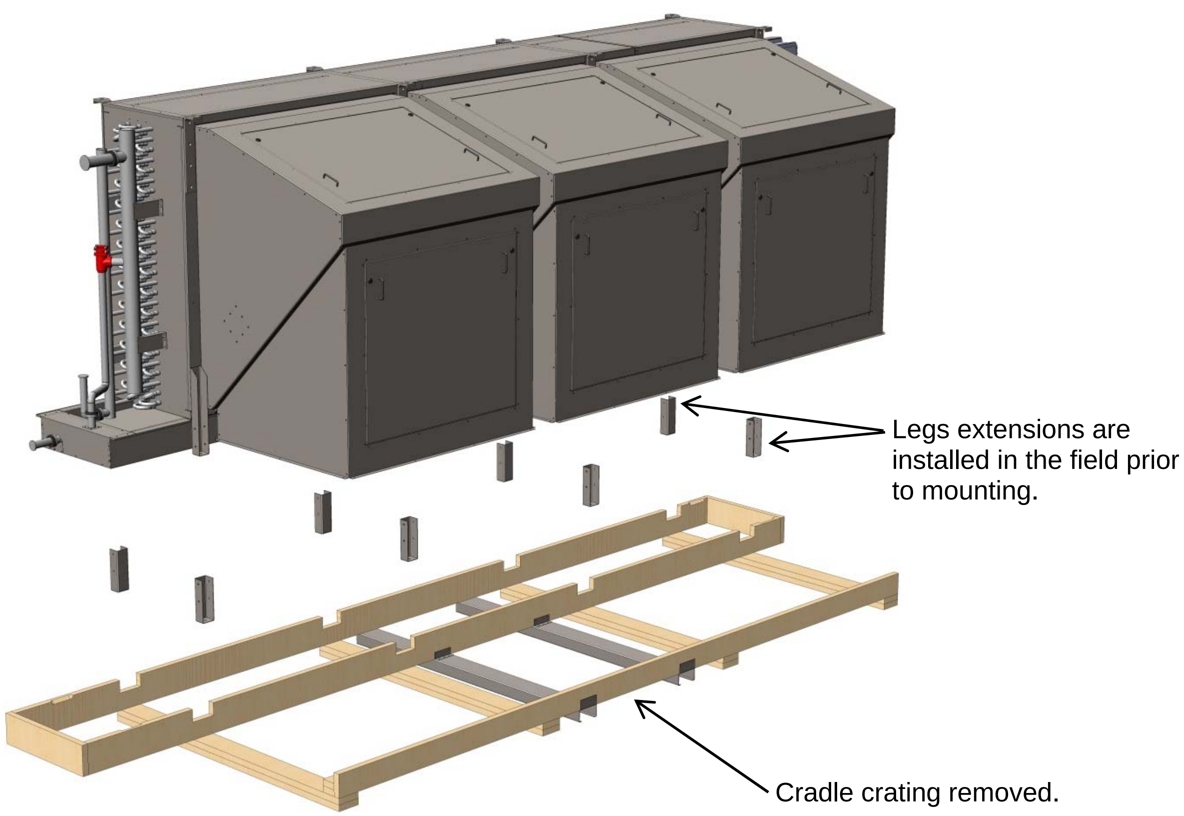
A+L 45° Unit


Typical rigging points for crane lifting or hoisting.
Use fork lift pockets for transporting or lifting with forklift.


Cradle crating removed.
Shipping straps and bracing can be discarded after mounting.

A+L Penthouse Unit





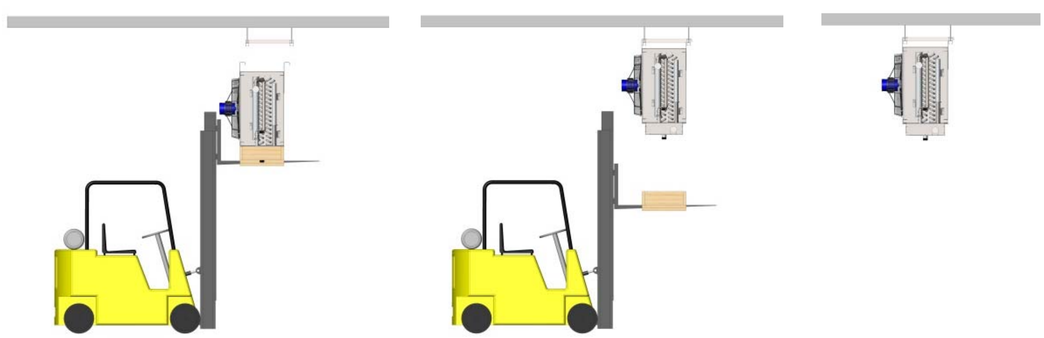
2.3. **Mounting**

2.3.1. Units are designed to be suspended from the ceiling structure. Care must be taken to ensure that the ceiling structure is adequately strong to support the weight of the unit(s). Each unit has hangers to accept two threaded rods at each end of the unit, and two between each fan bay. A rod must be used for each hanger. The installer must ensure that the size of the rod used is adequate to support the unit for any local conditions (seismic, etc.). In some cases, additional hanger bracing may be required.

2.3.2. Hanger rod and hardware selection and size are to be provided by the design engineer using sound engineering practices. For proper support, all hangers must be used.

2.3.3. The unit must be lifted to the secured hanger rods and secured in place such that the top of the unit is level and each hanger provides equal support. Securely tightened double nuts with washers, or equivalent, must be used above and below the hanger hole to minimize the chances of loosening due to vibration.

2.3.4. Units can be provided with the Colmac Smart Hanger system which reduces installation time. Smart Hanger brackets and rails allow air cooler units to be hung from the ceiling without any personnel leaving the floor level.



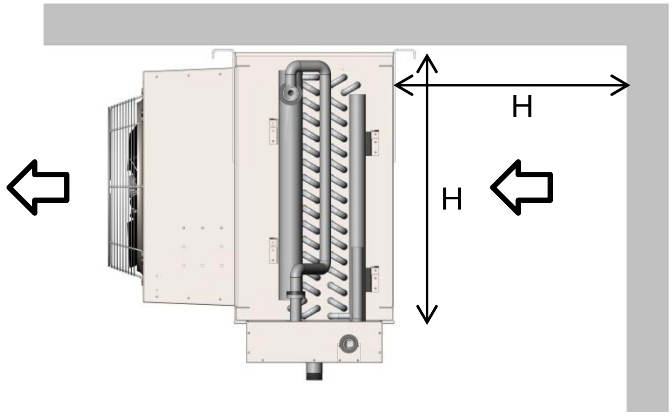
2.3.5. Adjustable legs are provided optionally for floor mounted installations. For proper support, all legs must be supported on a level structural member and must be securely positioned such that the top of the unit will be level.

2.3.6. Depending on the location and installer preference, the shipping/handling skid may be removed before or after the unit is set in its final position. Once set in position, all legs should be bolted or welded to the supporting structure to prevent movement.

2.4. **Location**

2.4.1. For best placement, units should be located in the room opposite the doors, or placed in such a way that air from open doors cannot be drawn directly into the evaporator coil. Colmac recommends against the placement of units directly over doorways. If no alternative exists except placement over doorways, steps must be taken to restrict air infiltration and mitigate dockside moisture.

2.4.2. Unit(s) should be located to permit unobstructed airflow both to and from the unit. The intake face of the unit should be located at least one unit height away from any wall or other significant obstruction. The discharge area should be adequately free and clear of obstructions, such as building structures, racks, or product, to permit the desired air throw.



2.4.3. For units with removable panels for coil cleaning, clearances should be greater for ease of access and ladder placement.

2.4.4. Units with hinged fan panels require a completely unencumbered area slightly greater than the hinged panel width.

2.4.5. In general, it is good practice to provide approximately 3-feet clearance on all sides of the unit to permit inspection, service, and maintenance.

2.4.6. If the unit has electric defrost heaters, allow for the necessary heater pull area at the end(s) of the unit, as noted on the unit drawings.

2.4.7. The unit(s) should be located so that the air pattern covers the entire room.

2.4.8. Minimize refrigerant pipe runs relative to the compressors. Minimize drain line runs.

2.4.9. The units must be mounted level for proper performance and refrigeration oil return.

2.4.10. Defrost water drain lines should be pitched away from the drain connections on the unit.

3. PIPING

3.1. **Refrigerant Piping**

3.1.1. For Ammonia applications, all refrigeration and piping components must be installed by qualified personnel in accordance with the IIAR Ammonia Refrigeration Piping Handbook and other applicable local and national codes. Piping practices for ammonia are also described in the “System Practices for Ammonia Refrigerant” chapter in the ASHRAE Refrigeration Handbook.

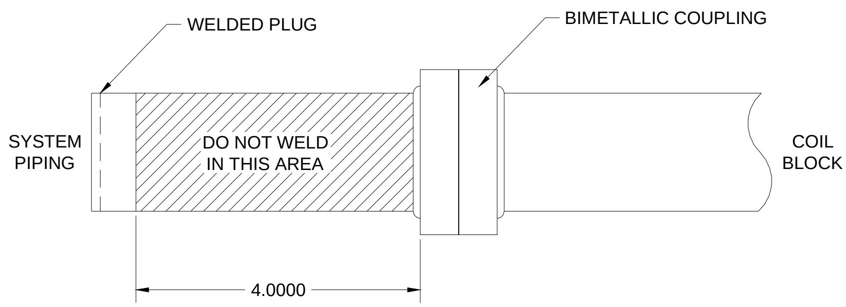
3.1.2. For Halocarbon applications, all refrigeration and piping components must be installed by qualified personnel in accordance with the “System Practices for Halocarbon Refrigerants” chapter in the ASHRAE Refrigeration Handbook and other applicable local and national codes.

3.1.3. Piping is to be designed and supported independent of the evaporator to minimize the transmission of vibration, to permit expansion and contraction, and to impose no load on the evaporator connections.

3.1.4. Pipe sizes are to be established according to good engineering design practices, taking into account all applicable facets of the system: the connection size provided by Colmac should not be used to determine the system piping.

3.1.5. The nitrogen holding charge should be permitted to remain intact as long as possible. When ready to connect the refrigerant piping, slowly vent the nitrogen charge to the atmosphere, and then remove the temporary connection caps. Note that these temporary capping provisions are not intended for refrigeration service and must be removed prior to placing the coil in service.

3.1.6. Standard coil connections for units having all aluminum coil construction utilize bimetallic couplings with carbon steel stubs which can be welded directly to system piping after removal of the factory welded cap. Remove cap so that at least 4" of the connection stub remains. Do not weld within 4" of the bimetallic coupler.



3.1.7. Carbon steel connections will be Schedule 80 pipe for connections less than or equal to 1-1/2" in diameter or Schedule 40 for connections 2" in diameter and greater.

3.1.8. Standard coil connections for halocarbon systems are copper "sweat" connections.

3.1.9. Prior to charging the system with refrigerant, the entire system must be pressure tested to ensure there are no leaks and evacuated to remove moisture.

3.2. **Thermal Expansion Valves**

3.2.1. Perform the following tasks when installing a thermal expansion valve (TXV) on a direct expansion system:

- Confirm that the distributor orifice and retainer wire is in place and was not dislodged during shipping and handling. Note that some hot gas defrost systems will have a side port for hot gas located between the distributor orifice and the distributor.
- For ammonia systems, confirm that the discharge tube is removed from the outlet of the TXV.
- Install the expansion valve immediately adjacent to the distributor with no elbows, valves, or fittings in between. If a side port must be provided, the orifice must be removed to the upstream side of the port, adjacent to the TXV.
- Connect the equalizer tube.
- Secure the expansion valve bulb directly on a horizontal length of pipe, as close to the suction header as possible, but not at a trap nor downstream from a trap. The

preferred location on the pipe is in the 3, 4, 8, or 9 o'clock position. Do not place the bulb at the 6 or 12 o'clock positions.

3.2.2. CAUTION: It is recommended that a suction trap, or suction accumulator, be used on all direct expansion systems for compressor protection.

3.3. **Hot Gas Defrost Piping**

3.3.1. With this method of defrost, some of the hot discharge gas from the compressor is routed into the evaporator instead of the condenser. During hot gas defrost, the coil temperature should be high enough to melt frost and ice on the coil, but low enough so that heat and steam loss to the refrigerated space are minimized.

3.3.2. Only 1/3 of the evaporators in a system should be defrosted at one time. Example: if total evaporator capacity is 100 tons (352 kW), then evaporators with no more than 33 tons (116 kW) of capacity should be defrosted at once. Consult factory if your system does not permit this.

3.3.3. Suggested methods of piping can be seen in Figure 1 thru 4. To maintain uninterrupted gas flow and a clear, fully drainable condensing surface, hot gas is always fed through the evaporator from the top down. For a bottom feed coil, this involves feeding the suction header with hot gas, as is seen in Figure 1. For a top feed coil, like in a Top Feed Recirculated or a Direct Expansion evaporator, the liquid header/distributor is fed with hot gas. This can be seen in Figure 2 for Top Feed Recirculated and in Figure 3 for Direct Expansion. Figure 4 shows hot gas piping for gravity flooded evaporators.

3.3.4. Figures 1 through 4 show control valve groups arranged for forward-cycle hot gas defrost. With this method, hot gas is piped in series through the unit cooler, first through the hot gas drainpan loop, and then through the coil. This method requires the use of a third line to the air unit to supply hot gas. Consult the Factory for information regarding other hot gas defrost options.

3.3.5. For evaporators with cooling capacity 15 tons and greater, a soft start solenoid valve is recommended (See Figures 1 through 4). Soft Start uses a secondary, smaller solenoid capable of letting a reduced amount of hot gas into the defrost system at the beginning of defrost, while the main hot gas solenoid remains closed. Once the system is up to a pre-designated pressure (~40 psig), the main hot gas solenoid is opened, allowing the system to approach its normal operating pressure. The Soft Start system eases the unit cooler into the defrost cycle, limiting unwanted problems like check valve chatter, pipe movements, and most of all, liquid hammer. This control method is particularly useful on larger systems.

3.3.6. All hot gas piping located in cold spaces should be insulated, as well as all hot gas piping located outdoors in cold climates.

3.3.7. The amount of hot gas supplied will depend on the inlet pressure of the hot gas, and the capacity of the air unit.

3.3.8. Ammonia - Hot gas is typically supplied to evaporators by one of two methods:

- Install a pressure regulator in the compressor room at the hot gas takeoff. Set the regulator to approximately 100 psig (689.5 kPa), then size the piping to achieve 75 to 85 psig (517 to 586 kPa) condensing pressure at the evaporators, accordingly.

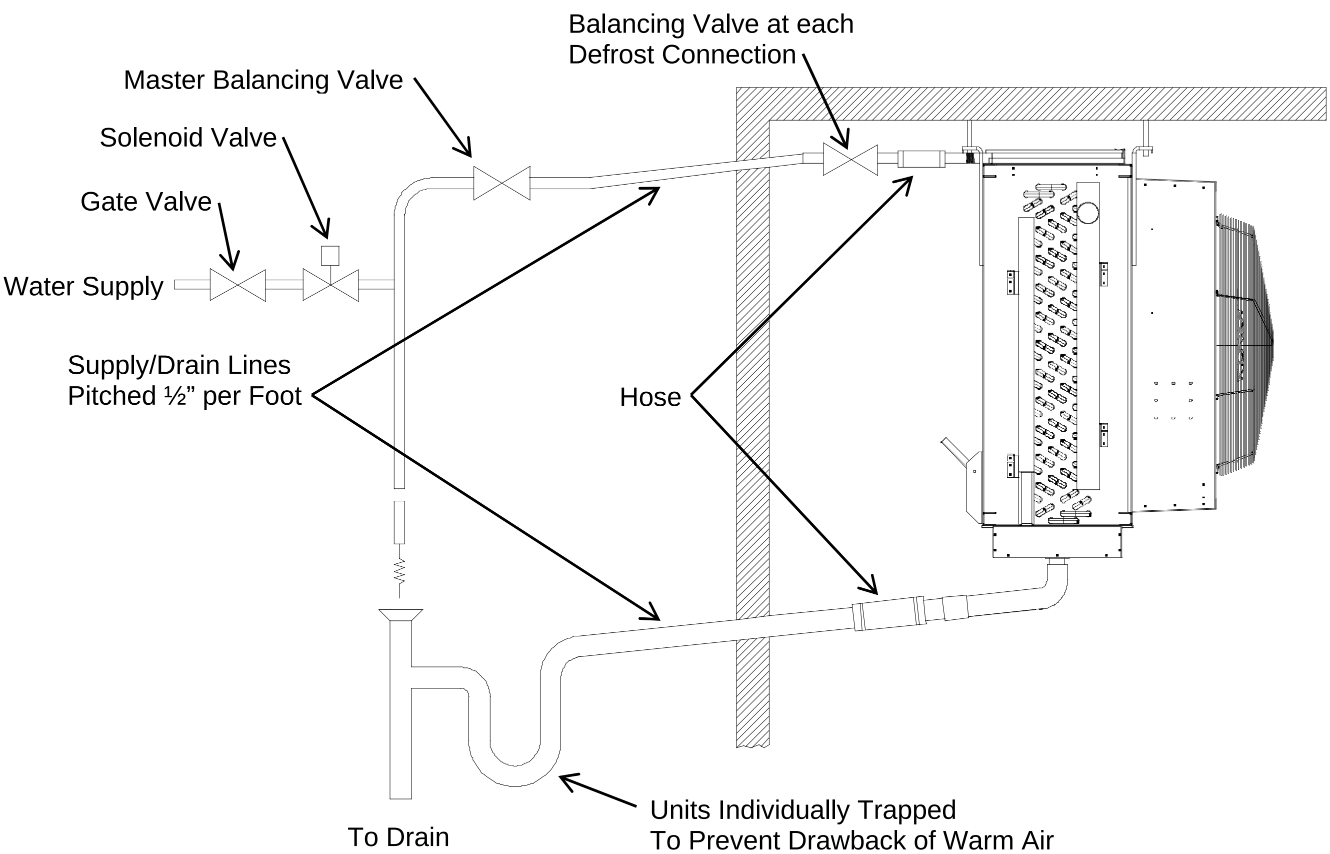
- In branches leading to each evaporator from the main hot gas line, install a pressure regulator set at approximately 75 to 85 psig (517 to 586 kPa), then size the branches accordingly.

3.3.9. Halocarbon – Hot gas piping is typically sized to accommodate twice the normal refrigerant mass flow from the evaporator. Pressure drop is not as critical for the Halocarbon defrost cycle, so refrigerant velocity can be used as the criterion for line size. It is suggested that hot gas lines are sized for the refrigerant velocity between 1000 to 2000 ft/min (5 to 10.2 m/s).

3.4. **Water Defrost Piping (Supply Water)**

3.4.1. Water defrosting consists of distributing water over the coil surface for a very short period of time, then draining the water from the piping before freezing can occur.

3.4.2. The figure below shows typical water defrost piping and controls layout for water defrosted evaporators. A solenoid valve in the water supply line to one or more defrost units, opens under control of an automatic timer to allow water to the units. Water flow to unit water distribution pans is metered by manually adjusted balancing or globe valves. A length of 1/4 in OD tubing is installed as shown in all of the figures to drain the supply piping when the solenoid valve closes, and the defrost period ends. A slope of 1/2 in. per foot is recommended for all supply lines to maintain adequate drainage. All four unit coolers are piped similarly, with the major exception being the A+D unit cooler. The A+D has two water distribution pans per side and two drainpans, and as such, requires additional consideration when piping.



3.4.3. For normal conditions, Table 2 may be used to select water supply sizes. However, if supply water pressure is lower than 30 psig (207 kPa), then the supply piping should be sized larger.

3.4.4. The following procedure should be used when sizing supply water piping:

- Choose a preliminary pipe size from Table 2.
- List the equivalent lengths of all fittings and valves given in Table 3.
- Add the sum of all equivalent lengths, to the lengths of all straight pipe runs.
- Divide the total length from step 3 by 100.
- Obtain the Pressure Loss per 100 feet of pipe from Table 6. Multiply this by the number obtained in Step 4. (This is the pressure loss through the pipe, valves and fittings due to length and flow impedances)
- List the change in elevation (+ is up, - is down) of all vertical pipe runs and determine pressure losses in pipe from the gain in elevation from Table 4. The sum of Step 5, Step 6 plus a 5 psig allowance, is the total pressure loss through pipe valves and fittings, and must not exceed the water pressure in the supply main. If it does exceed supply pressure, recalculate steps 2 through 7 with a larger pipe.

Table 2
Recommended Pipe Size, Water Defrost Supply

Pipe Size	Schedule 40 Steel		Copper & Plastic	
(IPS, inches)	GPM	L/s	GPM	L/s
1	3 to 7	(0.2 to 0.4)	3 to 7	(0.2 to 0.4)
1-1/4	8 to 15	(0.5 to 0.9)	8 to 12	(0.5 to 0.8)
1-1/2	15 to 22	(1.0 to 1.4)	13 to 20	(0.9 to 1.3)
2	23 to 40	(1.5 to 2.5)	21 to 45	(1.4 to 2.8)
2-1/2	41 to 70	(2.6 to 4.4)	46 to 80	(2.9 to 5.0)
3	71 to 130	(4.5 to 8.2)	81 to 130	(5.1 to 8.2)
4	131 to 250	(8.3 to 15.8)	131 to 270	(8.3 to 17.0)

* Based on pressure loss of 1 to 4 ft / 100 ft (100 to 400 Pa/m)

Table 3
Equivalent Length of Water Defrost Pipe Fittings, Feet

Pipe Size, (IPS, inches)	1	1-1/4	1-1/2	2	2-1/2	3	4
Solenoid	15.0	16.0	16.0	18.0	18.0	20.0	--
90° Elbow	5.2	6.6	7.4	8.5	9.3	11.0	13.0
Tee	6.6	8.7	9.9	12.0	13.0	17.0	21.0
Coupling or Gate Valve	0.8	1.1	1.2	1.5	1.7	1.9	2.5
Globe Valve	29.0	37.0	42.0	54.0	62.0	79.0	110.0
Angle Valve	17.0	18.0	18.0	21.0	22.0	28.0	38.0

Add equivalent length of all fittings to length of same straight pipe to obtain total length for use on Table 8.

Table 4
Pressure Loss Due to Elevation

Elevation, (ft)	5	7	9	12	16	23	35	46	60
Pressure Loss, (psi)	2	3	4	5	7	10	15	20	26

Table 5
Water Defrost
Recommended Drain Line Sizes

Water Flow, (GPM)	15	25	42	63	89	170	275	550
Pipe Size, (IPS, inches)	2	2.5	3	3.5	4	5	6	8

Table 6
Water Capacity, GPM
Sch 40 Pipe

Pipe Size	**Pressure Loss Per 100 ft, psi**						
(IPS, Inches)	**2**	**5**	**10**	**15**	**20**	**30**	**50**
1	8	12.8	19.1	24	27.8	33.9	44.5
1-1/4	17.4	26.9	29.7	49.5	57.4	70	91.9
1-1/2	25.9	41	60	74.1	85.5	106.5	140
2	51.4	79.6	116.7	144.7	166.9	203.2	268
2-1/2	80.9	127.6	186	229	264.6	330.8	390
3	144.3	227.6	331.6	407.2	467.7	575.4	--
4	292	469.6	671.8	826.8	961.7	--	--

** For SCH 40 steel pipe. Multiply psig values by 0.86 for PVC or Copper Pipe.

Notes:

- If the water supply pressure is unknown, it may be measured by installing a gauge and valve at the “takeoff” point. The pressure should be measured with water flowing near the desired rate.
- In some instances, (as with 2” pipe), it may be desirable to use a solenoid valve to fit the next size smaller pipe. (As with all valves and fittings, determine the correct equivalent length to calculate pressure loss)

3.5. **Defrost Drain Piping**

3.5.1. Drain connections from the drainpan should be individually trapped. Individual trapping prevents warm air from being drawn back through the drain pipe of non-defrosting units. Drain line size should be at least equivalent to the unit cooler drain connection size. For Water Defrost, use Table 5 for sizing defrost drain line sizes.

3.5.2. Within the refrigerated space, the drain line should be pitched sharply down, at least 1/2 in/ft (4 cm/m) and be as short as possible. It should also be heat traced and insulated along its entire length. Traps should be located in a warm area outside the refrigerated space. Any traps or extensive lengths of pipe located outdoors must be heated and insulated to prevent freeze up. Any such heater should be connected for continuous operation. Standard industry practice is for 20 Watts / linear foot of pipe @ 0°F (-17.8°C) and 30 Watts / linear foot of pipe @ -20°F (-28.9°C).

3.5.3. The trap requires static head to overcome the resistance to flow. For this reason, it should be located in the vertical piping at least 2' below the unit (preferably outside of the refrigerated space). The trap should not be heated if it is located in a space in which the temperature is continuously above freezing. This avoids the possibility of boiling the trap dry. The piping should include a cross or tee to facilitate cleanout.

3.5.4. All piping should be adequately supported independent of the unit so no load is imposed on the pan connection. In some cases, consideration should be given to using a union at/near the pan connection to enable disconnecting the drain line for maintenance.

3.5.5. Caution- Do not apply torque to the drain pan connection; use two wrenches to secure the pipe union.

3.5.6. Drainpan and drain lines should be inspected routinely for evidence of ice buildup. Periodic manual maintenance of icing drainpans and drain lines may be required if less than ideal frosting/defrosting conditions have existed. See the Troubleshooting chart for information regarding the diagnosis of freezing drainpans and drain lines.

3.6. **Connection Sizes**

3.6.1. Refrigerant, defrost supply, and defrost drain connection sizes are pre-determined by the factory and the customer. Connection sizes are automatically selected through the use of our proprietary selection software. More information on connection sizing can be found in the ASHRAE Refrigeration Handbook.

4. ELECTRICAL

4.1. **General**

4.1.1. All wiring must be performed by qualified personnel, in compliance with national and local codes and standards.

4.1.2. Refer to the unit nameplate and the specific certified wiring drawings for details. The nameplate contains the required electrical power characteristics and the serial number, which can be cross- referenced to the certified prints.

4.1.3. Standard motors for A+R, A+S, and A+D air coolers include internal thermal overload protection. Custom motors may require external overload relays.

4.1.4. Standard motors for A+L and A+M air coolers do not include thermal overload protection.

4.1.5. Select feeder circuit protection, branch circuit protection, motor contactors, overload relays, and wire sizes in accordance with applicable local and national codes.

4.1.6. Field wiring connections are made to at a common electrical enclosure. The electrical enclosure and internal components may differ depending on unit type and customer specification.

4.1.7. Complete electrical controls with a UL 508 Enclosed Industrial Control Panel listing can be provided at the customer's request.

4.1.8. Units equipped with electric defrost and/or special electrical controls will be provided with specific wiring diagrams.

4.2. **Variable Frequency Drives**

4.2.1. There are many factors that can contribute to the success or failure of VFDs applied to Colmac equipment, most of which are the direct responsibility of the installing electrical contractor. The general design requirements listed below represent the minimum criteria for proper VFD system design. Care should be taken to follow all of the drive manufacturer's recommendations and all applicable electrical codes and standards.

- Motors - Ensure that "Inverter Duty" rated motors are used in situations where VFDs are applied. Colmac motors that are specified as "Inverter Duty" will comply with the National Electrical Manufacturers Association (NEMA) requirements for VFD compatible motors. This type of motor construction, which includes a special winding wire insulation system as well as phase paper installed between the windings, is the accepted industry standard for inverter duty motors.

- Grounding - It is essential that the electrical system, building steel, motor and drive be properly grounded. The National Electric Code (NEC) describes the minimum requirements for grounding and bonding an electrical system for safe operation. In addition to providing a ground from the drive chassis and motor frame to earth ground, Colmac recommends a separate ground conductor from the motor frame to the VFD ground bus. Proper grounding is a critically important means of mitigating bearing current failures.

- Cabling – Conductors should be rated and sized appropriately for the motor load, voltage drop, and environmental conditions. Colmac recommends the use of shielded VFD cable for several reasons. VFD cables are specifically designed for higher voltages, manufactured to higher quality standards and provide a more consistent insulation wall thickness. VFD specific cables are designed to withstand the reflected wave and resulting corona effects. Also, minimizing the length of the conductors from the drive to the motor will help reduce the magnification of the reflected wave. Shielded cables can also help to reduce bearing pitting by directing the destructive current to ground. Both ends of the shield should be bonded and care should be taken to maintain this bond when there are interruptions in the conductor run (i.e. local motor disconnect).

- Carrier Frequencies – Colmac recommends setting the drive carrier frequency as low as possible (typically 2 kHz). Lower carrier frequencies result in higher levels of audible VFD noise, but will help to reduce destructive bearing currents.

- Line and Load Reactors – Ensure that the drive manufacturer's recommendations are followed with regard to sizing and use of line and load reactors. Issues with line voltage imbalance, reflected wave phenomena, switched power factor correction capacitors, and long line lengths can be mitigated with properly sized line and load reactors. Line lengths should be minimized whenever possible.

- Motor Speed – Generally it is not recommended to over speed motors or to operate motors at less than 25% of the motor rated speed.

5. GENERAL OPERATION

5.1. **Before Startup** - Following is a representative checklist of items to be checked prior to startup. It is not, nor is it intended to be, a comprehensive checklist for the many varying industrial refrigeration systems. Consult with a qualified system startup expert for assistance.

- Make sure unit is mounted securely using all hangers, and is level.
- Make sure unit voltage agrees with supply voltage.
- Make sure system is wired correctly and in accordance with the guidelines laid out in this IOM, as well as local and national standards that may apply.
- Check torque on all electrical connections.
- Confirm the supply voltage is within 10% of design and the phase-to-phase imbalance is within 2%.
- Make sure that all fan set screws are tight.
- Check fan direction and amperage.
- Make sure all piping is done completely and in accordance with the guidelines laid out in this IOM, as well as in accordance with standard good practice.
- Make sure that liquid supply suction and hot gas supply (as applicable) service valves are open.
- Check drainage of drain pan and drain piping by pouring water into drainpan.
- Check water defrost distribution – see “Regulating Water Flow Rate”. (Water Defrost units only)

5.2. **After Startup**

- Check the compressor for possible overload immediately after start up.
- Check fan rotation of all fans to make sure air is moving in proper direction.
- Check the air unit operation for proper refrigerant charge.
- Confirm the room thermostat and/or control system are functioning properly.
- Look and listen for any excessive vibration, severe valve chatter, water hammer, or moving pipes, and correct as necessary.
- Heavy moisture loads are usually encountered when starting a system for the first time. This will cause rapid frost buildup on the unit. During the initial pull-down we suggest that the frost buildup be watched and that the unit be defrosted manually as required.
- Evaporators with liquid feed orifices for liquid overfeed must have liquid refrigerant supplied to the coil inlet at a pressure 5 psig (35 kPa) above saturated suction pressure, and at a temperature not exceeding 30°F (16.7°C) above saturated suction temperature. Please consult factory if conditions exceed these recommendations.

5.3. **Field Adjustments -** Perform the following functions when commissioning A+ Series™ evaporators, based on the refrigerant feed system and defrost technique being employed on the particular unit. These instructions are not, nor are they intended to be, a comprehensive list of tasks required to successfully commission all A+ Series™ evaporators. Consult with a qualified system startup expert for assistance.

5.3.1. Recirculated & Controlled Pressure Receiver Feed:

- Open hand expansion valves (HEVs) slowly and observe frost/condensate formation on all return bends, top and bottom alike.
- The proper setting may be achieved by observing the frost or condensate on all return bends and opening the HEV until all return bends are evenly wetted or frosted.
- Alternatively, if the defrost relief regulator is connected to the liquid line and is equipped with a gauge, set the HEV to achieve a 5 psi rise in pressure when the liquid solenoid valve is energized.

5.3.2. Flooded Feed:

- Verify that the liquid level is at the design level in the surge drum.
- Open and adjust the liquid feed HEV to allow for the solenoid to be energized approximately 70% of the time at design temperature difference (TD).

5.3.3. Direct Expansion Feed:

- After room temperature has been achieved, check the superheat, and adjust the thermal expansion valve.
- If the coil is being starved, resulting in too much superheat at the desired room temperature, reduce the superheat setting of the valve by turning the adjusting stem counter-clockwise.
- If there is not enough superheat, increase the setting by turning the adjusting stem clockwise.
- After waiting approximately 30 minutes, re-check the superheat and re-adjust the thermal expansion valve.
- Repeat until the unit operation is stable.
- Note that 10°F is the minimum superheat required to fully stroke a conventional TXV and that 10°F superheat requires an 11 or 12°F split between the room return air temperature and the evaporating temperature.

5.3.4. Brine, Glycol or Water Feed:

- Vent the system, bleed off all air, and check for water hammer. Verify the feed solenoid valve or mixing valve function.

5.3.5. Hot Gas Defrost:

- Allow the unit to frost, then initiate the defrost cycle.
- Monitor the leaving air temperature. It should show a rise if the pump-out time is sufficient.
- Monitor the condensate flow. It should diminish to a trickle prior to hot gas termination.
- Check the bottom of the coil for residual ice or frost.
- Do not allow long hot gas times that cause coil steaming.
- If more than 15 minutes of hot gas is required, there may be system design problems.
- Monitor the bleed time. The pressure of the coil should be within 25 psig of suction pressure by the end of the bleed cycle.
- Monitor the fan delay. The free water on the coil should be frozen prior to the fans starting.
- Make adjustments to the various function times as necessary

5.3.6. Electric Defrost:

- Allow the unit to frost, then initiate the defrost cycle.
- Monitor the leaving air temperature. It should show a rise if the pump-out time is sufficient.
- Monitor the condensate flow. It should diminish to a trickle prior to heater termination.
- Check the bottom of the coil for residual ice or frost.
- Do not allow long heater on times that cause coil steaming.

- Verify the operation of the defrost termination thermostat and remove the start-up jumper, if used.
- Verify that all of the heaters are working by checking the amp draw.
- Monitor the fan delay. The free water on the coil should be frozen prior to the fans starting.
- Make adjustments to the various function times as necessary

5.3.7. Water Defrost:

- Allow the unit to frost, then initiate the defrost cycle.
- Monitor the leaving air temperature. It should show a rise if the pump-out time is sufficient.
- Monitor the water flow and check for even flow coverage, overflows or excessive splashing.
- Check the coil for any residual frost or ice.
- Monitor the fan delay. The free water on the coil should be frozen prior to the fans starting if the unit is in a freezer.
- Make adjustments to the various function times and flow rates as necessary.

5.4. **Defrost Selection**

5.4.1. Determination of defrost should be based on several variables. Energy costs, availability of sufficient supply of water or hot gas, system first cost considerations, and last but not least, the refrigerated spaces operating temperature. Air defrost can certainly not be applied in cold storage applications with temperatures below 38°F. Likewise, the use of a hot gas system in a +42°F (5.6°C) room is not appropriate. Table 1 shows recommended guidelines for defrost system selection relative to refrigerated room temperature.

Table 1
Recommended Room Temperature Ranges for Different Defrost Types

Temperature Range	Hot Gas Defrost	Water Defrost	Electric Defrost	Air Defrost
Low Temp (<20°F [-6.7°C])	YES	YES	YES	NO
Medium Temp (<38°F and >20°F [-6.7°C])	YES	YES	YES	NO
High Temp (>38°F [7.2°C])	N/A	N/A	N/A	YES

5.5. **Hot Gas Defrost Operation**

5.5.1. Condition of Operation - Hot Gas Defrost can be used for any design criteria, including Low-Temp and Medium-Temp.

5.5.2. Proper hot gas defrost operation is entirely dependent on hot refrigerant latent condensation during the defrost operation. This requires hot gas to be delivered to the evaporator at a saturation pressure necessary for condensation to occur during defrost. Typical design hot gas saturation temperatures run between 50°F (10°C) to 60°F (15.6°C). Table 7 shows the equivalent saturation pressures, for a variety of refrigerants, required at the evaporator to accommodate this temperature range.

Table 7
Hot Gas Pressures for Various Refrigerants

Refrigerant	**R22**	**Ammonia (R717)**	**R507a**	**R404a**
Hot Gas Pressure @ Evaporator	~85 to100 psig (~688 to 791 kPa)	~75 to 90 psig (~619 to 722 kPa)	~105 to 125 psig (~826 to 964 kPa)	~105 to 125 psig (~826 to 964 kPa)

5.5.3. Hot Gas Supply line pressure should be maintained at less than the system condensing pressure. This serves two purposes; the first being decreased energy losses due to excessive heat gain, and the second being that condensing pressure has a tendency to fluctuate with ambient conditions and with the load. Maintaining the Hot Gas Supply pressure at less than the system condensing pressure helps ensure a constant Hot Gas pressure at the evaporator.

5.5.4. Sequence of Hot Gas Defrost Operation

5.5.4.1. Recirculated Bottom Feed Evaporators (See Figure 1)

- Close Liquid Solenoid and continue operating fan motors.
- Pump down liquid refrigerant from coil for a period of approximately 15 minutes (or as long as required). Any cold liquid refrigerant remaining in the coil at the beginning of defrost will greatly reduce the effectiveness of the hot gas defrost operation and can extend the time required for defrost. Evidence of residual liquid refrigerant can be seen in the form of uneven melting or the absence of melting on the lower tubes of the evaporator coil.
- Stop fan motors.
- Open Hot Gas Pilot Solenoid to close Gas-Powered Suction Stop Valve.
- On Coils of 15 tons cooling capacity and larger, open Soft Start Hot Gas Solenoid to gradually bring coil up to near defrost pressure.
- Open Hot Gas Solenoid to start defrost. Duration of defrost should be long enough to clear coil and pan. Extending the defrost period longer than this is not necessarily better.
- Close Hot Gas Solenoid (and Soft Start Hot Gas Solenoid if applicable) to end defrost.
- Open Equalizing Bleed Valve to gradually bring evaporator back down to suction pressure.
- Close Hot Gas Pilot Solenoid to open the Gas-Powered Suction Stop Valve. At the same time, open the Liquid Solenoid to start cooling the coil.
- After a delay to refreeze remaining water droplets on the coil, restart the fans.

5.5.4.2. Recirculated Top Feed and Direct Expansion Evaporators (See Figure 2 and 3)

- Close Liquid Solenoid and continue operating fan motors.
- Pump down liquid refrigerant from coil for a period of approximately 15 minutes (or as long as required). Any cold liquid refrigerant remaining in the coil at the beginning of defrost will greatly reduce the effectiveness of the hot gas defrost operation. Evidence of residual liquid refrigerant can be seen in the form of uneven melting or the absence of melting on the lower tubes of the evaporator coil.
- Stop fan motors.

- Open Hot Gas Pilot Solenoid to close Gas-Powered Suction Stop Valve.
- On Coils of 15 tons cooling capacity and larger, open Soft Start Hot Gas Solenoid to gradually bring coil up to near defrost pressure.
- Open Hot Gas Solenoid to start defrost. Duration of defrost should be long enough to clear coil and pan. Extending the defrost period longer than this is not necessarily better.
- Close Hot Gas Solenoid (and Soft Start Hot Gas Solenoid if applicable) to end defrost.
- Energize the Defrost Relief Regulator to the wide open position to gradually bring the evaporator back down to suction pressure (equalize).
- Close Hot Gas Pilot Solenoid to open the Gas-Powered Suction Stop Valve. At the same time, de-energize the Defrost Regulator Valve.
- Open the Liquid Solenoid to start cooling the coil.
- After a delay to refreeze remaining water droplets on the coil, restart the fans.

5.5.4.3. Gravity Flooded Evaporators (See Figure 4)

- Close Liquid Solenoid and stop fan motors.
- Open Hot Gas Pilot Solenoid to close the two Gas-Powered Stop Valves in the coil liquid and suction lines.
- On Coils of 15 tons cooling capacity and larger, open Soft Start Hot Gas Solenoid to gradually bring coil up to near defrost pressure.
- Open Hot Gas Solenoid to start defrost. Duration of defrost should be long enough to clear coil and pan. Extending the defrost period longer than this is not necessarily better.
- Close Hot Gas Solenoid (and Soft Start Hot Gas Solenoid if applicable) to end defrost.
- Energize the Defrost Relief Regulator to the wide open position to gradually bring the evaporator back down to suction pressure (equalize).
- Close Hot Gas Pilot Solenoid to open the Gas-Powered Suction Stop Valves. At the same time, de-energize the Defrost Regulator Valve.
- Open the Liquid Solenoid.
- After a delay to refreeze remaining water droplets on the coil, restart the fans.

5.5.4.4. Setting Hot Gas Defrost Timer. Time periods should be set as follows:

- Length of defrost should be set to the minimum time necessary to melt all frost. Defrost operation beyond this point will convert liquid water to steam, leading to secondary condensation and freezing on non-heated areas of the unit cooler and introduced unwanted heat gain into the controlled space.
- Depending on frost loading conditions, defrost duration can typically last anywhere from 12 to 20 minutes, and in most cases, should never exceed 30 minutes.
- Actual defrost times must be determined from careful observation of defrost operation and adherence to the previously mentioned guidelines. Frost is usually heaviest on the air-entering side of the coil, and inspection of fins on this side can usually be used to determine if complete defrost has occurred. Periodic observation of the defrost cycle throughout the year is necessary to maintain a properly operating defrost system.

NOTICE: Once frost turns to ice, the amount of time required to melt increases. Incomplete defrosting may allow excessive ice to build up which could damage the machinery. Allowing ice to build up on the fan blades will result in excessive vibration which could lead to catastrophic failure. It is imperative that the end user inspect the unit coolers regularly for proper defrosting. Manual defrosting may be required to remove ice buildup.

5.6. **Water Defrost Operation**

5.6.1. Condition of Operation - Water Defrost can be used for all temperature ranges.

5.6.2. Sequence of Water Defrost Operation

- Stop refrigeration by closing liquid solenoid.
- Pump down liquid refrigerant from coil for a period at least equal to 15 minutes. Any liquid refrigerant that may remain in the coil during defrost will greatly reduce the effectiveness of the hot gas defrost operation. Evidence of residual liquid refrigerant during defrost can be seen in the form of uneven melting or the absence of melting on the lower tubes of the evaporator coil.
- Stop fan motors.
- Open water valve for the necessary time of defrost.
- Allow water to drain from fins.
- Bleed evaporator pressure back down to normal suction pressure.
- Start refrigeration to cool the evaporator.
- Restart fan motors.

5.6.3. Setting Water Defrost Timer

5.6.3.1. Instructions for adjustment of Defrost Timer should be shown in the Timer User's Manual.

5.6.3.2. Time periods should be set as follows:

- The delay period for pump down and fan stoppage is approximately 1 minute. With very large coils where time for pump-down after shutting the refrigerant solenoid valve may be longer, the delay period may be longer. Set the delay accordingly.
- Set the water spray to five minutes, initially. In actual practice, it may take as little as three minutes to clear frost from the coil, and only in rare instances would it take as long as fifteen minutes.
- Actual defrost times must be determined from careful observation of defrost operation and adherence to the previously mentioned guidelines. Frost is usually heaviest on the air-entering side of the coil, and inspection of fins on this side can usually be used to determine if complete defrost has occurred. Periodic observation of the defrost cycle throughout the year is necessary to maintain a properly operating defrost system. If more than fifteen minutes is required to completely remove frost, it is an indication that something may be wrong, such as inadequate water supply.
- Set drain period for two minutes. This should be ample time for water to drain off of the coil before starting up the fans.
- The frequency of defrosting will vary with room temperature and relative humidity.

NOTICE: Once frost turns to ice, the amount of time required to melt increases. Incomplete defrosting may allow excessive ice to build up which could damage the machinery. Allowing ice to build up on the fan blades will result in excessive vibration which could lead to catastrophic failure. It is imperative that the end user inspect the unit coolers regularly for proper defrosting. Manual defrosting may be required to remove ice buildup.

5.6.4. Specifying Water Defrost Temperature

5.6.4.1. Adequate temperature of the water defrost supply must be maintained throughout the defrost cycle to guarantee adequate defrost under varying room temperature conditions. Recommended water temperatures as a function of room temperature are found in Table 8.

Table 8
Recommended Water Defrost Temperatures

Room Temperature	**Water Temperature**
-20°F to 30°F (-28.9°C to -1.1°C)	At least 50°F (10°C)
30°F to 32°F (-1.1°C to 0°C)	At least 45°F (7.2°C)
32°F (0°C) and up	At least 40°F (4.4°C)

5.6.5. Regulating Water Flow Rate

5.6.5.1. Water flow rate is controlled by adjusting the balancing valve at each unit. Adjust flow rate to fully saturate the coil fin surfaces in defrost water, making sure not to overflow the distribution pan, which can result in undesirable splashing. In some areas, the water pressure may become very low during daytime hours due to usage in the same building or neighborhood. In such instances, it may be necessary to set the timer to defrost when adequate water pressure is available.

5.7. **Electric Defrost Operation**

5.7.1. Condition of Operation - Electric Defrost can be used for any design criteria, including Low-Temp, Medium-Temp, and High-Temp Applications.

5.7.2. Sequence of Electric Defrost Operation

- Stop refrigeration by closing liquid solenoid.
- Pump down liquid refrigerant from coil for a period at least equal to 15 minutes. Any liquid refrigerant that may remain in the coil during defrost will greatly reduce the effectiveness of the electric defrost operation. Evidence of residual liquid refrigerant during defrost can be seen in the form of uneven melting or the absence of melting on the lower tubes of the evaporator coil.
- Stop fan motors.
- Energize power to electric defrost heating elements for the necessary time of defrost.
- De-energize power to heating elements when defrost is complete.
- Start refrigeration to cool the evaporator.
- Restart fan motors.

5.7.3. Setting Electric Defrost Timer - Time periods should be set as follows:

- Length of defrost should be set to the minimum time necessary to melt all frost. Defrost operation beyond this point will convert liquid water to steam, leading to secondary condensation and freezing on non-heated areas of the unit cooler and introduced unwanted heat gain into the controlled space.
- Average defrost times can vary anywhere from fifteen to twenty minutes, and in most cases, should never exceed thirty minutes.
- Actual defrost times must be determined from careful observation of defrost operation and adherence to the previously mentioned guidelines. Frost is

usually heaviest on the air-entering side of the coil, and inspection of fins on this side can usually be used to determine if complete defrost has occurred. Periodic observation of the defrost cycle throughout the year is necessary to maintain a properly operating defrost system.

NOTICE: Once frost turns to ice, the amount of time required to melt increases. Incomplete defrosting may allow excessive ice to build up which could damage the machinery. Allowing ice to build up on the fan blades will result in excessive vibration which could lead to catastrophic failure. It is imperative that the end user inspect the unit coolers regularly for proper defrosting. Manual defrosting may be required to remove ice buildup.

5.8. **Air Defrost Operation**

5.8.1. Condition of Operation - Air Defrost can be used for High-Temp installations only.

5.8.2. Sequence of Air Defrost Operation

- Pump down liquid refrigerant from coil for a period at least equal to 15 minutes. Any liquid refrigerant that may remain in the coil during defrost will greatly reduce the effectiveness of the air defrost operation. Evidence of residual liquid refrigerant during defrost can be seen in the form of uneven melting or the absence of melting on the lower tubes of the evaporator coil.
- Allow fans to continue operating for the necessary time of defrost.
- Re-introduce refrigerant into evaporator and re-start refrigeration to cool the evaporator.

5.8.3. Setting Air Defrost Timer

5.8.3.1. Time periods should be set as follows:

- Time to defrost should be just long enough to melt all frost.

6. EMERGENCY SITUATIONS

6.1. During normal operation the units described in this IOM contain either ammonia or one of several possible halocarbon refrigerants. There are hazards and risks associated with all refrigerants. Refrigerant leaks can cause an emergency situation. Refer to the facility “Emergency Planning Policy” and “Hazardous Chemical Communication Policy” for the proper methods of dealing with any potential emergency situation resulting from a refrigerant leak.

7. MAINTENANCE

7.1. **WARNING:** Prior to any maintenance being performed, unit must be locked out and tagged out per the Lockout/Tag Out policy of the facility where installed.

7.2. Note that equipment may be damaged by incompatible cleaning agents or water condensate from defrost that is contaminated by airborne impurities. It is the responsibility of the owner/operator to be familiar with these chemicals and the room environment and to select compatible agents and materials of construction.

7.3. Refer to the certified submittals for a listing of the materials used in the specific evaporator in question.

7.4. Consult with a qualified chemical/corrosion expert to ensure compatibility and to develop a plan to address any special circumstances, such as airborne impurities.

7.5. System Maintenance Schedule (recommended maximum time periods)

7.5.1. Every month

- The system should be periodically checked for proper defrosting and defrost timing due to variations in the quantity and pattern of frost.
- Frost accumulation is dependent on the following: temperature of the space, type of product stored, product loading rate, traffic, moisture content of air entering conditioned space, etc.
- It may be necessary to periodically adjust number of defrost cycles or duration of each defrost cycle to accommodate these varying conditions.

7.5.2. Every 6 months

- Check refrigeration system for charge level, oil level, and any evidence of leaks.
- Tighten all electrical connections.
- Check operation of control system and proper functioning of defrost solenoids, drain line heaters, thermostats, etc.
- Check that all safety controls are operating appropriately.

7.6. Evaporator Maintenance Schedule (recommended maximum time periods)

7.6.1. Every 6 months

- Clean the coil surface.
- Inspect defrost drain pan. Clean if necessary. Check for proper drainage.
- For Water Defrost, inspect water defrost distribution pans. Clean if necessary.
- Inspect all insulated supply and drain lines.
- Check all wiring.
- Check all motors and fans, tightening when necessary all motor mounting bolts and fan set screws.

NOTICE: Do not use alkaline detergents on Aluminum coil surfaces, as corrosion may result and cause refrigerant containment failure.

7.7. **Replacement Parts**

7.7.1. Replacement parts which are covered under the conditions of Colmac Coil's warranty (see Limited Warranty) will be reimbursed at the part cost only. For replacement parts, warranted or otherwise, contact Colmac Coil directly. When contacting Colmac Coil with the explanation of failure, have the complete model number, serial number, date of installation, and date of failure at hand.

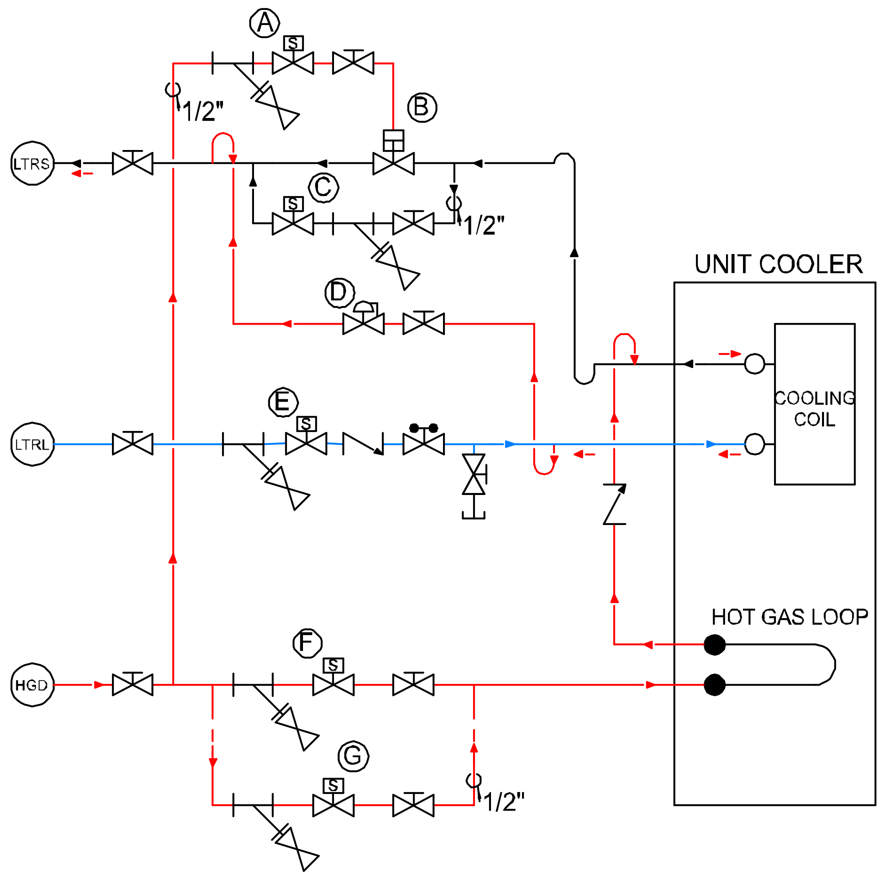
7.8. **Troubleshooting**

SYMPTOM	POSSIBLE CAUSE	POSSIBLE SOLUTION
1. Coil not clearing of frost during defrost cycle.	1. Insufficient number of defrost cycles. 2. Insufficient time for each defrost cycle. 3. Hot Gas refrigerant pressure too low. 4. Defective timer or pressure regulator. 5. Excessive air/moisture infiltration resulting in unreasonably high frost load. 6. Fan still operating during defrost.	1. Adjust timer for more defrost cycles. 2. Adjust for increased defrost duration. 3. Adjust pressure regulator/back pressure regulator for increased pressure. Check condenser fans/pumps for proper operation. 4. Replace timer/regulator. 5. Consider some form of air/moisture infiltration mitigation, i.e. dock conditioning, air curtains, improved doors 6. Cycle fans off during defrost. Check defrost timer or other fan control device for proper operation.
2. Ice building in drainpan.	1. Drain line plugged. 2. Drain line not sloped as required. 3. Unit Cooler not level. 4. Drain line heater not operating adequately. 5. Defective defrosting timer/thermostat/pressure regulator. 6. Hot Gas Piping not adequately supported, forcing hot gas loop away from drainpan. 7. Improper piping and/or inadequate flow of hot gas to pan. 8. Steam created during defrost is condensing above unit and dripping/freezing onto unheated areas of evaporator.	1. Clean drain line. 2. Adjust as necessary. 3. Adjust as necessary. 4. Repair or replace as necessary. 5. Repair or replace as necessary. 6. Add additional hot gas piping support. 7. Increase hot gas flow to drain pan. 8. See Symptom #4 below.
3. Uneven coil frosting.	1. Unit Cooler located too close to door or other room opening. 2. Unit Cooler not level, causing uneven loading. 3. Defrost cycle time too short. 4. Fans not operating correctly. 5. Liquid supply not sufficient to properly feed unit. 6. Liquid control device not open or large enough.	1. Relocate as necessary. 2. Adjust as necessary. 3. Increase duration of each defrost cycle. 4. Check fans and fan motors for proper operation. Replace or repair as needed. 5. Increase refrigerant supply to unit cooler. Check strainers, expansion valves, etc. 6. Correct or replace as necessary.

SYMPTOM	POSSIBLE CAUSE	POSSIBLE SOLUTION
4. Ice accumulating on ceiling above evaporator or in air section or around motors, fans, and fan venturis.	1. Defrost cycle time too long, "overcooking" the unit. 2. Too many defrosts cycles during a 24-hour period. 3. Defective defrosting timer/thermostat/pressure regulator.	1. Decrease duration of each defrost cycle. 2. Decrease number of defrost cycles. 3. Repair or replace as necessary.
5. Elevated Room Temperature	1. Room thermostat set incorrectly. 2. Low refrigerant charge. 3. Airflow restricted to evaporator. 4. Undersized evaporators for required heat load. 5. Fan motors not operating. 6. Insufficient refrigerant flow.	1. Check thermostat and adjust appropriately. 2. Add refrigerant. 3. Check evaporator for airflow blockage, including ice buildup, foreign matter, etc. Clean as necessary. 4. If heat load exceeds design conditions, evaporator operating conditions may have to be changed, or evaporators will need to be added to the conditioned space. 5. Check fans and fan motors for proper operation. Replace or repair as needed. 6. Check strainers, hand expansion valves, etc.
6. Frequent Fan and/or Motor Failure	1. Unit cycling too frequently, causing excessive fatigue related wear and tear. 2. Check quality of power supply.	1. Limit number of cycles, whether it is for capacity control or defrost operation. 2. Install power conditioning equipment, phase failure relays, etc.
7. Insufficient Airthrow	1. Unit too close to wall, product, etc. for proper return air supply to fan. 2. Unit obstructed with ice blockage. 3. No air throw straightener specified with unit purchase. 4. Fan and/or fan motors not operating correctly. 5. VFD fan speed too low.	1. Relocate unit to allow for unobstructed airflow. 2. See Symptoms 1-4 above. 3. Purchase optional airthrow straighteners from evaporator manufacturer. 4. Check fans and fan motors for proper operation. Replace or repair as needed. 5. Increase fan speed.

FIGURE 1

HOT GAS DEFROST PIPING
RECIRCULATED BOTTOM FEED EVAPORATOR

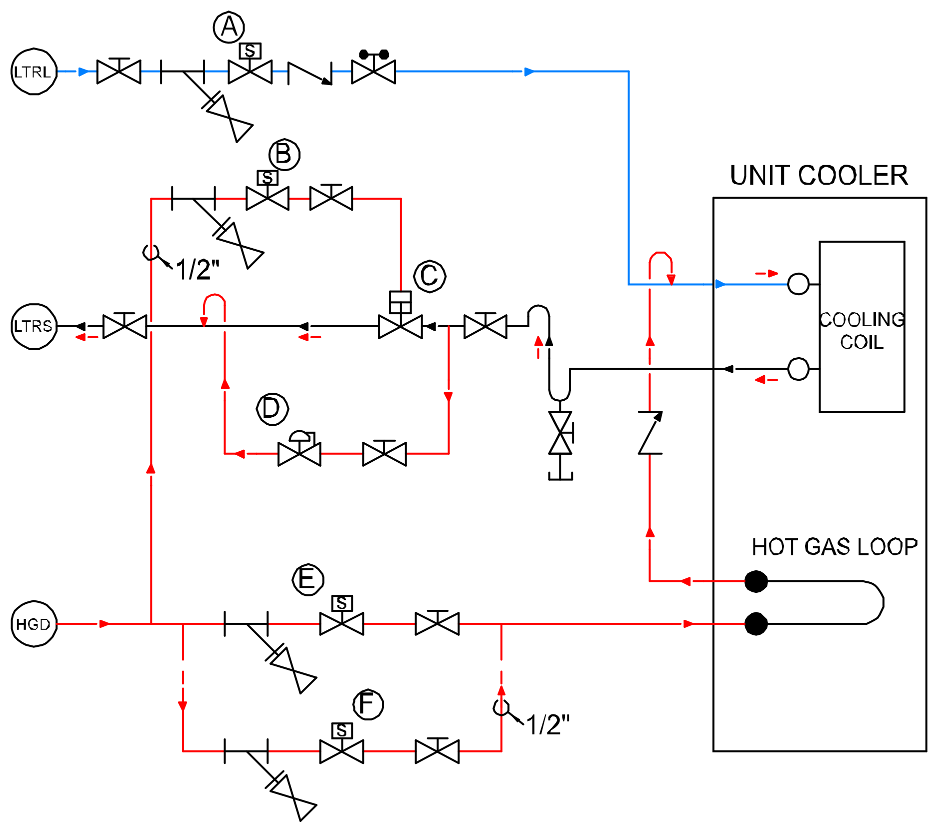


	HAND EXPANSION VALVE
	GLOBE VALVE
	GAS POWERED SUCTION STOP VALVE
	SOLENOID VALVE
	DEFROST PRESSURE REGULATOR
	CHECK VALVE
	STRAINER, BLOW-OFF
	DRAIN
	HOT GAS FLOW
	SATURATED LIQUID FLOW
	SATURATED LIQUID & VAPOR FLOW

HGD	HOT GAS DEFROST SUPPLY
LTRS	LOW-TEMP RECIRCULATED SUCTION
LTRL	LOW-TEMP RECIRCULATED LIQUID
A	PILOT SOLENOID VALVE (S8 OR HS8)
B	GAS POWERED SUCTION STOP VALVE (CK2 OR HCK2)
C	EQUALIZING BLEED VALVE (S8 OR HS8)
D	DEFROST RELIEF REGULATOR (A4AK OR HA4AK)
E	LIQUID SOLENOID (S4A OR HS4A)
F	HOT GAS SOLENOID (S4A OR HS4A)
G	SOFT START HOT GAS SOLENDOID (S8 OR HS8) (RECOMENDED FOR EVAPORATORS OF 15 TONS OR GREATER COOLING CAPACITY)

FIGURE 2

HOT GAS DEFROST PIPING
RECIRCULATED TOP FEED EVAPORATOR



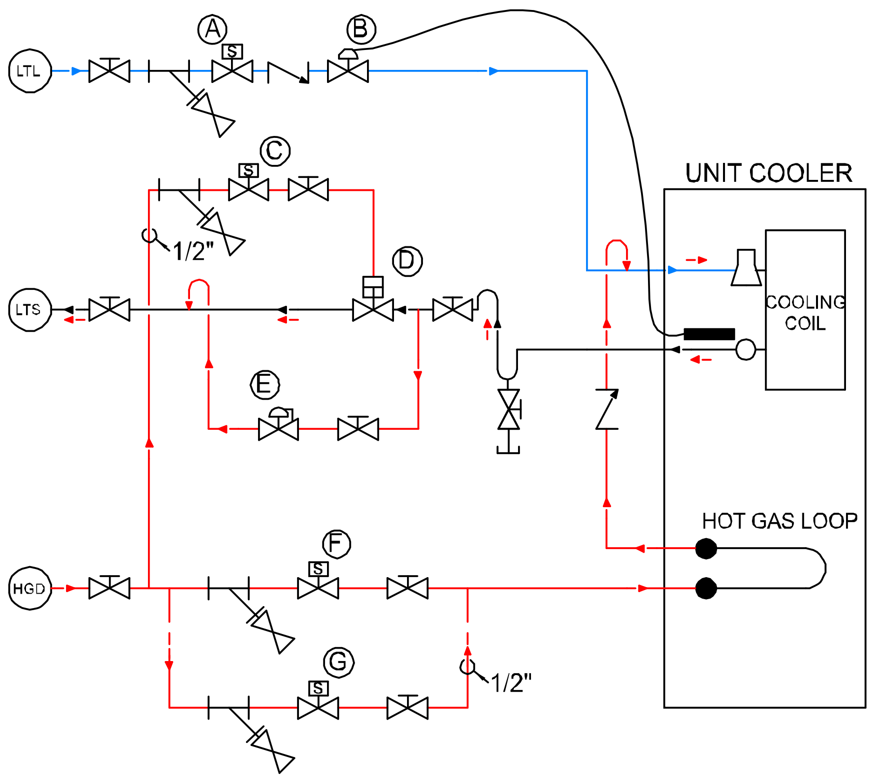
- HAND EXPANSION VALVE
- GLOBE VALVE
- GAS POWERED SUCTION STOP VALVE
- SOLENOID VALVE
- DEFROST PRESSURE REGULATOR
- CHECK VALVE
- STRAINER, BLOW-OFF
- DRAIN
- HOT GAS FLOW
- SATURATED LIQUID FLOW
- SATURATED LIQUID & VAPOR FLOW

HGD	HOT GAS DEFROST SUPPLY
LTRS	LOW-TEMP RECIRCULATED SUCTION
LTRL	LOW-TEMP RECIRCULATED LIQUID
A	LIQUID SOLENOID (S4A OR HS4A)
B	PILOT SOLENOID VALVE (S8 OR HS8)
C	GAS POWERED SUCTION STOP VALVE (CK2 OR HCK2)
D	DEFROST RELIEF REGULATOR W/ WIDE OPENING FEATURE FOR EQUALIZING (A4A OR HA4A)
E	HOT GAS SOLENOID (S4A OR HS4A)
F	SOFT START HOT GAS SOLENDOID (S8 OR HS8) (RECOMENDED FOR EVAPORATORS OF 15 TONS OR GREATER COOLING CAPACITY)

NOTE 1: DEFROST PRESSURE REGULATOR OPERATES WIDE-OPEN DURING NORMAL OPERATION, AND OPERATED AS REGULATOR DURING DEFROST.

FIGURE 3

HOT GAS DEFROST PIPING
DIRECT EXPANSION EVAPORATOR



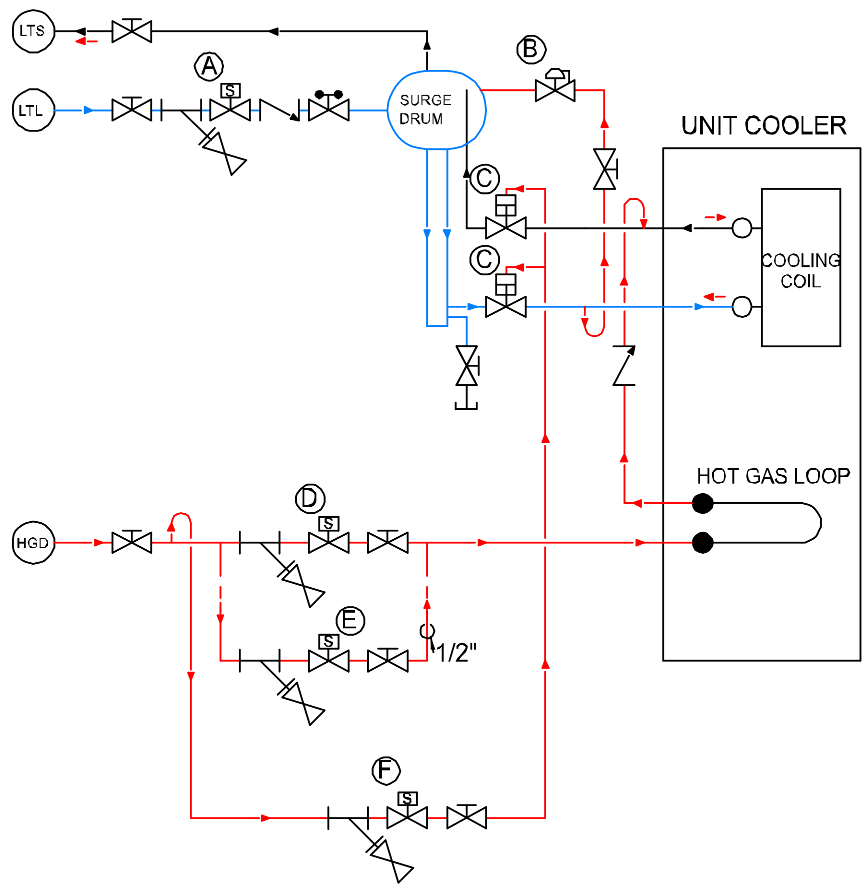
HAND EXPANSION VALVE	
GLOBE VALVE	
GAS POWERED SUCTION STOP VALVE	
SOLENOID VALVE	
DEFROST PRESSURE REGULATOR	
THERMAL EXPANSION VALVE	
CHECK VALVE	
STRAINER, BLOW-OFF	
DRAIN	
HOT GAS FLOW	
SATURATED LIQUID FLOW	
SUPERHEATED VAPOR FLOW	

HGD	HOT GAS DEFROST SUPPLY
LTS	LOW-TEMP SUCTION
LTL	LOW-TEMP LIQUID
A	LIQUID SOLENOID (S4A OR HS4A)
B	THERMAL EXPANSION VALVE
C	PILOT SOLENOID VALVE (S8 OR HS8)
D	GAS POWERED SUCTION STOP VALVE (CK2 OR HCK2)
E	DEFROST RELIEF REGULATOR W/ WIDE OPENING FEATURE FOR EQUALIZING (A4AB OR HA4AB)
F	HOT GAS SOLENOID (S4A OR HS4A)
G	SOFT START HOT GAS SOLENDOID (S8 OR HS8) (RECOMENDED FOR EVAPORATORS OF 15 TONS OR GREATER COOLING CAPACITY)

NOTE 1: DEFROST PRESSURE REGULATOR OPERATES WIDE-OPEN DURING NORMAL OPERATION, AND OPERATED AS REGULATOR DURING DEFROST.

FIGURE 4

HOT GAS DEFROST PIPING
GRAVITY FLOODED EVAPORATOR



HAND EXPANSION VALVE		HGD	HOT GAS DEFROST SUPPLY
GLOBE VALVE		LTS	LOW-TEMP SUCTION
GAS POWERED SUCTION STOP VALVE		LTL	LOW-TEMP LIQUID
SOLENOID VALVE		A	LIQUID SOLENOID (S4A OR HS4A)
DEFROST PRESSURE REGULATOR		B	DEFROST RELIEF REGULATOR W/ WIDE OPENING FEATURE FOR EQUALIZING (A4AB OR HA4AB)
CHECK VALVE		C	GAS POWERED SUCTION STOP VALVE(CK2 OR HCK2)
STRAINER, BLOW-OFF		D	HOT GAS SOLENOID (S4A OR HS4A)
DRAIN		E	SOFT START HOT GAS SOLENDOID (S8 OR HS8) (RECOMENDED FOR EVAPORATORS OF 15 TONS OR GREATER COOLING CAPACITY)
HOT GAS FLOW		F	PILOT SOLENOID VALVE (S8 OR HS8)
SATURATED LIQUID FLOW			
SATURATED LIQUID & VAPOR FLOW			

Colmac reserves the right to change product design and specifications without notice.

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Manufacturing Inc.
PO Box 571 • Colville, WA 99114 • USA
Tel +1.509.684.2595 ▪ Fax +1.509.684.8331
www.colmaccoil.com

A+L Air Cooler (AL Tube) Engineering Specifications

1. **General**
    1.1. This specification covers “A+L” type air coolers having aluminum tubes and aluminum fins intended for use in refrigeration systems.

2. **Selection / Rating Method**
    2.1. Evaporators shall be selected using DT1 rating method. DTM rating method shall not be used.
    2.2. Evaporators shall be selected on the basis of room relative humidity as shown in the drawing.

3. **Tubing**
    3.1. Coil block shall be constructed with alloy 3003 aluminum tubing.
    3.2. Calculated working pressure of the coil tubing (per ASME Pressure Vessel Code Sec. VIII) shall be no less than 300 psig.
    3.3. Tubing shall be constructed from raw material that is made in the USA, as defined by material test reports, which are to be supplied upon customer request.

4. **Tube Pattern**
    4.1. Tube pattern shall be selected for optimum performance and defrost efficiency from one of the three patterns below:
        4.1.1. 5/8” OD - 1.5” x 1.299” equilateral staggered
        4.1.2. 5/8” OD – 1.97” (50 mm) inline
        4.1.3. 7/8” OD - 2.25” x 1.949” equilateral staggered

5. **Fins**
    5.1. Shall be aluminum 1100 alloy, no less than 0.010” (0.25 mm) thick.
    5.2. Fins shall be continuous flat or configured plate type with full length, self-spacing collars. Spiral, “L-foot”, or wrap-on type fins shall not be allowed.
    5.3. Tubes shall be expanded into fin collars to form a tight mechanical bond between tube and fin.

6. **Headers**
    6.1. Headers shall be made of ASME B241, Alloy 6061 aluminum no less than ANSI schedule 40 pipes.

7. **Connections**
    7.1. Liquid, suction, and hot gas connections shall be carbon steel pipe no less than schedule 40, certified to ASME SA-106/B. Bolted type flange union connections shall not be allowed.
    7.2. In the case of pumped bottom feed, liquid and hot gas connections shall be oriented vertically up.
    7.3. In the case of pumped bottom feed, liquid connection to coil header pipe shall be below the level of the lowest tube in the coil to effectively trap condensate during defrost.

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7.4. Coil connections shall be terminated with a welded steel head at the factory. One "Schrader" type valve shall be provided by the manufacturer mounted at the factory in one of the coil connection terminations for the purpose of measuring the shipping charge upon arrival at the jobsite.

7.5. The manufacturer shall charge each coil with a shipping charge of 5-20 psig dry air or nitrogen. A label on the coil connection near the Schrader valve shall be provided indicating the factory charge pressure.

8. Cleanliness

8.1. The manufacturer shall insure that the coils are free from internal dirt, scale, and water.

9. Welding/QC

9.1. All tube welds shall be made by Tungsten Inert Gas (TIG) welding process.

9.2. All welds shall be performed by ASME certified welders per the requirements of the manufacturer's WPS documents. Copies of all WPS, PQR, and Welder Qualification documents used in the fabrication of the coil shall be made available to the engineer upon request.

9.3. Copies of the manufacturer's Quality Control Manual shall be made available to the engineer upon request.

10. Leak Testing

10.1. Coils shall be tested for leaks after welding at no less than 500 psig (35 bar), dry air under water.

10.2. Test certificates for each coil shall be provided by the manufacturer to the engineer upon request.

11. Circuiting

11.1. <u>Types RT and RB (Recirc Top Feed and Recirc Bottom Feed)</u>

11.1.1. Liquid overfeed orifices shall be installed at the entrance to each coil circuit, sized for a maximum 5 psi pressure drop at the design refrigerant flow rate.

11.1.2. Units with vertical header arrangements shall have circuiting designed for parallel flow of refrigerant relative to direction of air flow.

11.1.3. Units with horizontal header arrangements shall have circuiting designed for cross flow of refrigerant relative to the direction of air flow.

11.2. <u>Type FL (Gravity Flooded)</u>

11.2.1. Units with vertical header arrangements shall have circuiting designed for parallel flow of refrigerant relative to direction of air flow.

11.2.2. Units with horizontal header arrangements shall have circuiting designed for cross flow of refrigerant relative to the direction of air flow..

11.3. <u>Type DX (Direct Expansion)</u>

11.3.1. Units with vertical header arrangements shall have circuiting designed for counter flow of refrigerant relative to direction of air flow to maximize suction gas superheat for best operation of thermostatic expansion valves.

11.3.2. Units with horizontal header arrangements shall have circuiting designed for cross flow of refrigerant relative to direction of air flow. Circuits must have crossover circuiting to equalize circuit l oading.

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11.4. Type BW (Single Phase Liquids)
- 11.4.1. Units with vertical header arrangements shall have circuiting designed for counter flow of refrigerant relative to direction.
- 11.4.2. Units with horizontal header arrangements shall have circuiting designed for cross flow of refrigerant relative to direction of air flow. Circuits must have crossover circuiting to equalize circuit loading.

12. Fans

12.1. Construction.
- 12.1.1. Propeller fans shall be constructed of cast aluminum or non-ferrous polymer, as required by the contract.
- 12.1.2. Hub shall be removable type for ease of service. Integral fan/motor combinations with non-removable fans shall not be allowed.
- 12.1.3. Fans shall be true airfoil shape and shall be non-overloading type

12.2. Fan Guards.
- 12.2.1. Fans shall be fully guarded with OSHA approved wire guards.

12.3. Direction of Air Flow
- 12.3.1. Fans and motors shall be mounted on the air leaving side of the coil for draw through operation.

13. Fan Motors

13.1. Fan motors shall be standard NEMA frame size, inverter ready, integral horsepower, induction three phase, totally enclosed severe duty, with sealed ball bearings.

13.2. Motor service factor shall be no less than 1.15.

13.3. Motors shall have internal rotor construction. External rotor construction motors shall not be allowed.

13.4. Fan motors shall be individually wired by the manufacturer to individual junction boxes on the exterior of the unit cabinet.

14. Cabinet

14.1. General
- 14.1.1. Standard construction shall be of G90 mill Galvanized Steel, Alloy 5052 Aluminum, or 304L Stainless Steel as required in the contract. Painted or coated cabinet parts shall not be allowed.

14.2. Optional Smart Hanger System
- 14.2.1. When specified, units shall be provided with Colmac Smart Hanger brackets that will allow the unit to be suspended from pre-mounted structural channels provided by the manufacturer.
- 14.2.2. Hanger brackets shall be adjustable in the vertical direction to allow for various mounting heights.

14.3. Standard Air Section
- 14.3.1. Fans and motors shall be arranged for horizontal air discharge, mounted on the air leaving side of the coil section (draw through).
- 14.3.2. Fan panels shall be hinged to allow access for maintenance and cleaning.

14.4. 45 Degree Down Discharge Air Section
- 14.4.1. Fans and motors shall be arranged for 45 degree down air discharge when required by contract.

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14.4.2. Air discharge section to be factory mounted on the air leaving side and tilted down at 45 degree angle from the vertical plane.

14.5. Penthouse Air Section

14.5.1. Fan and motors shall be arranged for vertical down air discharge when required by the contract. Penthouse air section shall be factory mounted on the air leaving side of the coil section (draw through).

14.5.2. Access doors shall be provided to allow access to each individual fan and motor for service.

15. Drainpans

15.1. The inner drainpan shall be constructed of Alloy 5052 Aluminum.

15.2. Drainpan shall be designed to cover the coil section of the cooler cabinet.

15.3. Drainpan to be triple pitch, V-bottom design, such that water flows front to center, rear to center, and end to end to a single drain.

15.4. Drain outlet shall be constructed as a full radius, formed directly into the drain pan to eliminate the possibility of water pooling around the drain connection.

15.5. When required by the contract, drainpan shall be insulated with a minimum of 1” thick insulation.

15.5.1. The insulation shall be fully covered with a sheet metal insulation shield of mill galvanized steel, aluminum, or 304L stainless steel as required by the contract.

16. Defrost

16.1. Hot Gas Defrost

16.1.1. General

16.1.1.1. Coil shall be arranged for hot gas defrosting.

16.1.2. Pan Loop

16.1.2.1. A hot gas pan loop of round Alloy 3003 aluminum tubing shall be provided to warm the inner drainpan during defrost. Pan loop designs using square tubing or cross-sections other than round shall not be allowed.

16.1.2.1.1. Pan loop headers are to be held outside the ends of the drain pan to allow for full contact of the tubes with the pan.

16.1.2.1.2. The pan loop shall be attached to the underside of the inner drainpan by means of full length clips designed to keep the pan loop in tight contact with the pan by spring force. The pan loop shall not be mounted in the drainpan where it can contact the defrost water.

16.1.2.1.3. The pan loop outlet pipe shall be arranged such that a liquid seal is formed below the lowest hot gas pan tube.

16.1.3. Pan Loop Check Valve

16.1.3.1. When defrost condensate is being lifted into an overhead condensate return line, a properly sized in-line check valve shall be installed by the manufacturer. Check valve is to be installed between the outlet of the pan loop and the coil per the piping diagram provided by the manufacturer.

16.1.3.2. All portions of the check valve and piping shall be held within the footprint of the drainpan.

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16.2. Water Defrost.
16.2.1. General
16.2.1.1. Coil shall be arranged for water defrosting.
16.2.2. Water Distribution Pans
16.2.2.1. Water shall be distributed evenly over the coil fin surfaces by means of water distribution pans.
16.2.2.2. Individual water distribution pans shall be provided one per fan section in the cooler.
16.2.2.3. Water distribution pans shall be removable for inspection and cleaning.
16.2.2.4. Defrost water flow shall be thermodynamically calculated and specified by coil manufacturer such that the flow rate is the minimum needed to heat the mass of coil metal and melt the frost.

16.3. Air Defrost.
16.3.1. Coil shall be arranged for air (off cycle) defrosting.
16.4. Electric Defrost.
16.4.1. General
16.4.1.1. Coil shall be arranged for electric defrosting.
16.4.2. Heating elements
16.4.2.1. Heating elements shall be tubular type, UL listed, with stainless steel sheath.
16.4.2.2. Elements shall be inserted into the fin collars, and spaced throughout the coil core such that the coil core is completely clear of frost and ice at the end of each defrost.

16.4.2.3. Heating elements shall be wired to a common NEMA 3R (minimum) panel.
16.4.2.4. Heated elements shall be attached to coil core by means of a self-centering spring that acts to reset the heater's position during each defrost (US Patent No. 7,712,327).

17. Packaging

17.1. Units shall be crated on a wooden skid constructed of no less than 2" x 8" timbers.
17.2. Units shall be crated fully assembled (including drainpan) in an upright position ready for mounting in the field.
17.3. Crating shall support the full weight of the evaporator.
17.4. Crating shall be removable by means of gravity only.

18. IOM Manuals

18.1. Installation, Operation, and Maintenance Manuals shall be provided. Number of copies and routings shall be provided per the requirements of the contract.

19. Approved Vendor

19.1. Approved Vendor: Colmac Coil Manufacturing, Inc. Model: A+L Series

20. Ordering Information

20.1. Please Specify:

20.1.1. Complete model number.
20.1.2. Saturated suction temperature.
20.1.3. Room temperature.
20.1.4. Overfeed ratio (if pump recirculated).
20.1.5. Options or special features.

21. Optional Features

1.1. Variable Fin Spacing

1.1.1. Coil core fins shall be arranged for highest frost capacity by varying the fin spacing for the air entering rows of tubes.
1.1.2. Fin spacing in fins per inch shall be specified according to contract.

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A+L Air Cooler (Cu Tube) Engineering Specifications

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   1.1. This specification covers "A+L" type air coolers having copper tubes and aluminum fins intended for use in refrigeration systems.

2. **Selection / Rating Method**
   2.1. Evaporators shall be selected using DT1 rating method.
   2.2. DTM rating method shall not be used.
   2.3. Evaporators shall be selected on the basis of room relative humidity as shown in the drawing.

3. **Tubing**
   3.1. Coil block shall be constructed with UNS C12200 copper tubing certified to ASTM B-75.
   3.2. Calculated working pressure of the coil tubing (per ASME Pressure Vessel Code Sec. VIII) shall be no less than 300 psig.
   3.3. Tubing shall be constructed from raw material that is made in the USA, as defined by material test reports, which are to be supplied upon customer request.

4. **Tube Pattern**
   4.1. Tube pattern shall be selected for optimum performance and defrost efficiency from one of the three patterns below:
      4.1.1. 5/8" OD - 1.5" x 1.299" equilateral staggered
      4.1.2. 5/8" OD – 1.97" (50 mm) inline
      4.1.3. 7/8" OD - 2.25" x 1.949" equilateral staggered

5. **Fins**
   5.1. Fins shall be selected from one of the four materials below, based on optimum performance in the operating environment.
      5.1.1. Aluminum 1100 alloy, no less than 0.010" (0.25 mm) thick.
      5.1.2. 304L stainless steel, no less than 0.010" " (0.25 mm) thick.
      5.1.3. Copper, no less than no less than 0.010" " (0.25 mm) thick.
   5.2. Fins shall be continuous flat or configured plate type with full length, self-spacing collars. Spiral, "L-foot", or wrap-on type fins shall not be allowed.
   5.3. Tubes shall be expanded into fin collars to form a tight mechanical bond between tube and fin.

6. **Headers**
   6.1. Headers shall be made of UNS C12200 Type L copper tubing certified to ASTM B-88.

7. **Connections**
   7.1. Liquid, suction, and hot gas connections shall be UNS C12200 Type L copper tubing certified to ASTM B-88. Bolted type flange union connections shall not be allowed.
   7.2. In the case of pumped bottom feed, liquid and hot gas connections shall be oriented vertically up.
   7.3. In the case of pumped bottom feed, liquid connection to coil header pipe shall be below the level of the lowest tube in the coil to effectively trap condensate during defrost.

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7.4. Coil connections shall be terminated with a brazed copper head at the factory. One "Schrader" type valve shall be provided by the manufacturer mounted at the factory in one of the coil connection terminations for the purpose of measuring the shipping charge upon arrival at the jobsite.

7.5. The manufacturer shall charge each coil with a shipping charge of 5-20 psig dry air or nitrogen. A label on the coil connection near the Schrader valve shall be provided indicating the factory charge pressure.

8. Cleanliness

8.1. The manufacturer shall insure that the coils are free from internal dirt, scale, and water.

9. Brazing/QC

9.1. All tube and header joints shall be made with high temperature brazing filler metal certified to no less than BCuP-3 (5% Silver Solder).
9.2. All brazing shall be performed by ASME certified brazers per the requirements of the manufacturer's BPS documents. Copies of all BPS, PQR, and Brazer Qualification documents used in the fabrication of the coil shall be made available to the engineer upon request.
9.3. Copies of the manufacturer's Quality Control Manual shall be made available to the engineer upon request.

10. Leak Testing

10.1. Coils shall be tested for leaks after brazing at no less than 350 psig (25 bar), dry air under water.
10.2. Test certificates for each coil shall be provided by the manufacturer to the engineer upon request.

11. Circuiting

11.1. <u>Types RT and RB (Recirc Top Feed and Recirc Bottom Feed)</u>
 11.1.1. Liquid overfeed orifices shall be installed at the entrance to each coil circuit, sized for a maximum 5 psi pressure drop at the design refrigerant flow rate.
 11.1.2. Units with vertical header arrangements shall have circuiting designed for parallel flow of refrigerant relative to direction of air flow.
 11.1.3. Units with horizontal header arrangements shall have circuiting designed for cross flow of refrigerant relative to the direction of air flow.

11.2. <u>Type FL (Gravity Flooded)</u>
 11.2.1. Units with vertical header arrangements shall have circuiting designed for parallel flow of refrigerant relative to direction of air flow.
 11.2.2. Units with horizontal header arrangements shall have circuiting designed for cross flow of refrigerant relative to the direction of air flow..

11.3. <u>Type DX (Direct Expansion)</u>
 11.3.1. Units with vertical header arrangements shall have circuiting designed for counter flow of refrigerant relative to direction of air flow to maximize suction gas superheat for best operation of thermostatic expansion valves.
 11.3.2. Units with horizontal header arrangements shall have circuiting designed for cross flow of refrigerant relative to direction of air flow. Circuits must have crossover circuiting to equalize circuit loading.

11.4. Type BW (Single Phase Liquids)

11.4.1. Units with vertical header arrangements shall have circuiting designed for counter flow of refrigerant relative to direction.

11.4.2. Units with horizontal header arrangements shall have circuiting designed for cross flow of refrigerant relative to direction of air flow. Circuits must have crossover circuiting to equalize circuit loading.

12. Fans

12.1. Construction.

12.1.1. Propeller fans shall be constructed of cast aluminum or non-ferrous polymer, as required by the contract.

12.1.2. Hub shall be removable type for ease of service. Integral fan/motor combinations with non-removable fans shall not be allowed.

12.1.3. Fans shall be true airfoil shape and shall be non-overloading type

12.2. Fan Guards.

12.2.1. Fans shall be fully guarded with OSHA approved wire guards.

12.3. Direction of Air Flow

12.3.1. Fans and motors shall be mounted on the air leaving side of the coil for draw through operation.

13. Fan Motors

13.1. Fan motors shall be standard NEMA frame size, inverter ready, integral horsepower, induction three phase, totally enclosed severe duty, with sealed ball bearings.

13.2. Motor service factor shall be no less than 1.15.

13.3. Motors shall have internal rotor construction. External rotor construction motors shall not be allowed.

13.4. Fan motors shall be individually wired by the manufacturer to individual junction boxes on the exterior of the unit cabinet.

14. Cabinet

14.1. General

14.1.1. Standard construction shall be of G90 mill Galvanized Steel, Alloy 5052 Aluminum, or 304L Stainless Steel as required in the contract. Painted or coated cabinet parts shall not be allowed.

14.2. Optional Smart Hanger System

14.2.1. When specified, units shall be provided with Colmac Smart Hanger brackets that will allow the unit to be suspended from pre-mounted structural channels provided by the manufacturer.

14.2.2. Hanger brackets shall be adjustable in the vertical direction to allow for various mounting heights.

14.3. Standard Air Section

14.3.1. Fans and motors shall be arranged for horizontal air discharge, mounted on the air leaving side of the coil section (draw through).

14.3.2. Fan panels shall be hinged to allow access for maintenance and cleaning.

14.4. 45 Degree Down Discharge Air Section

14.4.1. Fans and motors shall be arranged for 45 degree down air discharge when required by contract.

14.4.2. Air discharge section to be factory mounted on the air leaving side and tilted down at 45 degree angle from the vertical plane.

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14.5. Penthouse Air Section

14.5.1. Fan and motors shall be arranged for vertical down air discharge when required by the contract. Penthouse air section shall be factory mounted on the air leaving side of the coil section (draw through).

14.5.2. Access doors shall be provided to allow access to each individual fan and motor for service.

15. Drainpans

15.1. The inner drainpan shall be constructed of Alloy 5052 Aluminum.

15.2. Drainpan shall be designed to cover the coil section of the cooler cabinet.

15.3. Drainpan to be triple pitch, V-bottom design, such that water flows front to center, rear to center, and end to end to a single drain.

15.4. Drain outlet shall be constructed as a full radius, formed directly into the drain pan to eliminate the possibility of water pooling around the drain connection.

15.5. When required by the contract, drainpan shall be insulated with a minimum of 1" thick insulation.

15.5.1. The insulation shall be fully covered with a sheet metal insulation shield of mill galvanized steel, aluminum, or 304L stainless steel as required by the contract.

16. Defrost

16.1. Hot Gas Defrost

16.1.1. General

16.1.1.1. Coil shall be arranged for hot gas defrosting.

16.1.2. Pan Loop

16.1.2.1. A hot gas pan loop of round Alloy 3003 aluminum tubing shall be provided to warm the inner drainpan during defrost. Pan loop designs using square tubing or cross-sections other than round shall not be allowed.

16.1.2.1.1. Pan loop headers are to be held outside the ends of the drain pan to allow for full contact of the tubes with the pan.

16.1.2.1.2. The pan loop shall be attached to the underside of the inner drainpan by means of full length clips designed to keep the pan loop in tight contact with the pan by spring force. The pan loop shall not be mounted in the drainpan where it can contact the defrost water.

16.1.2.1.3. The pan loop outlet pipe shall be arranged such that a liquid seal is formed below the lowest hot gas pan tube.

16.1.3. Pan Loop Check Valve

16.1.3.1. When defrost condensate is being lifted into an overhead condensate return line, a properly sized in-line check valve shall be installed by the manufacturer. Check valve is to be installed between the outlet of the pan loop and the coil per the piping diagram provided by the manufacturer.

16.1.3.2. All portions of the check valve and piping shall be held within the footprint of the drainpan.

16.2. Water Defrost.

16.2.1. General

16.2.1.1. Coil shall be arranged for water defrosting.

16.2.2. Water Distribution Pans

16.2.2.1. Water shall be distributed evenly over the coil fin surfaces by means of water distribution pans.

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16.2.2.2. Individual water distribution pans shall be provided one per fan section in the cooler.
16.2.2.3. Water distribution pans shall be removable for inspection and cleaning.
16.2.2.4. Defrost water flow shall be thermodynamically calculated and specified by coil manufacturer such that the flow rate is the minimum needed to heat the mass of coil metal and melt the frost.

16.3. Air Defrost.
16.3.1. Coil shall be arranged for air (off cycle) defrosting.
16.4. Electric Defrost.
16.4.1. General
16.4.1.1. Coil shall be arranged for electric defrosting.
16.4.2. Heating elements
16.4.2.1. Heating elements shall be tubular type, UL listed, with stainless steel sheath.
16.4.2.2. Elements shall be inserted into the fin collars, and spaced throughout the coil core such that the coil core is completely clear of frost and ice at the end of each defrost.

16.4.2.3. Heating elements shall be wired to a common NEMA 3R (minimum) panel.
16.4.2.4. Heated elements shall be attached to coil core by means of a self-centering spring that acts to reset the heater's position during each defrost (US Patent No. 7,712,327).

17. Packaging
17.1. Units shall be crated on a wooden skid constructed of no less than 2" x 8" timbers.
17.2. Units shall be crated fully assembled (including drainpan) in an upright position ready for mounting in the field.
17.3. Crating shall support the full weight of the evaporator.
17.4. Crating shall be removable by means of gravity only.

18. IOM Manuals
18.1. Installation, Operation, and Maintenance Manuals shall be provided. Number of copies and routings shall be provided per the requirements of the contract.

19. Approved Vendor
19.1. Approved Vendor: Colmac Coil Manufacturing, Inc. Model: A+L Series

20. Ordering Information
20.1. Please Specify:
20.1.1. Complete model number.
20.1.2. Saturated suction temperature.
20.1.3. Room temperature.
20.1.4. Overfeed ratio (if pump recirculated).
20.1.5. Options or special features.

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21. Optional Features

1.1. Variable Fin Spacing

1.1.1. Coil core fins shall be arranged for highest frost capacity by varying the fin spacing for the air entering rows of tubes.

1.1.2. Fin spacing in fins per inch shall be specified according to contract.

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A+L Air Cooler (Galvanized) Engineering Specifications

1. **General**
   1.1. This specification covers "A+L" type air coolers having galvanized steel tubes and fins intended for use in refrigeration systems.

2. **Selection / Rating Method**
   2.1. Evaporators shall be selected using DT1 rating method.
   2.2. DTM rating method shall not be used.
   2.3. Evaporators shall be selected on the basis of room relative humidity as shown in the drawing.

3. **Tubing**
   3.1. Coil block shall be constructed with ASME SA-214 carbon steel tubing.
   3.2. Calculated working pressure of the coil tubing (per ASME Pressure Vessel Code Sec. VIII) shall be no less than 300 psig.
   3.3. Tubing shall be constructed from raw material that is made in the USA, as defined by material test reports, which are to be supplied upon customer request.

4. **Tube Pattern**
   4.1.1. Tube pattern shall be 7/8" OD - 2.25" x 1.949" equilateral staggered

5. **Fins**
   5.1. Shall be carbon steel, no less than 0.010" (0.25 mm) thick.
   5.2. Fins shall be continuous flat or configured plate type with full length, self-spacing collars. Spiral, "L-foot", or wrap-on type fins shall not be allowed.
   5.3. Fin collars shall be configured so that molten zinc completely bonds the tubes and fins.

6. **Headers**
   6.1. Headers shall be made of carbon steel pipe certified to ASME SA-106/B, no less than ANSI schedule 40.

7. **Connections**
   7.1. Liquid, suction, and hot gas connections shall be carbon steel pipe no less than schedule 40, certified to ASME SA-106/B. Bolted type flange union connections shall not be allowed.
   7.2. In the case of pumped bottom feed, liquid and hot gas connections shall be oriented vertically up.
   7.3. In the case of pumped bottom feed, liquid connection to coil header pipe shall be below the level of the lowest tube in the coil to effectively trap condensate during defrost.
   7.4. Coil connections shall be terminated with a welded steel head at the factory. One "Schrader" type valve shall be provided by the manufacturer mounted at the factory in one of the coil connection terminations for the purpose of measuring the shipping charge upon arrival at the jobsite.
   7.5. The manufacturer shall charge each coil with a shipping charge of 5-20 psig dry air or nitrogen. A label on the coil connection near the Schrader valve shall be provided indicating the factory charge pressure.

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8. Cleanliness

8.1. The manufacturer shall insure that the coils are free from internal dirt, scale, and water.

9. Welding/QC

9.1. All tube and header welds shall be made by Tungsten Inert Gas (TIG) welding process.
9.2. All welds shall be performed by ASME certified welders per the requirements of the manufacturer's WPS documents. Copies of all WPS, PQR, and Welder Qualification documents used in the fabrication of the coil shall be made available to the engineer upon request.
9.3. Copies of the manufacturer's Quality Control Manual shall be made available to the engineer upon request.

10. Leak Testing

10.1. Coils shall be tested for leaks after welding at no less than 500 psig (35 bar), dry air under water.
10.2. Test certificates for each coil shall be provided by the manufacturer to the engineer upon request.

11. Circuiting

11.1. <u>Types RT and RB (Recirc Top Feed and Recirc Bottom Feed)</u>
11.1.1. Liquid overfeed orifices shall be installed at the entrance to each coil circuit, sized for a maximum 5 psi pressure drop at the design refrigerant flow rate.
11.1.2. Units with vertical header arrangements shall have circuiting designed for parallel flow of refrigerant relative to direction of air flow.
11.1.3. Units with horizontal header arrangements shall have circuiting designed for cross flow of refrigerant relative to the direction of air flow.
11.2. <u>Type FL (Gravity Flooded)</u>
11.2.1. Units with vertical header arrangements shall have circuiting designed for parallel flow of refrigerant relative to direction of air flow.
11.2.2. Units with horizontal header arrangements shall have circuiting designed for cross flow of refrigerant relative to the direction of air flow.
11.3. <u>Type DX (Direct Expansion)</u>
11.3.1. Units with vertical header arrangements shall have circuiting designed for counter flow of refrigerant relative to direction of air flow to maximize suction gas superheat for best operation of thermostatic expansion valves.
11.3.2. Units with horizontal header arrangements shall have circuiting designed for cross flow of refrigerant relative to direction of air flow. Circuits must have crossover circuiting to equalize circuit loading.
11.4. <u>Type BW (Single Phase Liquids)</u>
11.4.1. Units with vertical header arrangements shall have circuiting designed for counter flow of refrigerant relative to direction.
11.4.2. Units with horizontal header arrangements shall have circuiting designed for cross flow of refrigerant relative to direction of air flow. Circuits must have crossover circuiting to equalize circuit loading.

12. Galvanizing

12.1. Carbon steel coil core to be hot-dip galvanized per ASTM A-123 for corrosion protection.

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13. Fans

13.1. Construction.

13.1.1. Propeller fans shall be constructed of cast aluminum or non-ferrous polymer, as required by the contract.

13.1.2. Hub shall be removable type for ease of service. Integral fan/motor combinations with non-removable fans shall not be allowed.

13.1.3. Fans shall be true airfoil shape and shall be non-overloading type

13.2. Fan Guards.

13.2.1. Fans shall be fully guarded with OSHA approved wire guards.

13.3. Direction of Air Flow

13.3.1. Fans and motors shall be mounted on the air leaving side of the coil for draw through operation.

14. Fan Motors

14.1. Fan motors shall be standard NEMA frame size, inverter ready, integral horsepower, induction three phase, totally enclosed severe duty, with sealed ball bearings.

14.2. Motor service factor shall be no less than 1.15.

14.3. Motors shall have internal rotor construction. External rotor construction motors shall not be allowed.

14.4. Fan motors shall be individually wired by the manufacturer to individual junction boxes on the exterior of the unit cabinet.

15. Cabinet

15.1. General

15.1.1. Standard construction shall be of G90 mill Galvanized Steel, Alloy 5052 Aluminum, or 304L Stainless Steel as required in the contract. Painted or coated cabinet parts shall not be allowed.

15.2. Optional Smart Hanger System

15.2.1. When specified, units shall be provided with Colmac Smart Hanger brackets that will allow the unit to be suspended from pre-mounted structural channels provided by the manufacturer.

15.2.2. Hanger brackets shall be adjustable in the vertical direction to allow for various mounting heights.

15.3. Standard Air Section

15.3.1. Fans and motors shall be arranged for horizontal air discharge, mounted on the air leaving side of the coil section (draw through).

15.3.2. Fan panels shall be hinged to allow access for maintenance and cleaning.

15.4. 45 Degree Down Discharge Air Section

15.4.1. Fans and motors shall be arranged for 45 degree down air discharge when required by contract.

15.4.2. Air discharge section to be factory mounted on the air leaving side and tilted down at 45 degree angle from the vertical plane.

15.5. Penthouse Air Section

15.5.1. Fan and motors shall be arranged for vertical down air discharge when required by the contract. Penthouse air section shall be factory mounted on the air leaving side of the coil section (draw through).

15.5.2. Access doors shall be provided to allow access to each individual fan and motor for service.

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16. Drainpans

16.1. The inner drainpan shall be constructed of Alloy 5052 Aluminum.

16.2. Drainpan shall be designed to cover the coil section of the cooler cabinet.

16.3. Drainpan to be triple pitch, V-bottom design, such that water flows front to center, rear to center, and end to end to a single drain.

16.4. Drain outlet shall be constructed as a full radius, formed directly into the drain pan to eliminate the possibility of water pooling around the drain connection.

16.5. When required by the contract, drainpan shall be insulated with a minimum of 1" thick insulation.

16.5.1. The insulation shall be fully covered with a sheet metal insulation shield of mill galvanized steel, aluminum, or 304L stainless steel as required by the contract.

17. Defrost

17.1. Hot Gas Defrost

17.1.1. General

17.1.1.1. Coil shall be arranged for hot gas defrosting.

17.1.2. Pan Loop

17.1.2.1. A hot gas pan loop of round Alloy 3003 aluminum tubing shall be provided to warm the inner drainpan during defrost. Pan loop designs using square tubing or cross-sections other than round shall not be allowed.

17.1.2.1.1. Pan loop headers are to be held outside the ends of the drain pan to allow for full contact of the tubes with the pan.

17.1.2.1.2. The pan loop shall be attached to the underside of the inner drainpan by means of full length clips designed to keep the pan loop in tight contact with the pan by spring force. The pan loop shall not be mounted in the drainpan where it can contact the defrost water.

17.1.2.1.3. The pan loop outlet pipe shall be arranged such that a liquid seal is formed below the lowest hot gas pan tube.

17.1.3. Pan Loop Check Valve

17.1.3.1. When defrost condensate is being lifted into an overhead condensate return line, a properly sized in-line check valve shall be installed by the manufacturer. Check valve is to be installed between the outlet of the pan loop and the coil per the piping diagram provided by the manufacturer.

17.1.3.2. All portions of the check valve and piping shall be held within the footprint of the drainpan.

17.2. Water Defrost.

17.2.1. General

17.2.1.1. Coil shall be arranged for water defrosting.

17.2.2. Water Distribution Pans

17.2.2.1. Water shall be distributed evenly over the coil fin surfaces by means of water distribution pans.

17.2.2.2. Individual water distribution pans shall be provided one per fan section in the cooler.

17.2.2.3. Water distribution pans shall be removable for inspection and cleaning.

17.2.2.4. Defrost water flow shall be thermodynamically calculated and specified by coil manufacturer such that the flow rate is the minimum needed to heat the mass of coil metal and melt the frost.

17.3. Air Defrost.

17.3.1. Coil shall be arranged for air (off cycle) defrosting.

17.4. Electric Defrost.

17.4.1. General

17.4.1.1. Coil shall be arranged for electric defrosting.

17.4.2. Heating elements

17.4.2.1. Heating elements shall be tubular type, UL listed, with stainless steel sheath.

17.4.2.2. Elements shall be inserted into the fin collars, and spaced throughout the coil core such that the coil core is completely clear of frost and ice at the end of each defrost.

17.4.2.3. Heating elements shall be wired to a common NEMA 3R (minimum) panel.

17.4.2.4. Heated elements shall be attached to coil core by means of a self-centering spring that acts to reset the heater's position during each defrost (US Patent No. 7,712,327).

18. Packaging

18.1. Units shall be crated on a wooden skid constructed of no less than 2" x 8" timbers.

18.2. Units shall be crated fully assembled (including drainpan) in an upright position ready for mounting in the field.

18.3. Crating shall support the full weight of the evaporator.

18.4. Crating shall be removable by means of gravity only.

19. IOM Manuals

19.1. Installation, Operation, and Maintenance Manuals shall be provided. Number of copies and routings shall be provided per the requirements of the contract.

20. Approved Vendor

20.1. Approved Vendor: Colmac Coil Manufacturing, Inc. Model: A+L Series

21. Ordering Information

21.1. Please Specify:

21.1.1. Complete model number.

21.1.2. Saturated suction temperature.

21.1.3. Room temperature.

21.1.4. Overfeed ratio (if pump recirculated).

21.1.5. Options or special features.

22. Optional Features

1.1. Variable Fin Spacing

1.1.1. Coil core fins shall be arranged for highest frost capacity by varying the fin spacing for the air entering rows of tubes.

1.1.2. Fin spacing in fins per inch shall be specified according to contract.

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A+L Air Cooler (SST Tube) Engineering Specifications

1. **General**
   1.1. This specification covers “A+L” type air coolers having stainless steel tubes and aluminum fins intended for use in refrigeration systems.

2. **Selection / Rating Method**
   2.1. Evaporators shall be selected using DT1 rating method.
   2.2. DTM rating method shall not be used.
   2.3. Evaporators shall be selected on the basis of room relative humidity as shown in the drawing.

3. **Tubing**
   3.1. Coil block shall be constructed with 304L stainless steel tubing.
   3.2. Calculated working pressure of the coil tubing (per ASME Pressure Vessel Code Sec. VIII) shall be no less than 300 psig.
   3.3. Tubing shall be constructed from raw material that is made in the USA, as defined by material test reports, which are to be supplied upon customer request.

4. **Tube Pattern**
   4.1. Tube pattern shall be selected for optimum performance and defrost efficiency from one of the three patterns below:
      4.1.1. 5/8” OD - 1.5” x 1.299” equilateral staggered
      4.1.2. 5/8” OD – 1.97” (50 mm) inline
      4.1.3. 7/8” OD - 2.25” x 1.949” equilateral staggered

5. **Fins**
   5.1. Fins shall be selected from one of the four materials below, based on optimum performance in the operating environment.
      5.1.1. Aluminum 1100 alloy, no less than 0.010” (0.25 mm) thick.
      5.1.2. 304L stainless steel, no less than 0.010” ” (0.25 mm) thick.
      5.1.3. Colmac Anti-Microbial alloy, no less than 0.010” ” (0.25 mm) thick.
         5.1.3.1. Coil core fins shall be constructed of a metal alloy that exhibits anti-microbial properties.
         5.1.3.2. Fins shall completely cover the coil tube surfaces exposed to the airstream by means of a full-length self-spacing fin collar.
         5.1.3.3. Coil coatings are not allowed. All surfaces to be a base metal alloy.
   5.2. Fins shall be continuous flat or configured plate type with full length, self-spacing collars. Spiral, “L-foot”, or wrap-on type fins shall not be allowed.
   5.3. Tubes shall be expanded into fin collars to form a tight mechanical bond between tube and fin.

6. **Headers**
   6.1. Headers shall be made of 304L stainless steel pipe certified to ASME SA-240/304L, no less than ANSI schedule 40.

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7. Connections

7.1. Liquid, suction, and hot gas connections shall be carbon steel pipe no less than schedule 40, certified to ASME SA-240/304L. Bolted type flange union connections shall not be allowed.

7.2. In the case of pumped bottom feed, liquid and hot gas connections shall be oriented vertically up.

7.3. In the case of pumped bottom feed, liquid connection to coil header pipe shall be below the level of the lowest tube in the coil to effectively trap condensate during defrost.

7.4. Coil connections shall be terminated with a welded steel head at the factory. One "Schrader" type valve shall be provided by the manufacturer mounted at the factory in one of the coil connection terminations for the purpose of measuring the shipping charge upon arrival at the jobsite.

7.5. The manufacturer shall charge each coil with a shipping charge of 5-20 psig dry air or nitrogen. A label on the coil connection near the Schrader valve shall be provided indicating the factory charge pressure.

8. Cleanliness

8.1. The manufacturer shall insure that the coils are free from internal dirt, scale, and water.

9. Welding/QC

9.1. All tube and header welds shall be made by Tungsten Inert Gas (TIG) welding process.

9.2. All welds shall be performed by ASME certified welders per the requirements of the manufacturer's WPS documents. Copies of all WPS, PQR, and Welder Qualification documents used in the fabrication of the coil shall be made available to the engineer upon request.

9.3. Copies of the manufacturer's Quality Control Manual shall be made available to the engineer upon request.

10. Leak Testing

10.1. Coils shall be tested for leaks after welding at no less than 500 psig (35 bar), dry air under water.

10.2. Test certificates for each coil shall be provided by the manufacturer to the engineer upon request.

11. Circuiting

11.1. <u>Types RT and RB (Recirc Top Feed and Recirc Bottom Feed)</u>

11.1.1. Liquid overfeed orifices shall be installed at the entrance to each coil circuit, sized for a maximum 5 psi pressure drop at the design refrigerant flow rate.

11.1.2. Units with vertical header arrangements shall have circuiting designed for parallel flow of refrigerant relative to direction of air flow.

11.1.3. Units with horizontal header arrangements shall have circuiting designed for cross flow of refrigerant relative to the direction of air flow.

11.2. <u>Type FL (Gravity Flooded)</u>

11.2.1. Units with vertical header arrangements shall have circuiting designed for parallel flow of refrigerant relative to direction of air flow.

11.2.2. Units with horizontal header arrangements shall have circuiting designed for cross flow of refrigerant relative to the direction of air flow..

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11.3. Type DX (Direct Expansion)
- 11.3.1. Units with vertical header arrangements shall have circuiting designed for counter flow of refrigerant relative to direction of air flow to maximize suction gas superheat for best operation of thermostatic expansion valves.
- 11.3.2. Units with horizontal header arrangements shall have circuiting designed for cross flow of refrigerant relative to direction of air flow. Circuits must have crossover circuiting to equalize circuit loading.

11.4. Type BW (Single Phase Liquids)
- 11.4.1. Units with vertical header arrangements shall have circuiting designed for counter flow of refrigerant relative to direction.
- 11.4.2. Units with horizontal header arrangements shall have circuiting designed for cross flow of refrigerant relative to direction of air flow. Circuits must have crossover circuiting to equalize circuit loading.

12. Fans

12.1. Construction.
- 12.1.1. Propeller fans shall be constructed of cast aluminum or non-ferrous polymer, as required by the contract.
- 12.1.2. Hub shall be removable type for ease of service. Integral fan/motor combinations with non-removable fans shall not be allowed.
- 12.1.3. Fans shall be true airfoil shape and shall be non-overloading type

12.2. Fan Guards.
- 12.2.1. Fans shall be fully guarded with OSHA approved wire guards.

12.3. Direction of Air Flow
- 12.3.1. Fans and motors shall be mounted on the air leaving side of the coil for draw through operation.

13. Fan Motors

13.1. Fan motors shall be standard NEMA frame size, inverter ready, integral horsepower, induction three phase, totally enclosed severe duty, with sealed ball bearings.

13.2. Motor service factor shall be no less than 1.15.

13.3. Motors shall have internal rotor construction. External rotor construction motors shall not be allowed.

13.4. Fan motors shall be individually wired by the manufacturer to individual junction boxes on the exterior of the unit cabinet.

14. Cabinet

14.1. General
- 14.1.1. Standard construction shall be of G90 mill Galvanized Steel, Alloy 5052 Aluminum, or 304L Stainless Steel as required in the contract. Painted or coated cabinet parts shall not be allowed.

14.2. Optional Smart Hanger System
- 14.2.1. When specified, units shall be provided with Colmac Smart Hanger brackets that will allow the unit to be suspended from pre-mounted structural channels provided by the manufacturer.
- 14.2.2. Hanger brackets shall be adjustable in the vertical direction to allow for various mounting heights.

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14.3. Standard Air Section

14.3.1. Fans and motors shall be arranged for horizontal air discharge, mounted on the air leaving side of the coil section (draw through).

14.3.2. Fan panels shall be hinged to allow access for maintenance and cleaning.

14.4. 45 Degree Down Discharge Air Section

14.4.1. Fans and motors shall be arranged for 45 degree down air discharge when required by contract.

14.4.2. Air discharge section to be factory mounted on the air leaving side and tilted down at 45 degree angle from the vertical plane.

14.5. Penthouse Air Section

14.5.1. Fan and motors shall be arranged for vertical down air discharge when required by the contract. Penthouse air section shall be factory mounted on the air leaving side of the coil section (draw through).

14.5.2. Access doors shall be provided to allow access to each individual fan and motor for service.

15. Drainpans

15.1. The inner drainpan shall be constructed of Alloy 5052 Aluminum.

15.2. Drainpan shall be designed to cover the coil section of the cooler cabinet.

15.3. Drainpan to be triple pitch, V-bottom design, such that water flows front to center, rear to center, and end to end to a single drain.

15.4. Drain outlet shall be constructed as a full radius, formed directly into the drain pan to eliminate the possibility of water pooling around the drain connection.

15.5. When required by the contract, drainpan shall be insulated with a minimum of 1" thick insulation.

15.5.1. The insulation shall be fully covered with a sheet metal insulation shield of mill galvanized steel, aluminum, or 304L stainless steel as required by the contract.

16. Defrost

16.1. Hot Gas Defrost

16.1.1. General

16.1.1.1. Coil shall be arranged for hot gas defrosting.

16.1.2. Pan Loop

16.1.2.1. A hot gas pan loop of round Alloy 3003 aluminum tubing shall be provided to warm the inner drainpan during defrost. Pan loop designs using square tubing or cross-sections other than round shall not be allowed.

16.1.2.1.1. Pan loop headers are to be held outside the ends of the drain pan to allow for full contact of the tubes with the pan.

16.1.2.1.2. The pan loop shall be attached to the underside of the inner drainpan by means of full length clips designed to keep the pan loop in tight contact with the pan by spring force. The pan loop shall not be mounted in the drainpan where it can contact the defrost water.

16.1.2.1.3. The pan loop outlet pipe shall be arranged such that a liquid seal is formed below the lowest hot gas pan tube.

16.1.3. Pan Loop Check Valve

16.1.3.1. When defrost condensate is being lifted into an overhead condensate return line, a properly sized in-line check valve shall be installed by the manufacturer. Check valve is to be installed between the outlet of the pan loop and the coil per the piping diagram provided by the manufacturer.

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16.1.3.2. All portions of the check valve and piping shall be held within the footprint of the drainpan.

16.2. Water Defrost.

16.2.1. General

16.2.1.1. Coil shall be arranged for water defrosting.

16.2.2. Water Distribution Pans

16.2.2.1. Water shall be distributed evenly over the coil fin surfaces by means of water distribution pans.

16.2.2.2. Individual water distribution pans shall be provided one per fan section in the cooler.

16.2.2.3. Water distribution pans shall be removable for inspection and cleaning.

16.2.2.4. Defrost water flow shall be thermodynamically calculated and specified by coil manufacturer such that the flow rate is the minimum needed to heat the mass of coil metal and melt the frost.

16.3. Air Defrost.

16.3.1. Coil shall be arranged for air (off cycle) defrosting.

16.4. Electric Defrost.

16.4.1. General

16.4.1.1. Coil shall be arranged for electric defrosting.

16.4.2. Heating elements

16.4.2.1. Heating elements shall be tubular type, UL listed, with stainless steel sheath.

16.4.2.2. Elements shall be inserted into the fin collars, and spaced throughout the coil core such that the coil core is completely clear of frost and ice at the end of each defrost.

16.4.2.3. Heating elements shall be wired to a common NEMA 3R (minimum) panel.

16.4.2.4. Heated elements shall be attached to coil core by means of a self-centering spring that acts to reset the heater's position during each defrost (US Patent No. 7,712,327).

17. Packaging

17.1. Units shall be crated on a wooden skid constructed of no less than 2" x 8" timbers.

17.2. Units shall be crated fully assembled (including drainpan) in an upright position ready for mounting in the field.

17.3. Crating shall support the full weight of the evaporator.

17.4. Crating shall be removable by means of gravity only.

18. IOM Manuals

18.1. Installation, Operation, and Maintenance Manuals shall be provided. Number of copies and routings shall be provided per the requirements of the contract.

19. Approved Vendor

19.1. Approved Vendor: Colmac Coil Manufacturing, Inc. Model: A+L Series

20. Ordering Information

20.1. Please Specify:

20.1.1. Complete model number.

20.1.2. Saturated suction temperature.

20.1.3. Room temperature.

20.1.4. Overfeed ratio (if pump recirculated).

20.1.5. Options or special features.

21. Optional Features

1.1. Variable Fin Spacing

1.1.1. Coil core fins shall be arranged for highest frost capacity by varying the fin spacing for the air entering rows of tubes.

1.1.2. Fin spacing in fins per inch shall be specified according to contract.

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A+M Air Cooler (AL Tube) Engineering Specifications

1. **General**
   1.1. This specification covers “A+M” type air coolers having aluminum tubes and aluminum fins intended for use in refrigeration systems.

2. **Selection / Rating Method**
   2.1. Evaporators shall be selected using DT1 rating method.
   2.2. DTM rating method shall not be used.
   2.3. Evaporators shall be selected on the basis of room relative humidity as shown in the drawing.

3. **Tubing**
   3.1. Coil block shall be constructed with alloy 3003 aluminum tubing.
   3.2. Calculated working pressure of the coil tubing (per ASME Pressure Vessel Code Sec. VIII) shall be no less than 300 psig.
   3.3. Tubing shall be constructed from raw material that is made in the USA, as defined by material test reports, which are to be supplied upon customer request.

4. **Tube Pattern**
   4.1. Tube pattern shall be selected for optimum performance and defrost efficiency from one of the three patterns below:
      4.1.1. 5/8” OD - 1.5” x 1.299” equilateral staggered
      4.1.2. 5/8” OD – 1.97” (50 mm) inline
      4.1.3. 7/8” OD - 2.25” x 1.949” equilateral staggered

5. **Fins**
   5.1. Shall be aluminum 1100 alloy, no less than 0.010” (0.25 mm) thick.
   5.2. Fins shall be continuous flat or configured plate type with full length, self-spacing collars. Spiral, “L-foot”, or wrap-on type fins shall not be allowed.
   5.3. Tubes shall be expanded into fin collars to form a tight mechanical bond between tube and fin.

6. **Headers**
   6.1. Headers shall be made of ASME B241, Alloy 6061 aluminum no less than ANSI schedule 40 pipes.

7. **Connections**
   7.1. Liquid, suction, and hot gas connections shall be carbon steel pipe no less than schedule 40, certified to ASME SA-106/B. Bolted type flange union connections shall not be allowed.
   7.2. In the case of pumped bottom feed, liquid and hot gas connections shall be oriented vertically up.
   7.3. In the case of pumped bottom feed, liquid connection to coil header pipe shall be below the level of the lowest tube in the coil to effectively trap condensate during defrost.
   7.4. Coil connections shall be terminated with a welded steel head at the factory. One “Schrader” type valve shall be provided by the manufacturer mounted at the factory in one of the coil connection terminations for the purpose of measuring the shipping

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charge upon arrival at the jobsite.

7.5. The manufacturer shall charge each coil with a shipping charge of 5-20 psig dry air or nitrogen. A label on the coil connection near the Schrader valve shall be provided indicating the factory charge pressure.

8. Cleanliness

8.1. The manufacturer shall insure that the coils are free from internal dirt, scale, and water.

9. Welding/QC

9.1. All tube welds shall be made by Tungsten Inert Gas (TIG) welding process.

9.2. All welds shall be performed by ASME certified welders per the requirements of the manufacturer's WPS documents. Copies of all WPS, PQR, and Welder Qualification documents used in the fabrication of the coil shall be made available to the engineer upon request.

9.3. Copies of the manufacturer's Quality Control Manual shall be made available to the engineer upon request.

10. Leak Testing

10.1. Coils shall be tested for leaks after welding at no less than 500 psig (35 bar), dry air under water.

10.2. Test certificates for each coil shall be provided by the manufacturer to the engineer upon request.

11. Circuiting

11.1. <u>Types RT and RB (Recirc Top Feed and Recirc Bottom Feed)</u>

11.1.1. Liquid overfeed orifices shall be installed at the entrance to each coil circuit, sized for a maximum 5 psi pressure drop at the design refrigerant flow rate.

11.1.2. Units with vertical header arrangements shall have circuiting designed for parallel flow of refrigerant relative to direction of air flow.

11.1.3. Units with horizontal header arrangements shall have circuiting designed for cross flow of refrigerant relative to the direction of air flow.

11.2. <u>Type FL (Gravity Flooded)</u>

11.2.1. Units with vertical header arrangements shall have circuiting designed for parallel flow of refrigerant relative to direction of air flow.

11.2.2. Units with horizontal header arrangements shall have circuiting designed for cross flow of refrigerant relative to the direction of air flow..

11.3. <u>Type DX (Direct Expansion)</u>

11.3.1. Units with vertical header arrangements shall have circuiting designed for counter flow of refrigerant relative to direction of air flow to maximize suction gas superheat for best operation of thermostatic expansion valves.

11.3.2. Units with horizontal header arrangements shall have circuiting designed for cross flow of refrigerant relative to direction of air flow. Circuits must have crossover circuiting to equalize circuit loading.

11.4. <u>Type BW (Single Phase Liquids)</u>

11.4.1. Units with vertical header arrangements shall have circuiting designed for counter flow of refrigerant relative to direction.

11.4.2. Units with horizontal header arrangements shall have circuiting designed for cross flow of refrigerant relative to direction of air flow. Circuits must have crossover circuiting to equalize circuit loading.

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12. Fans

12.1. Construction.

12.1.1. Propeller fans shall be constructed of cast aluminum or non-ferrous polymer, as required by the contract.

12.1.2. Hub shall be removable type for ease of service. Integral fan/motor combinations with non-removable fans shall not be allowed.

12.1.3. Fans shall be true airfoil shape and shall be non-overloading type

12.2. Fan Guards.

12.2.1. Fans shall be fully guarded with OSHA approved wire guards.

12.3. Direction of Air Flow

12.3.1. Fans and motors shall be mounted on the air leaving side of the coil for draw through operation.

13. Fan Motors

13.1. Fan motors shall be standard NEMA frame size, inverter ready, integral horsepower, induction three phase, totally enclosed severe duty, with sealed ball bearings.

13.2. Motor service factor shall be no less than 1.15.

13.3. Motors shall have internal rotor construction. External rotor construction motors shall not be allowed.

13.4. Fan motors shall be individually wired by the manufacturer to individual junction boxes on the exterior of the unit cabinet.

14. Cabinet

14.1. General

14.1.1. Standard construction shall be of G90 mill Galvanized Steel, Alloy 5052 Aluminum, or 304L Stainless Steel as required in the contract. Painted or coated cabinet parts shall not be allowed.

14.2. Optional Smart Hanger System

14.2.1. When specified, units shall be provided with Colmac Smart Hanger brackets that will allow the unit to be suspended from pre-mounted structural channels provided by the manufacturer.

14.2.2. Hanger brackets shall be adjustable in the vertical direction to allow for various mounting heights.

14.3. Standard Air Section

14.3.1. Fans and motors shall be arranged for horizontal air discharge, mounted on the air leaving side of the coil section (draw through).

14.4. 45 Degree Down Discharge Air Section

14.4.1. Fans and motors shall be arranged for 45 degree down air discharge when required by contract.

14.4.2. Air discharge section to be factory mounted on the air leaving side and tilted down at 45 degree angle from the vertical plane.

14.5. Penthouse Air Section

14.5.1. Fan and motors shall be arranged for vertical down air discharge when required by the contract. Penthouse air section shall be factory mounted on the air leaving side of the coil section (draw through).

14.5.2. Access doors shall be provided to allow access to each individual fan and motor for service.

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15. Drainpans

15.1. The inner drainpan shall be constructed of Alloy 5052 Aluminum.

15.2. Drainpan shall be designed to cover the coil section of the cooler cabinet.

15.3. Drainpan to be triple pitch, V-bottom design, such that water flows front to center, rear to center, and end to end to a single drain.

15.4. Drain outlet shall be constructed as a full radius, formed directly into the drain pan to eliminate the possibility of water pooling around the drain connection.

15.5. When required by the contract, drainpan shall be insulated with a minimum of 1" thick insulation.

15.5.1. The insulation shall be fully covered with a sheet metal insulation shield of mill galvanized steel, aluminum, or 304L stainless steel as required by the contract.

16. Defrost

16.1. Hot Gas Defrost

16.1.1. General

16.1.1.1. Coil shall be arranged for hot gas defrosting.

16.1.2. Pan Loop

16.1.2.1. A hot gas pan loop of round Alloy 3003 aluminum tubing shall be provided to warm the inner drainpan during defrost. Pan loop designs using square tubing or cross-sections other than round shall not be allowed.

16.1.2.1.1. Pan loop headers are to be held outside the ends of the drain pan to allow for full contact of the tubes with the pan.

16.1.2.1.2. The pan loop shall be attached to the underside of the inner drainpan by means of full length clips designed to keep the pan loop in tight contact with the pan by spring force. The pan loop shall not be mounted in the drainpan where it can contact the defrost water.

16.1.2.1.3. The pan loop outlet pipe shall be arranged such that a liquid seal is formed below the lowest hot gas pan tube.

16.1.3. Pan Loop Check Valve

16.1.3.1. When defrost condensate is being lifted into an overhead condensate return line, a properly sized in-line check valve shall be installed by the manufacturer. Check valve is to be installed between the outlet of the pan loop and the coil per the piping diagram provided by the manufacturer.

16.1.3.2. All portions of the check valve and piping shall be held within the footprint of the drainpan.

16.2. Water Defrost.

16.2.1. General

16.2.1.1. Coil shall be arranged for water defrosting.

16.2.2. Water Distribution Pans

16.2.2.1. Water shall be distributed evenly over the coil fin surfaces by means of water distribution pans.

16.2.2.2. Individual water distribution pans shall be provided one per fan section in the cooler.

16.2.2.3. Water distribution pans shall be removable for inspection and cleaning.

16.2.2.4. Defrost water flow shall be thermodynamically calculated and specified by coil manufacturer such that the flow rate is the minimum needed to heat the mass of coil metal and melt the frost.

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16.3. Air Defrost.
16.3.1. Coil shall be arranged for air (off cycle) defrosting.
16.4. Electric Defrost.
16.4.1. General
16.4.1.1. Coil shall be arranged for electric defrosting.
16.4.2. Heating elements
16.4.2.1. Heating elements shall be tubular type, UL listed, with stainless steel sheath.
16.4.2.2. Elements shall be inserted into the fin collars, and spaced throughout the coil core such that the coil core is completely clear of frost and ice at the end of each defrost.

16.4.2.3. Heating elements shall be wired to a common NEMA 3R (minimum) panel.
16.4.2.4. Heated elements shall be attached to coil core by means of a self-centering spring that acts to reset the heater's position during each defrost (US Patent No. 7,712,327).

17. Packaging
17.1. Units shall be crated on a wooden skid constructed of no less than 2" x 8" timbers.
17.2. Units shall be crated fully assembled (including drainpan) in an upright position ready for mounting in the field.
17.3. Crating shall support the full weight of the evaporator.
17.4. Crating shall be removable by means of gravity only.

18. IOM Manuals
18.1. Installation, Operation, and Maintenance Manuals shall be provided. Number of copies and routings shall be provided per the requirements of the contract.

19. Approved Vendor
19.1. Approved Vendor: Colmac Coil Manufacturing, Inc. Model: A+M Series

20. Ordering Information
20.1. Please Specify:
20.1.1. Complete model number.
20.1.2. Saturated suction temperature.
20.1.3. Room temperature.
20.1.4. Overfeed ratio (if pump recirculated).
20.1.5. Options or special features.

21. Optional Features

1.1. Variable Fin Spacing
1.1.1. Coil core fins shall be arranged for highest frost capacity by varying the fin spacing for the air entering rows of tubes.
1.1.2. Fin spacing in fins per inch shall be specified according to contract.

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A+M Air Cooler (Cu Tube) Engineering Specifications

1. **General**
   1.1. This specification covers “A+M” type air coolers having copper tubes and aluminum fins intended for use in refrigeration systems.

2. **Selection / Rating Method**
   2.1. Evaporators shall be selected using DT1 rating method.
   2.2. DTM rating method shall not be used.
   2.3. Evaporators shall be selected on the basis of room relative humidity as shown in the drawing.

3. **Tubing**
   3.1. Coil block shall be constructed with UNS C12200 copper tubing certified to ASTM B-75.
   3.2. Calculated working pressure of the coil tubing (per ASME Pressure Vessel Code Sec. VIII) shall be no less than 300 psig.
   3.3. Tubing shall be constructed from raw material that is made in the USA, as defined by material test reports, which are to be supplied upon customer request.

4. **Tube Pattern**
   4.1. Tube pattern shall be selected for optimum performance and defrost efficiency from one of the three patterns below:
      4.1.1. 5/8” OD - 1.5” x 1.299” equilateral staggered
      4.1.2. 5/8” OD – 1.97” (50 mm) inline
      4.1.3. 7/8” OD - 2.25” x 1.949” equilateral staggered

5. **Fins**
   5.1. Fins shall be selected from one of the four materials below based on optimum performance and the environment in which the cooler will operate.
      5.1.1. Aluminum 1100 alloy, no less than 0.010” (0.25 mm) thick.
      5.1.2. 304L stainless steel, no less than 0.010” ” (0.25 mm) thick.
      5.1.3. Copper, no less than no less than 0.010” ” (0.25 mm) thick.
   5.2. Fins shall be continuous flat or configured plate type with full length, self-spacing collars. Spiral, “L-foot”, or wrap-on type fins shall not be allowed.
   5.3. Tubes shall be expanded into fin collars to form a tight mechanical bond between tube and fin.

6. **Headers**
   6.1. Headers shall be made of UNS C12200 Type L copper tubing certified to ASTM B-88.

7. **Connections**
   7.1. Liquid, suction, and hot gas connections shall be UNS C12200 Type L copper tubing certified to ASTM B-88. Bolted type flange union connections shall not be allowed.
   7.2. In the case of pumped bottom feed, liquid and hot gas connections shall be oriented vertically up.
   7.3. In the case of pumped bottom feed, liquid connection to coil header pipe shall be below the level of the lowest tube in the coil to effectively trap condensate during defrost.

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7.4. Coil connections shall be terminated with a brazed copper head at the factory. One "Schrader" type valve shall be provided by the manufacturer mounted at the factory in one of the coil connection terminations for the purpose of measuring the shipping charge upon arrival at the jobsite.

7.5. The manufacturer shall charge each coil with a shipping charge of 5-20 psig dry air or nitrogen. A label on the coil connection near the Schrader valve shall be provided indicating the factory charge pressure.

8. Cleanliness

8.1. The manufacturer shall insure that the coils are free from internal dirt, scale, and water.

9. Brazing/QC

9.1. All tube and header joints shall be made with high temperature brazing filler metal certified to no less than BCuP-3 (5% Silver Solder).
9.2. All brazing shall be performed by ASME certified brazers per the requirements of the manufacturer's BPS documents. Copies of all BPS, PQR, and Brazer Qualification documents used in the fabrication of the coil shall be made available to the engineer upon request.
9.3. Copies of the manufacturer's Quality Control Manual shall be made available to the engineer upon request.

10. Leak Testing

10.1. Coils shall be tested for leaks after brazing at no less than 350 psig (25 bar), dry air under water.
10.2. Test certificates for each coil shall be provided by the manufacturer to the engineer upon request.

11. Circuiting

11.1. <u>Types RT and RB (Recirc Top Feed and Recirc Bottom Feed)</u>
11.1.1. Liquid overfeed orifices shall be installed at the entrance to each coil circuit, sized for a maximum 5 psi pressure drop at the design refrigerant flow rate.
11.1.2. Units with vertical header arrangements shall have circuiting designed for parallel flow of refrigerant relative to direction of air flow.
11.1.3. Units with horizontal header arrangements shall have circuiting designed for cross flow of refrigerant relative to the direction of air flow.
11.2. <u>Type FL (Gravity Flooded)</u>
11.2.1. Units with vertical header arrangements shall have circuiting designed for parallel flow of refrigerant relative to direction of air flow.
11.2.2. Units with horizontal header arrangements shall have circuiting designed for cross flow of refrigerant relative to the direction of air flow..
11.3. <u>Type DX (Direct Expansion)</u>
11.3.1. Units with vertical header arrangements shall have circuiting designed for counter flow of refrigerant relative to direction of air flow to maximize suction gas superheat for best operation of thermostatic expansion valves.
11.3.2. Units with horizontal header arrangements shall have circuiting designed for cross flow of refrigerant relative to direction of air flow. Circuits must have crossover circuiting to equalize circuit loading.

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11.4. Type BW (Single Phase Liquids)
- 11.4.1. Units with vertical header arrangements shall have circuiting designed for counter flow of refrigerant relative to direction.
- 11.4.2. Units with horizontal header arrangements shall have circuiting designed for cross flow of refrigerant relative to direction of air flow. Circuits must have crossover circuiting to equalize circuit loading.

12. Fans

12.1. Construction.
- 12.1.1. Propeller fans shall be constructed of cast aluminum or non-ferrous polymer, as required by the contract.
- 12.1.2. Hub shall be removable type for ease of service. Integral fan/motor combinations with non-removable fans shall not be allowed.
- 12.1.3. Fans shall be true airfoil shape and shall be non-overloading type

12.2. Fan Guards.
- 12.2.1. Fans shall be fully guarded with OSHA approved wire guards.

12.3. Direction of Air Flow
- 12.3.1. Fans and motors shall be mounted on the air leaving side of the coil for draw through operation.

13. Fan Motors

13.1. Fan motors shall be standard NEMA frame size, inverter ready, integral horsepower, induction three phase, totally enclosed severe duty, with sealed ball bearings.

13.2. Motor service factor shall be no less than 1.15.

13.3. Motors shall have internal rotor construction. External rotor construction motors shall not be allowed.

13.4. Fan motors shall be individually wired by the manufacturer to individual junction boxes on the exterior of the unit cabinet.

14. Cabinet

14.1. General
- 14.1.1. Standard construction shall be of G90 mill Galvanized Steel, Alloy 5052 Aluminum, or 304L Stainless Steel as required in the contract. Painted or coated cabinet parts shall not be allowed.

14.2. Optional Smart Hanger System
- 14.2.1. When specified, units shall be provided with Colmac Smart Hanger brackets that will allow the unit to be suspended from pre-mounted structural channels provided by the manufacturer.
- 14.2.2. Hanger brackets shall be adjustable in the vertical direction to allow for various mounting heights.

14.3. Standard Air Section
- 14.3.1. Fans and motors shall be arranged for horizontal air discharge, mounted on the air leaving side of the coil section (draw through).

14.4. 45 Degree Down Discharge Air Section
- 14.4.1. Fans and motors shall be arranged for 45 degree down air discharge when required by contract.
- 14.4.2. Air discharge section to be factory mounted on the air leaving side and tilted down at 45 degree angle from the vertical plane.

14.5. Penthouse Air Section

14.5.1. Fan and motors shall be arranged for vertical down air discharge when required by the contract. Penthouse air section shall be factory mounted on the air leaving side of the coil section (draw through).

14.5.2. Access doors shall be provided to allow access to each individual fan and motor for service.

15. Drainpans

15.1. The inner drainpan shall be constructed of Alloy 5052 Aluminum.

15.2. Drainpan shall be designed to cover the coil section of the cooler cabinet.

15.3. Drainpan to be triple pitch, V-bottom design, such that water flows front to center, rear to center, and end to end to a single drain.

15.4. Drain outlet shall be constructed as a full radius, formed directly into the drain pan to eliminate the possibility of water pooling around the drain connection.

15.5. When required by the contract, drainpan shall be insulated with a minimum of 1" thick insulation.

15.5.1. The insulation shall be fully covered with a sheet metal insulation shield of mill galvanized steel, aluminum, or 304L stainless steel as required by the contract.

16. Defrost

16.1. Hot Gas Defrost

16.1.1. General

16.1.1.1. Coil shall be arranged for hot gas defrosting.

16.1.2. Pan Loop

16.1.2.1. A hot gas pan loop of round Alloy 3003 aluminum tubing shall be provided to warm the inner drainpan during defrost. Pan loop designs using square tubing or cross-sections other than round shall not be allowed.

16.1.2.1.1. Pan loop headers are to be held outside the ends of the drain pan to allow for full contact of the tubes with the pan.

16.1.2.1.2. The pan loop shall be attached to the underside of the inner drainpan by means of full length clips designed to keep the pan loop in tight contact with the pan by spring force. The pan loop shall not be mounted in the drainpan where it can contact the defrost water.

16.1.2.1.3. The pan loop outlet pipe shall be arranged such that a liquid seal is formed below the lowest hot gas pan tube.

16.1.3. Pan Loop Check Valve

16.1.3.1. When defrost condensate is being lifted into an overhead condensate return line, a properly sized in-line check valve shall be installed by the manufacturer. Check valve is to be installed between the outlet of the pan loop and the coil per the piping diagram provided by the manufacturer.

16.1.3.2. All portions of the check valve and piping shall be held within the footprint of the drainpan.

16.2. Water Defrost.

16.2.1. General

16.2.1.1. Coil shall be arranged for water defrosting.

16.2.2. Water Distribution Pans

16.2.2.1. Water shall be distributed evenly over the coil fin surfaces by means of water distribution pans.

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16.2.2.2. Individual water distribution pans shall be provided one per fan section in the cooler.
16.2.2.3. Water distribution pans shall be removable for inspection and cleaning.
16.2.2.4. Defrost water flow shall be thermodynamically calculated and specified by coil manufacturer such that the flow rate is the minimum needed to heat the mass of coil metal and melt the frost.

16.3. Air Defrost.
16.3.1. Coil shall be arranged for air (off cycle) defrosting.
16.4. Electric Defrost.
16.4.1. General
16.4.1.1. Coil shall be arranged for electric defrosting.
16.4.2. Heating elements
16.4.2.1. Heating elements shall be tubular type, UL listed, with stainless steel sheath.
16.4.2.2. Elements shall be inserted into the fin collars, and spaced throughout the coil core such that the coil core is completely clear of frost and ice at the end of each defrost.

16.4.2.3. Heating elements shall be wired to a common NEMA 3R (minimum) panel.
16.4.2.4. Heated elements shall be attached to coil core by means of a self-centering spring that acts to reset the heater's position during each defrost (US Patent No. 7,712,327).

17. Packaging
17.1. Units shall be crated on a wooden skid constructed of no less than 2" x 8" timbers.
17.2. Units shall be crated fully assembled (including drainpan) in an upright position ready for mounting in the field.
17.3. Crating shall support the full weight of the evaporator.
17.4. Crating shall be removable by means of gravity only.

18. IOM Manuals
18.1. Installation, Operation, and Maintenance Manuals shall be provided. Number of copies and routings shall be provided per the requirements of the contract.

19. Approved Vendor
19.1. Approved Vendor: Colmac Coil Manufacturing, Inc. Model: A+M Series

20. Ordering Information
20.1. Please Specify:
20.1.1. Complete model number.
20.1.2. Saturated suction temperature.
20.1.3. Room temperature.
20.1.4. Overfeed ratio (if pump recirculated).
20.1.5. Options or special features.

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21. Optional Features

1.1. Variable Fin Spacing

1.1.1. Coil core fins shall be arranged for highest frost capacity by varying the fin spacing for the air entering rows of tubes.

1.1.2. Fin spacing in fins per inch shall be specified according to contract.

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A+M Air Cooler (Galvanized) Engineering Specifications

1. **General**
   1.1. This specification covers "A+M" type air coolers having galvanized steel tubes and fins intended for use in refrigeration systems.

2. **Selection / Rating Method**
   2.1. Evaporators shall be selected using DT1 rating method.
   2.2. DTM rating method shall not be used.
   2.3. Evaporators shall be selected on the basis of room relative humidity as shown in the drawing.

3. **Tubing**
   3.1. Coil block shall be constructed with ASME SA-214 carbon steel tubing.
   3.2. Calculated working pressure of the coil tubing (per ASME Pressure Vessel Code Sec. VIII) shall be no less than 300 psig.
   3.3. Tubing shall be constructed from raw material that is made in the USA, as defined by material test reports, which are to be supplied upon customer request.

4. **Tube Pattern**
   4.1.1. Tube pattern shall be 7/8" OD - 2.25" x 1.949" equilateral staggered

5. **Fins**
   5.1. Shall be carbon steel, no less than 0.010" (0.25 mm) thick.
   5.2. Fins shall be continuous flat or configured plate type with full length, self-spacing collars. Spiral, "L-foot", or wrap-on type fins shall not be allowed.
   5.3. Fin collars shall be configured so that molten zinc completely bonds the tubes and fins.

6. **Headers**
   6.1. Headers shall be made of carbon steel pipe certified to ASME SA-106/B, no less than ANSI schedule 40.

7. **Connections**
   7.1. Liquid, suction, and hot gas connections shall be carbon steel pipe no less than schedule 40, certified to ASME SA-106/B. Bolted type flange union connections shall not be allowed.
   7.2. In the case of pumped bottom feed, liquid and hot gas connections shall be oriented vertically up.
   7.3. In the case of pumped bottom feed, liquid connection to coil header pipe shall be below the level of the lowest tube in the coil to effectively trap condensate during defrost.
   7.4. Coil connections shall be terminated with a welded steel head at the factory. One "Schrader" type valve shall be provided by the manufacturer mounted at the factory in one of the coil connection terminations for the purpose of measuring the shipping charge upon arrival at the jobsite.
   7.5. The manufacturer shall charge each coil with a shipping charge of 5-20 psig dry air or nitrogen. A label on the coil connection near the Schrader valve shall be provided indicating the factory charge pressure.

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8. Cleanliness

8.1. The manufacturer shall insure that the coils are free from internal dirt, scale, and water.

9. Welding/QC

9.1. All tube and header welds shall be made by Tungsten Inert Gas (TIG) welding process.
9.2. All welds shall be performed by ASME certified welders per the requirements of the manufacturer's WPS documents. Copies of all WPS, PQR, and Welder Qualification documents used in the fabrication of the coil shall be made available to the engineer upon request.
9.3. Copies of the manufacturer's Quality Control Manual shall be made available to the engineer upon request.

10. Leak Testing

10.1. Coils shall be tested for leaks after welding at no less than 500 psig (35 bar), dry air under water.
10.2. Test certificates for each coil shall be provided by the manufacturer to the engineer upon request.

11. Circuiting

11.1. <u>Types RT and RB (Recirc Top Feed and Recirc Bottom Feed)</u>
11.1.1. Liquid overfeed orifices shall be installed at the entrance to each coil circuit, sized for a maximum 5 psi pressure drop at the design refrigerant flow rate.
11.1.2. Units with vertical header arrangements shall have circuiting designed for parallel flow of refrigerant relative to direction of air flow.
11.1.3. Units with horizontal header arrangements shall have circuiting designed for cross flow of refrigerant relative to the direction of air flow.

11.2. <u>Type FL (Gravity Flooded)</u>
11.2.1. Units with vertical header arrangements shall have circuiting designed for parallel flow of refrigerant relative to direction of air flow.
11.2.2. Units with horizontal header arrangements shall have circuiting designed for cross flow of refrigerant relative to the direction of air flow..

11.3. <u>Type DX (Direct Expansion)</u>
11.3.1. Units with vertical header arrangements shall have circuiting designed for counter flow of refrigerant relative to direction of air flow to maximize suction gas superheat for best operation of thermostatic expansion valves.
11.3.2. Units with horizontal header arrangements shall have circuiting designed for cross flow of refrigerant relative to direction of air flow. Circuits must have crossover circuiting to equalize circuit loading.

11.4. <u>Type BW (Single Phase Liquids)</u>
11.4.1. Units with vertical header arrangements shall have circuiting designed for counter flow of refrigerant relative to direction.
11.4.2. Units with horizontal header arrangements shall have circuiting designed for cross flow of refrigerant relative to direction of air flow. Circuits must have crossover circuiting to equalize circuit loading.

12. Galvanizing

12.1. Carbon steel coil core to be hot-dip galvanized per ASTM A-123 for corrosion protection.

13. Fans

13.1. Construction.

13.1.1. Propeller fans shall be constructed of cast aluminum or non-ferrous polymer, as required by the contract.

13.1.2. Hub shall be removable type for ease of service. Integral fan/motor combinations with non-removable fans shall not be allowed.

13.1.3. Fans shall be true airfoil shape and shall be non-overloading type

13.2. Fan Guards.

13.2.1. Fans shall be fully guarded with OSHA approved wire guards.

13.3. Direction of Air Flow

13.3.1. Fans and motors shall be mounted on the air leaving side of the coil for draw through operation.

14. Fan Motors

14.1. Fan motors shall be standard NEMA frame size, inverter ready, integral horsepower, induction three phase, totally enclosed severe duty, with sealed ball bearings.

14.2. Motor service factor shall be no less than 1.15.

14.3. Motors shall have internal rotor construction. External rotor construction motors shall not be allowed.

14.4. Fan motors shall be individually wired by the manufacturer to individual junction boxes on the exterior of the unit cabinet.

15. Cabinet

15.1. General

15.1.1. Standard construction shall be of G90 mill Galvanized Steel, Alloy 5052 Aluminum, or 304L Stainless Steel as required in the contract. Painted or coated cabinet parts shall not be allowed.

15.2. Optional Smart Hanger System

15.2.1. When specified, units shall be provided with Colmac Smart Hanger brackets that will allow the unit to be suspended from pre-mounted structural channels provided by the manufacturer.

15.2.2. Hanger brackets shall be adjustable in the vertical direction to allow for various mounting heights.

15.3. Standard Air Section

15.3.1. Fans and motors shall be arranged for horizontal air discharge, mounted on the air leaving side of the coil section (draw through).

15.4. 45 Degree Down Discharge Air Section

15.4.1. Fans and motors shall be arranged for 45 degree down air discharge when required by contract.

15.4.2. Air discharge section to be factory mounted on the air leaving side and tilted down at 45 degree angle from the vertical plane.

15.5. Penthouse Air Section

15.5.1. Fan and motors shall be arranged for vertical down air discharge when required by the contract. Penthouse air section shall be factory mounted on the air leaving side of the coil section (draw through).

15.5.2. Access doors shall be provided to allow access to each individual fan and motor for service.

16. Drainpans

16.1. The inner drainpan shall be constructed of Alloy 5052 Aluminum.

16.2. Drainpan shall be designed to cover the coil section of the cooler cabinet.

16.3. Drainpan to be triple pitch, V-bottom design, such that water flows front to center, rear to center, and end to end to a single drain.

16.4. Drain outlet shall be constructed as a full radius, formed directly into the drain pan to eliminate the possibility of water pooling around the drain connection.

16.5. When required by the contract, drainpan shall be insulated with a minimum of 1" thick insulation.

16.5.1. The insulation shall be fully covered with a sheet metal insulation shield of mill galvanized steel, aluminum, or 304L stainless steel as required by the contract.

17. Defrost

17.1. <u>Hot Gas Defrost</u>

17.1.1. General

17.1.1.1. Coil shall be arranged for hot gas defrosting.

17.1.2. Pan Loop

17.1.2.1. A hot gas pan loop of round Alloy 3003 aluminum tubing shall be provided to warm the inner drainpan during defrost. Pan loop designs using square tubing or cross-sections other than round shall not be allowed.

17.1.2.1.1. Pan loop headers are to be held outside the ends of the drain pan to allow for full contact of the tubes with the pan.

17.1.2.1.2. The pan loop shall be attached to the underside of the inner drainpan by means of full length clips designed to keep the pan loop in tight contact with the pan by spring force. The pan loop shall not be mounted in the drainpan where it can contact the defrost water.

17.1.2.1.3. The pan loop outlet pipe shall be arranged such that a liquid seal is formed below the lowest hot gas pan tube.

17.1.3. Pan Loop Check Valve

17.1.3.1. When defrost condensate is being lifted into an overhead condensate return line, a properly sized in-line check valve shall be installed by the manufacturer. Check valve is to be installed between the outlet of the pan loop and the coil per the piping diagram provided by the manufacturer.

17.1.3.2. All portions of the check valve and piping shall be held within the footprint of the drainpan.

17.2. <u>Water Defrost.</u>

17.2.1. General

17.2.1.1. Coil shall be arranged for water defrosting.

17.2.2. Water Distribution Pans

17.2.2.1. Water shall be distributed evenly over the coil fin surfaces by means of water distribution pans.

17.2.2.2. Individual water distribution pans shall be provided one per fan section in the cooler.

17.2.2.3. Water distribution pans shall be removable for inspection and cleaning.

17.2.2.4. Defrost water flow shall be thermodynamically calculated and specified by coil manufacturer such that the flow rate is the minimum needed to heat the mass of coil metal and melt the frost.

17.3. <u>Air Defrost.</u>

17.3.1. Coil shall be arranged for air (off cycle) defrosting.

17.4. Electric Defrost.

17.4.1. General

17.4.1.1. Coil shall be arranged for electric defrosting.

17.4.2. Heating elements

17.4.2.1. Heating elements shall be tubular type, UL listed, with stainless steel sheath.

17.4.2.2. Elements shall be inserted into the fin collars, and spaced throughout the coil core such that the coil core is completely clear of frost and ice at the end of each defrost.

17.4.2.3. Heating elements shall be wired to a common NEMA 3R (minimum) panel.

17.4.2.4. Heated elements shall be attached to coil core by means of a self-centering spring that acts to reset the heater's position during each defrost (US Patent No. 7,712,327).

18. Packaging

18.1. Units shall be crated on a wooden skid constructed of no less than 2" x 8" timbers.

18.2. Units shall be crated fully assembled (including drainpan) in an upright position ready for mounting in the field.

18.3. Crating shall support the full weight of the evaporator.

18.4. Crating shall be removable by means of gravity only.

19. IOM Manuals

19.1. Installation, Operation, and Maintenance Manuals shall be provided. Number of copies and routings shall be provided per the requirements of the contract.

20. Approved Vendor

20.1. Approved Vendor: Colmac Coil Manufacturing, Inc. Model: A+M Series

21. Ordering Information

21.1. Please Specify:

21.1.1. Complete model number.

21.1.2. Saturated suction temperature.

21.1.3. Room temperature.

21.1.4. Overfeed ratio (if pump recirculated).

21.1.5. Options or special features.

22. Optional Features

1.1. Variable Fin Spacing

1.1.1. Coil core fins shall be arranged for highest frost capacity by varying the fin spacing for the air entering rows of tubes.

1.1.2. Fin spacing in fins per inch shall be specified according to contract.

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A+M Air Cooler (SST Tube) Engineering Specifications

1. **General**
   1.1. This specification covers "A+M" type air coolers having stainless steel tubes and aluminum fins intended for use in refrigeration systems.

2. **Selection / Rating Method**
   2.1. Evaporators shall be selected using DT1 rating method.
   2.2. DTM rating method shall not be used.
   2.3. Evaporators shall be selected on the basis of room relative humidity as shown in the drawing.

3. **Tubing**
   3.1. Coil block shall be constructed with 304L stainless steel tubing.
   3.2. Calculated working pressure of the coil tubing (per ASME Pressure Vessel Code Sec. VIII) shall be no less than 300 psig.
   3.3. Tubing shall be constructed from raw material that is made in the USA, as defined by material test reports, which are to be supplied upon customer request.

4. **Tube Pattern**
   4.1. Tube pattern shall be selected for optimum performance and defrost efficiency from one of the three patterns below:
      4.1.1. 5/8" OD - 1.5" x 1.299" equilateral staggered
      4.1.2. 5/8" OD – 1.97" (50 mm) inline
      4.1.3. 7/8" OD - 2.25" x 1.949" equilateral staggered

5. **Fins**
   5.1. Fins shall be selected from one of the four materials below based on optimum performance and the environment in which the cooler will operate.
      5.1.1. Aluminum 1100 alloy, no less than 0.010" (0.25 mm) thick.
      5.1.2. 304L stainless steel, no less than 0.010" " (0.25 mm) thick.
      5.1.3. Colmac Anti-Microbial alloy, no less than 0.010" " (0.25 mm) thick.
         5.1.3.1. Coil core fins shall be constructed of a metal alloy that exhibits anti-microbial properties.
         5.1.3.2. Fins shall completely cover the coil tube surfaces exposed to the airstream by means of a full-length self-spacing fin collar.
         5.1.3.3. Coil coatings are not allowed. All surfaces to be a base metal alloy.
   5.2. Fins shall be continuous flat or configured plate type with full length, self-spacing collars. Spiral, "L-foot", or wrap-on type fins shall not be allowed.
   5.3. Tubes shall be expanded into fin collars to form a tight mechanical bond between tube and fin.

6. **Headers**
   6.1. Headers shall be made of 304L stainless steel pipe certified to ASME SA-240/304L, no less than ANSI schedule 40.

7. **Connections**
   7.1. Liquid, suction, and hot gas connections shall be carbon steel pipe no less than

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schedule 40, certified to ASME SA-240/304L. Bolted type flange union connections shall not be allowed.

7.2. In the case of pumped bottom feed, liquid and hot gas connections shall be oriented vertically up.

7.3. In the case of pumped bottom feed, liquid connection to coil header pipe shall be below the level of the lowest tube in the coil to effectively trap condensate during defrost.

7.4. Coil connections shall be terminated with a welded steel head at the factory. One "Schrader" type valve shall be provided by the manufacturer mounted at the factory in one of the coil connection terminations for the purpose of measuring the shipping charge upon arrival at the jobsite.

7.5. The manufacturer shall charge each coil with a shipping charge of 5-20 psig dry air or nitrogen. A label on the coil connection near the Schrader valve shall be provided indicating the factory charge pressure.

8. Cleanliness

8.1. The manufacturer shall insure that the coils are free from internal dirt, scale, and water.

9. Welding/QC

9.1. All tube and header welds shall be made by Tungsten Inert Gas (TIG) welding process.

9.2. All welds shall be performed by ASME certified welders per the requirements of the manufacturer's WPS documents. Copies of all WPS, PQR, and Welder Qualification documents used in the fabrication of the coil shall be made available to the engineer upon request.

9.3. Copies of the manufacturer's Quality Control Manual shall be made available to the engineer upon request.

10. Leak Testing

10.1. Coils shall be tested for leaks after welding at no less than 500 psig (35 bar), dry air under water.

10.2. Test certificates for each coil shall be provided by the manufacturer to the engineer upon request.

11. Circuiting

11.1. <u>Types RT and RB (Recirc Top Feed and Recirc Bottom Feed)</u>

11.1.1. Liquid overfeed orifices shall be installed at the entrance to each coil circuit, sized for a maximum 5 psi pressure drop at the design refrigerant flow rate.

11.1.2. Units with vertical header arrangements shall have circuiting designed for parallel flow of refrigerant relative to direction of air flow.

11.1.3. Units with horizontal header arrangements shall have circuiting designed for cross flow of refrigerant relative to the direction of air flow.

11.2. <u>Type FL (Gravity Flooded)</u>

11.2.1. Units with vertical header arrangements shall have circuiting designed for parallel flow of refrigerant relative to direction of air flow.

11.2.2. Units with horizontal header arrangements shall have circuiting designed for cross flow of refrigerant relative to the direction of air flow..

11.3. <u>Type DX (Direct Expansion)</u>

11.3.1. Units with vertical header arrangements shall have circuiting designed for counter flow of refrigerant relative to direction of air flow to maximize suction gas superheat for best operation of thermostatic expansion valves.

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11.3.2. Units with horizontal header arrangements shall have circuiting designed for cross flow of refrigerant relative to direction of air flow. Circuits must have crossover circuiting to equalize circuit loading.

11.4. Type BW (Single Phase Liquids)

11.4.1. Units with vertical header arrangements shall have circuiting designed for counter flow of refrigerant relative to direction.

11.4.2. Units with horizontal header arrangements shall have circuiting designed for cross flow of refrigerant relative to direction of air flow. Circuits must have crossover circuiting to equalize circuit loading

12. Fans

12.1. Construction.

12.1.1. Propeller fans shall be constructed of cast aluminum or non-ferrous polymer, as required by the contract.

12.1.2. Hub shall be removable type for ease of service. Integral fan/motor combinations with non-removable fans shall not be allowed.

12.1.3. Fans shall be true airfoil shape and shall be non-overloading type

12.2. Fan Guards.

12.2.1. Fans shall be fully guarded with OSHA approved wire guards.

12.3. Direction of Air Flow

12.3.1. Fans and motors shall be mounted on the air leaving side of the coil for draw through operation.

13. Fan Motors

13.1. Fan motors shall be standard NEMA frame size, inverter ready, integral horsepower, induction three phase, totally enclosed severe duty, with sealed ball bearings.

13.2. Motor service factor shall be no less than 1.15.

13.3. Motors shall have internal rotor construction. External rotor construction motors shall not be allowed.

13.4. Fan motors shall be individually wired by the manufacturer to individual junction boxes on the exterior of the unit cabinet.

14. Cabinet

14.1. General

14.1.1. Standard construction shall be of G90 mill Galvanized Steel, Alloy 5052 Aluminum, or 304L Stainless Steel as required in the contract. Painted or coated cabinet parts shall not be allowed.

14.2. Optional Smart Hanger System

14.2.1. When specified, units shall be provided with Colmac Smart Hanger brackets that will allow the unit to be suspended from pre-mounted structural channels provided by the manufacturer.

14.2.2. Hanger brackets shall be adjustable in the vertical direction to allow for various mounting heights.

14.3. Standard Air Section

14.3.1. Fans and motors shall be arranged for horizontal air discharge, mounted on the air leaving side of the coil section (draw through).

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14.4. 45 Degree Down Discharge Air Section

14.4.1. Fans and motors shall be arranged for 45 degree down air discharge when required by contract.

14.4.2. Air discharge section to be factory mounted on the air leaving side and tilted down at 45 degree angle from the vertical plane.

14.5. Penthouse Air Section

14.5.1. Fan and motors shall be arranged for vertical down air discharge when required by the contract. Penthouse air section shall be factory mounted on the air leaving side of the coil section (draw through).

14.5.2. Access doors shall be provided to allow access to each individual fan and motor for service.

15. Drainpans

15.1. The inner drainpan shall be constructed of Alloy 5052 Aluminum.

15.2. Drainpan shall be designed to cover the coil section of the cooler cabinet.

15.3. Drainpan to be triple pitch, V-bottom design, such that water flows front to center, rear to center, and end to end to a single drain.

15.4. Drain outlet shall be constructed as a full radius, formed directly into the drain pan to eliminate the possibility of water pooling around the drain connection.

15.5. When required by the contract, drainpan shall be insulated with a minimum of 1" thick insulation.

15.5.1. The insulation shall be fully covered with a sheet metal insulation shield of mill galvanized steel, aluminum, or 304L stainless steel as required by the contract.

16. Defrost

16.1. Hot Gas Defrost

16.1.1. General

16.1.1.1. Coil shall be arranged for hot gas defrosting.

16.1.2. Pan Loop

16.1.2.1. A hot gas pan loop of round Alloy 3003 aluminum tubing shall be provided to warm the inner drainpan during defrost. Pan loop designs using square tubing or cross-sections other than round shall not be allowed.

16.1.2.1.1. Pan loop headers are to be held outside the ends of the drain pan to allow for full contact of the tubes with the pan.

16.1.2.1.2. The pan loop shall be attached to the underside of the inner drainpan by means of full length clips designed to keep the pan loop in tight contact with the pan by spring force. The pan loop shall not be mounted in the drainpan where it can contact the defrost water.

16.1.2.1.3. The pan loop outlet pipe shall be arranged such that a liquid seal is formed below the lowest hot gas pan tube.

16.1.3. Pan Loop Check Valve

16.1.3.1. When defrost condensate is being lifted into an overhead condensate return line, a properly sized in-line check valve shall be installed by the manufacturer. Check valve is to be installed between the outlet of the pan loop and the coil per the piping diagram provided by the manufacturer.

16.1.3.2. All portions of the check valve and piping shall be held within the footprint of the drainpan.

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16.2. Water Defrost.

16.2.1. General

16.2.1.1. Coil shall be arranged for water defrosting.

16.2.2. Water Distribution Pans

16.2.2.1. Water shall be distributed evenly over the coil fin surfaces by means of water distribution pans.

16.2.2.2. Individual water distribution pans shall be provided one per fan section in the cooler.

16.2.2.3. Water distribution pans shall be removable for inspection and cleaning.

16.2.2.4. Defrost water flow shall be thermodynamically calculated and specified by coil manufacturer such that the flow rate is the minimum needed to heat the mass of coil metal and melt the frost.

16.3. Air Defrost.

16.3.1. Coil shall be arranged for air (off cycle) defrosting.

16.4. Electric Defrost.

16.4.1. General

16.4.1.1. Coil shall be arranged for electric defrosting.

16.4.2. Heating elements

16.4.2.1. Heating elements shall be tubular type, UL listed, with stainless steel sheath.

16.4.2.2. Elements shall be inserted into the fin collars, and spaced throughout the coil core such that the coil core is completely clear of frost and ice at the end of each defrost.

16.4.2.3. Heating elements shall be wired to a common NEMA 3R (minimum) panel.

16.4.2.4. Heated elements shall be attached to coil core by means of a self-centering spring that acts to reset the heater's position during each defrost (US Patent No. 7,712,327).

17. Packaging

17.1. Units shall be crated on a wooden skid constructed of no less than 2" x 8" timbers.

17.2. Units shall be crated fully assembled (including drainpan) in an upright position ready for mounting in the field.

17.3. Crating shall support the full weight of the evaporator.

17.4. Crating shall be removable by means of gravity only.

18. IOM Manuals

18.1. Installation, Operation, and Maintenance Manuals shall be provided. Number of copies and routings shall be provided per the requirements of the contract.

19. Approved Vendor

19.1. Approved Vendor: Colmac Coil Manufacturing, Inc.   Model: A+M Series

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20. Ordering Information

20.1. Please Specify:

20.1.1. Complete model number.
20.1.2. Saturated suction temperature.
20.1.3. Room temperature.
20.1.4. Overfeed ratio (if pump recirculated).
20.1.5. Options or special features.

21. Optional Features

1.1. <u>Variable Fin Spacing</u>

1.1.1. Coil core fins shall be arranged for highest frost capacity by varying the fin spacing for the air entering rows of tubes.
1.1.2. Fin spacing in fins per inch shall be specified according to contract.

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A+S Air Cooler (AL Tube) Engineering Specifications

1. General

1.1. This specification covers “A+S” type air coolers having aluminum tubes and aluminum fins intended for use in refrigeration systems.

2. Selection / Rating Method

2.1. Evaporators shall be selected using DT1 rating method.
2.2. DTM rating method shall not be used.
2.3. Evaporators shall be selected on the basis of room relative humidity as shown in the drawing.

3. Tubing

3.1. Coil block shall be constructed with alloy 3003 aluminum tubing.
3.2. Calculated working pressure of the coil tubing (per ASME Pressure Vessel Code Sec. VIII) shall be no less than 300 psig.
3.3. Tubing shall be constructed from raw material that is made in the USA, as defined by material test reports, which are to be supplied upon customer request.

4. Tube Pattern

4.1. Tube pattern shall be selected for optimum performance and defrost efficiency from one of the three patterns below:
4.1.1. 5/8” OD - 1.5” x 1.299” equilateral staggered
4.1.2. 5/8” OD – 1.97” (50 mm) inline
4.1.3. 7/8” OD - 2.25” x 1.949” equilateral staggered

5. Fins

5.1. Shall be aluminum 1100 alloy, no less than 0.010” (0.25 mm) thick.
5.2. Fins shall be continuous flat or configured plate type with full length, self-spacing collars. Spiral, “L-foot”, or wrap-on type fins shall not be allowed.
5.3. Tubes shall be expanded into fin collars to form a tight mechanical bond between tube and fin.

6. Headers

6.1. Headers shall be made of ASME B241, Alloy 6061 aluminum no less than ANSI schedule 40 pipes.

7. Connections

7.1. Liquid, suction, and hot gas connections shall be carbon steel pipe no less than schedule 40, certified to ASME SA-106/B. Bolted type flange union connections shall not be allowed.
7.2. In the case of pumped bottom feed, liquid and hot gas connections shall be oriented vertically up.
7.3. In the case of pumped bottom feed, liquid connection to coil header pipe shall be below the level of the lowest tube in the coil to effectively trap condensate during defrost.
7.4. Coil connections shall be terminated with a welded steel head at the factory. One “Schrader” type valve shall be provided by the manufacturer mounted at the factory in one of the coil connection terminations for the purpose of measuring the shipping

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charge upon arrival at the jobsite.

7.5. The manufacturer shall charge each coil with a shipping charge of 5-20 psig dry air or nitrogen. A label on the coil connection near the Schrader valve shall be provided indicating the factory charge pressure.

8. Cleanliness

8.1. The manufacturer shall insure that the coils are free from internal dirt, scale, and water.

9. Welding/QC

9.1. All tube welds shall be made by Tungsten Inert Gas (TIG) welding process.

9.2. All welds shall be performed by ASME certified welders per the requirements of the manufacturer's WPS documents. Copies of all WPS, PQR, and Welder Qualification documents used in the fabrication of the coil shall be made available to the engineer upon request.

9.3. Copies of the manufacturer's Quality Control Manual shall be made available to the engineer upon request.

10. Leak Testing

10.1. Coils shall be tested for leaks after welding at no less than 500 psig (35 bar), dry air under water.

10.2. Test certificates for each coil shall be provided by the manufacturer to the engineer upon request.

11. Circuiting

11.1. <u>Types RT and RB (Recirc Top Feed and Recirc Bottom Feed)</u>

11.1.1. Liquid overfeed orifices shall be installed at the entrance to each coil circuit, sized for a maximum 5 psi pressure drop at the design refrigerant flow rate.

11.1.2. Units with vertical header arrangements shall have circuiting designed for parallel flow of refrigerant relative to direction of air flow.

11.1.3. Units with horizontal header arrangements shall have circuiting designed for cross flow of refrigerant relative to the direction of air flow.

11.2. <u>Type FL (Gravity Flooded)</u>

11.2.1. Units with vertical header arrangements shall have circuiting designed for parallel flow of refrigerant relative to direction of air flow.

11.2.2. Units with horizontal header arrangements shall have circuiting designed for cross flow of refrigerant relative to the direction of air flow..

11.3. <u>Type DX (Direct Expansion)</u>

11.3.1. Units with vertical header arrangements shall have circuiting designed for counter flow of refrigerant relative to direction of air flow to maximize suction gas superheat for best operation of thermostatic expansion valves.

11.3.2. Units with horizontal header arrangements shall have circuiting designed for cross flow of refrigerant relative to direction of air flow. Circuits must have crossover circuiting to equalize circuit loading.

11.4. <u>Type BW (Single Phase Liquids)</u>

11.4.1. Units with vertical header arrangements shall have circuiting designed for counter flow of refrigerant relative to direction.

11.4.2. Units with horizontal header arrangements shall have circuiting designed for cross flow of refrigerant relative to direction of air flow. Circuits must have crossover circuiting to equalize circuit loading.

12. Fans

12.1. Construction.

12.1.1. Propeller fans shall be constructed of cast aluminum or non-ferrous polymer, as required by the contract.

12.1.2. Hub shall be removable type for ease of service. Integral fan/motor combinations with non-removable fans shall not be allowed.

12.1.3. Fans shall be true airfoil shape and shall be non-overloading type

12.2. Fan Guards.

12.2.1. Fans shall be fully guarded with OSHA approved wire guards.

12.3. Direction of Air Flow

12.3.1. Fans and motors shall be mounted on the air leaving side of the coil for draw through operation.

13. Fan Motors

13.1. Fan motors shall be standard NEMA frame size, inverter ready, integral horsepower, induction three phase, totally enclosed severe duty, with sealed ball bearings.

13.2. Motor service factor shall be no less than 1.15.

13.3. Motors shall have internal rotor construction. External rotor construction motors shall not be allowed.

13.4. Fan motors shall be individually wired by the manufacturer to individual junction boxes on the exterior of the unit cabinet.

14. Cabinet

14.1. General

14.1.1. Standard construction shall be of G90 mill Galvanized Steel, Alloy 5052 Aluminum, or 304L Stainless Steel as required in the contract. Painted or coated cabinet parts shall not be allowed.

14.2. Optional Smart Hanger System

14.2.1. When specified, units shall be provided with Colmac Smart Hanger brackets that will allow the unit to be suspended from pre-mounted structural channels provided by the manufacturer.

14.2.2. Hanger brackets shall be adjustable in the vertical direction to allow for various mounting heights.

14.3. Standard Air Section

14.3.1. Fans and motors shall be arranged for horizontal air discharge, mounted on the air leaving side of the coil section (draw through).

14.4. 45 Degree Down Discharge Air Section

14.4.1. Fans and motors shall be arranged for 45 degree down air discharge when required by contract.

14.4.2. Air discharge section to be factory mounted on the air leaving side and tilted down at 45 degree angle from the vertical plane.

14.5. Penthouse Air Section

14.5.1. Fan and motors shall be arranged for vertical down air discharge when required by the contract. Penthouse air section shall be factory mounted on the air leaving side of the coil section (draw through).

14.5.2. Access doors shall be provided to allow access to each individual fan and motor for service.

15. Drainpans

15.1. The inner drainpan shall be constructed of Alloy 5052 Aluminum.

15.2. Drainpan shall be designed to cover the coil section of the cooler cabinet.

15.3. Drainpan to be triple pitch, V-bottom design, such that water flows front to center, rear to center, and end to end to a single drain.

15.4. Drain outlet shall be constructed as a full radius, formed directly into the drain pan to eliminate the possibility of water pooling around the drain connection.

15.5. When required by the contract, drainpan shall be insulated with a minimum of 1" thick insulation.

15.5.1. The insulation shall be fully covered with a sheet metal insulation shield of mill galvanized steel, aluminum, or 304L stainless steel as required by the contract.

16. Defrost

16.1. <u>Hot Gas Defrost</u>

16.1.1. General

16.1.1.1. Coil shall be arranged for hot gas defrosting.

16.1.2. Pan Loop

16.1.2.1. A hot gas pan loop of round Alloy 3003 aluminum tubing shall be provided to warm the inner drainpan during defrost. Pan loop designs using square tubing or cross-sections other than round shall not be allowed.

16.1.2.1.1. Pan loop headers are to be held outside the ends of the drain pan to allow for full contact of the tubes with the pan.

16.1.2.1.2. The pan loop shall be attached to the underside of the inner drainpan by means of full length clips designed to keep the pan loop in tight contact with the pan by spring force. The pan loop shall not be mounted in the drainpan where it can contact the defrost water.

16.1.2.1.3. The pan loop outlet pipe shall be arranged such that a liquid seal is formed below the lowest hot gas pan tube.

16.1.3. Pan Loop Check Valve

16.1.3.1. When defrost condensate is being lifted into an overhead condensate return line, a properly sized in-line check valve shall be installed by the manufacturer. Check valve is to be installed between the outlet of the pan loop and the coil per the piping diagram provided by the manufacturer.

16.1.3.2. All portions of the check valve and piping shall be held within the footprint of the drainpan.

16.2. <u>Water Defrost.</u>

16.2.1. General

16.2.1.1. Coil shall be arranged for water defrosting.

16.2.2. Water Distribution Pans

16.2.2.1. Water shall be distributed evenly over the coil fin surfaces by means of water distribution pans.

16.2.2.2. Individual water distribution pans shall be provided one per fan section in the cooler.

16.2.2.3. Water distribution pans shall be removable for inspection and cleaning.

16.2.2.4. Defrost water flow shall be thermodynamically calculated and specified by coil manufacturer such that the flow rate is the minimum needed to heat the mass of coil metal and melt the frost.

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16.3. Air Defrost.
16.3.1. Coil shall be arranged for air (off cycle) defrosting.
16.4. Electric Defrost.
16.4.1. General
16.4.1.1. Coil shall be arranged for electric defrosting.
16.4.2. Heating elements
16.4.2.1. Heating elements shall be tubular type, UL listed, with stainless steel sheath.
16.4.2.2. Elements shall be inserted into the fin collars, and spaced throughout the coil core such that the coil core is completely clear of frost and ice at the end of each defrost.

16.4.2.3. Heating elements shall be wired to a common NEMA 3R (minimum) panel.
16.4.2.4. Heated elements shall be attached to coil core by means of a self-centering spring that acts to reset the heater's position during each defrost (US Patent No. 7,712,327).

17. Packaging

17.1. Units shall be crated on a wooden skid constructed of no less than 2" x 8" timbers.
17.2. Units shall be crated fully assembled (including drainpan) in an upright position ready for mounting in the field.
17.3. Crating shall support the full weight of the evaporator.
17.4. Crating shall be removable by means of gravity only.

18. IOM Manuals

18.1. Installation, Operation, and Maintenance Manuals shall be provided. Number of copies and routings shall be provided per the requirements of the contract.

19. Approved Vendor

19.1. Approved Vendor: Colmac Coil Manufacturing, Inc. Model: A+S Series

20. Ordering Information

20.1. Please Specify:
20.1.1. Complete model number.
20.1.2. Saturated suction temperature.
20.1.3. Room temperature.
20.1.4. Overfeed ratio (if pump recirculated).
20.1.5. Options or special features.

21. Optional Features

1.1. Variable Fin Spacing
1.1.1. Coil core fins shall be arranged for highest frost capacity by varying the fin spacing for the air entering rows of tubes.
1.1.2. Fin spacing in fins per inch shall be specified according to contract.

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A+S Air Cooler (Cu Tube) Engineering Specifications

1. **General**
   1.1. This specification covers "A+S" type air coolers having copper tubes and aluminum fins intended for use in refrigeration systems.

2. **Selection / Rating Method**
   2.1. Evaporators shall be selected using DT1 rating method.
   2.2. DTM rating method shall not be used.
   2.3. Evaporators shall be selected on the basis of room relative humidity as shown in the drawing.

3. **Tubing**
   3.1. Coil block shall be constructed with UNS C12200 copper tubing certified to ASTM B-75.
   3.2. Calculated working pressure of the coil tubing (per ASME Pressure Vessel Code Sec. VIII) shall be no less than 300 psig.
   3.3. Tubing shall be constructed from raw material that is made in the USA, as defined by material test reports, which are to be supplied upon customer request.

4. **Tube Pattern**
   4.1. Tube pattern shall be selected for optimum performance and defrost efficiency from one of the three patterns below:
      4.1.1. 5/8" OD - 1.5" x 1.299" equilateral staggered
      4.1.2. 5/8" OD – 1.97" (50 mm) inline
      4.1.3. 7/8" OD - 2.25" x 1.949" equilateral staggered

5. **Fins**
   5.1. Fins shall be selected from one of the four materials below based on optimum performance and the environment in which the cooler will operate.
      5.1.1. Aluminum 1100 alloy, no less than 0.010" (0.25 mm) thick.
      5.1.2. 304L stainless steel, no less than 0.010" " (0.25 mm) thick.
      5.1.3. Copper, no less than no less than 0.010" " (0.25 mm) thick.
   5.2. Fins shall be continuous flat or configured plate type with full length, self-spacing collars. Spiral, "L-foot", or wrap-on type fins shall not be allowed.
   5.3. Tubes shall be expanded into fin collars to form a tight mechanical bond between tube and fin.

6. **Headers**
   6.1. Headers shall be made of UNS C12200 Type L copper tubing certified to ASTM B-88.

7. **Connections**
   7.1. Liquid, suction, and hot gas connections shall be UNS C12200 Type L copper tubing certified to ASTM B-88. Bolted type flange union connections shall not be allowed.
   7.2. In the case of pumped bottom feed, liquid and hot gas connections shall be oriented vertically up.
   7.3. In the case of pumped bottom feed, liquid connection to coil header pipe shall be below the level of the lowest tube in the coil to effectively trap condensate during defrost.
   7.4. Coil connections shall be terminated with a brazed copper head at the factory. One

"Schrader" type valve shall be provided by the manufacturer mounted at the factory in one of the coil connection terminations for the purpose of measuring the shipping charge upon arrival at the jobsite.

7.5. The manufacturer shall charge each coil with a shipping charge of 5-20 psig dry air or nitrogen. A label on the coil connection near the Schrader valve shall be provided indicating the factory charge pressure.

8. Cleanliness

8.1. The manufacturer shall insure that the coils are free from internal dirt, scale, and water.

9. Brazing/QC

9.1. All tube and header joints shall be made with high temperature brazing filler metal certified to no less than BCuP-3 (5% Silver Solder).
9.2. All brazing shall be performed by ASME certified brazers per the requirements of the manufacturer's BPS documents. Copies of all BPS, PQR, and Brazer Qualification documents used in the fabrication of the coil shall be made available to the engineer upon request.
9.3. Copies of the manufacturer's Quality Control Manual shall be made available to the engineer upon request.

10. Leak Testing

10.1. Coils shall be tested for leaks after brazing at no less than 350 psig (25 bar), dry air under water.
10.2. Test certificates for each coil shall be provided by the manufacturer to the engineer upon request.

11. Circuiting

11.1. <u>Types RT and RB (Recirc Top Feed and Recirc Bottom Feed)</u>
11.1.1. Liquid overfeed orifices shall be installed at the entrance to each coil circuit, sized for a maximum 5 psi pressure drop at the design refrigerant flow rate.
11.1.2. Units with vertical header arrangements shall have circuiting designed for parallel flow of refrigerant relative to direction of air flow.
11.1.3. Units with horizontal header arrangements shall have circuiting designed for cross flow of refrigerant relative to the direction of air flow.

11.2. <u>Type FL (Gravity Flooded)</u>
11.2.1. Units with vertical header arrangements shall have circuiting designed for parallel flow of refrigerant relative to direction of air flow.
11.2.2. Units with horizontal header arrangements shall have circuiting designed for cross flow of refrigerant relative to the direction of air flow..

11.3. <u>Type DX (Direct Expansion)</u>
11.3.1. Units with vertical header arrangements shall have circuiting designed for counter flow of refrigerant relative to direction of air flow to maximize suction gas superheat for best operation of thermostatic expansion valves.
11.3.2. Units with horizontal header arrangements shall have circuiting designed for cross flow of refrigerant relative to direction of air flow. Circuits must have crossover circuiting to equalize circuit loading.

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11.4. Type BW (Single Phase Liquids)
- 11.4.1. Units with vertical header arrangements shall have circuiting designed for counter flow of refrigerant relative to direction.
- 11.4.2. Units with horizontal header arrangements shall have circuiting designed for cross flow of refrigerant relative to direction of air flow. Circuits must have crossover circuiting to equalize circuit loading.

12. Fans

12.1. Construction.
- 12.1.1. Propeller fans shall be constructed of cast aluminum or non-ferrous polymer, as required by the contract.
- 12.1.2. Hub shall be removable type for ease of service. Integral fan/motor combinations with non-removable fans shall not be allowed.
- 12.1.3. Fans shall be true airfoil shape and shall be non-overloading type

12.2. Fan Guards.
- 12.2.1. Fans shall be fully guarded with OSHA approved wire guards.

12.3. Direction of Air Flow
- 12.3.1. Fans and motors shall be mounted on the air leaving side of the coil for draw through operation.

13. Fan Motors

13.1. Fan motors shall be standard NEMA frame size, inverter ready, integral horsepower, induction three phase, totally enclosed severe duty, with sealed ball bearings.

13.2. Motor service factor shall be no less than 1.15.

13.3. Motors shall have internal rotor construction. External rotor construction motors shall not be allowed.

13.4. Fan motors shall be individually wired by the manufacturer to individual junction boxes on the exterior of the unit cabinet.

14. Cabinet

14.1. General
- 14.1.1. Standard construction shall be of G90 mill Galvanized Steel, Alloy 5052 Aluminum, or 304L Stainless Steel as required in the contract. Painted or coated cabinet parts shall not be allowed.

14.2. Optional Smart Hanger System
- 14.2.1. When specified, units shall be provided with Colmac Smart Hanger brackets that will allow the unit to be suspended from pre-mounted structural channels provided by the manufacturer.
- 14.2.2. Hanger brackets shall be adjustable in the vertical direction to allow for various mounting heights.

14.3. Standard Air Section
- 14.3.1. Fans and motors shall be arranged for horizontal air discharge, mounted on the air leaving side of the coil section (draw through).

14.4. 45 Degree Down Discharge Air Section
- 14.4.1. Fans and motors shall be arranged for 45 degree down air discharge when required by contract.
- 14.4.2. Air discharge section to be factory mounted on the air leaving side and tilted down at 45 degree angle from the vertical plane.

14.5. Penthouse Air Section

14.5.1. Fan and motors shall be arranged for vertical down air discharge when required by the contract. Penthouse air section shall be factory mounted on the air leaving side of the coil section (draw through).

14.5.2. Access doors shall be provided to allow access to each individual fan and motor for service.

15. Drainpans

15.1. The inner drainpan shall be constructed of Alloy 5052 Aluminum.

15.2. Drainpan shall be designed to cover the coil section of the cooler cabinet.

15.3. Drainpan to be triple pitch, V-bottom design, such that water flows front to center, rear to center, and end to end to a single drain.

15.4. Drain outlet shall be constructed as a full radius, formed directly into the drain pan to eliminate the possibility of water pooling around the drain connection.

15.5. When required by the contract, drainpan shall be insulated with a minimum of 1" thick insulation.

15.5.1. The insulation shall be fully covered with a sheet metal insulation shield of mill galvanized steel, aluminum, or 304L stainless steel as required by the contract.

16. Defrost

16.1. Hot Gas Defrost

16.1.1. General

16.1.1.1. Coil shall be arranged for hot gas defrosting.

16.1.2. Pan Loop

16.1.2.1. A hot gas pan loop of round Alloy 3003 aluminum tubing shall be provided to warm the inner drainpan during defrost. Pan loop designs using square tubing or cross-sections other than round shall not be allowed.

16.1.2.1.1. Pan loop headers are to be held outside the ends of the drain pan to allow for full contact of the tubes with the pan.

16.1.2.1.2. The pan loop shall be attached to the underside of the inner drainpan by means of full length clips designed to keep the pan loop in tight contact with the pan by spring force. The pan loop shall not be mounted in the drainpan where it can contact the defrost water.

16.1.2.1.3. The pan loop outlet pipe shall be arranged such that a liquid seal is formed below the lowest hot gas pan tube.

16.1.3. Pan Loop Check Valve

16.1.3.1. When defrost condensate is being lifted into an overhead condensate return line, a properly sized in-line check valve shall be installed by the manufacturer. Check valve is to be installed between the outlet of the pan loop and the coil per the piping diagram provided by the manufacturer.

16.1.3.2. All portions of the check valve and piping shall be held within the footprint of the drainpan.

16.2. Water Defrost.

16.2.1. General

16.2.1.1. Coil shall be arranged for water defrosting.

16.2.2. Water Distribution Pans

16.2.2.1. Water shall be distributed evenly over the coil fin surfaces by means of water distribution pans.

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16.2.2.2. Individual water distribution pans shall be provided one per fan section in the cooler.
16.2.2.3. Water distribution pans shall be removable for inspection and cleaning.
16.2.2.4. Defrost water flow shall be thermodynamically calculated and specified by coil manufacturer such that the flow rate is the minimum needed to heat the mass of coil metal and melt the frost.

16.3. Air Defrost.
16.3.1. Coil shall be arranged for air (off cycle) defrosting.
16.4. Electric Defrost.
16.4.1. General
16.4.1.1. Coil shall be arranged for electric defrosting.
16.4.2. Heating elements
16.4.2.1. Heating elements shall be tubular type, UL listed, with stainless steel sheath.
16.4.2.2. Elements shall be inserted into the fin collars, and spaced throughout the coil core such that the coil core is completely clear of frost and ice at the end of each defrost.

16.4.2.3. Heating elements shall be wired to a common NEMA 3R (minimum) panel.
16.4.2.4. Heated elements shall be attached to coil core by means of a self-centering spring that acts to reset the heater's position during each defrost (US Patent No. 7,712,327).

17. Packaging
17.1. Units shall be crated on a wooden skid constructed of no less than 2" x 8" timbers.
17.2. Units shall be crated fully assembled (including drainpan) in an upright position ready for mounting in the field.
17.3. Crating shall support the full weight of the evaporator.
17.4. Crating shall be removable by means of gravity only.

18. IOM Manuals
18.1. Installation, Operation, and Maintenance Manuals shall be provided. Number of copies and routings shall be provided per the requirements of the contract.

19. Approved Vendor
19.1. Approved Vendor: Colmac Coil Manufacturing, Inc. Model: A+S Series

20. Ordering Information
20.1. Please Specify:
20.1.1. Complete model number.
20.1.2. Saturated suction temperature.
20.1.3. Room temperature.
20.1.4. Overfeed ratio (if pump recirculated).
20.1.5. Options or special features.

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21. **Optional Features**

1.1. Variable Fin Spacing

1.1.1. Coil core fins shall be arranged for highest frost capacity by varying the fin spacing for the air entering rows of tubes.

1.1.2. Fin spacing in fins per inch shall be specified according to contract.

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A+S Air Cooler (Galvanized) Engineering Specifications

1. **General**
   1.1. This specification covers “A+S” type air coolers having galvanized steel tubes and fins intended for use in refrigeration systems.

2. **Selection / Rating Method**
   2.1. Evaporators shall be selected using DT1 rating method.
   2.2. DTM rating method shall not be used.
   2.3. Evaporators shall be selected on the basis of room relative humidity as shown in the drawing.

3. **Tubing**
   3.1. Coil block shall be constructed with ASME SA-214 carbon steel tubing.
   3.2. Calculated working pressure of the coil tubing (per ASME Pressure Vessel Code Sec. VIII) shall be no less than 300 psig.
   3.3. Tubing shall be constructed from raw material that is made in the USA, as defined by material test reports, which are to be supplied upon customer request.

4. **Tube Pattern**
   4.1.1. Tube pattern shall be 7/8” OD - 2.25” x 1.949” equilateral staggered

5. **Fins**
   5.1. Shall be carbon steel, no less than 0.010” (0.25 mm) thick.
   5.2. Fins shall be continuous flat or configured plate type with full length, self-spacing collars. Spiral, “L-foot”, or wrap-on type fins shall not be allowed.
   5.3. Fin collars shall be configured so that molten zinc completely bonds the tubes and fins.

6. **Headers**
   6.1. Headers shall be made of carbon steel pipe certified to ASME SA-106/B, no less than ANSI schedule 40.

7. **Connections**
   7.1. Liquid, suction, and hot gas connections shall be carbon steel pipe no less than schedule 40, certified to ASME SA-106/B. Bolted type flange union connections shall not be allowed.
   7.2. In the case of pumped bottom feed, liquid and hot gas connections shall be oriented vertically up.
   7.3. In the case of pumped bottom feed, liquid connection to coil header pipe shall be below the level of the lowest tube in the coil to effectively trap condensate during defrost.
   7.4. Coil connections shall be terminated with a welded steel head at the factory. One “Schrader” type valve shall be provided by the manufacturer mounted at the factory in one of the coil connection terminations for the purpose of measuring the shipping charge upon arrival at the jobsite.
   7.5. The manufacturer shall charge each coil with a shipping charge of 5-20 psig dry air or nitrogen. A label on the coil connection near the Schrader valve shall be provided indicating the factory charge pressure.

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8. Cleanliness

8.1. The manufacturer shall insure that the coils are free from internal dirt, scale, and water.

9. Welding/QC

9.1. All tube and header welds shall be made by Tungsten Inert Gas (TIG) welding process.

9.2. All welds shall be performed by ASME certified welders per the requirements of the manufacturer's WPS documents. Copies of all WPS, PQR, and Welder Qualification documents used in the fabrication of the coil shall be made available to the engineer upon request.

9.3. Copies of the manufacturer's Quality Control Manual shall be made available to the engineer upon request.

10. Leak Testing

10.1. Coils shall be tested for leaks after welding at no less than 500 psig (35 bar), dry air under water.

10.2. Test certificates for each coil shall be provided by the manufacturer to the engineer upon request.

11. Circuiting

11.1. Types RT and RB (Recirc Top Feed and Recirc Bottom Feed)

11.1.1. Liquid overfeed orifices shall be installed at the entrance to each coil circuit, sized for a maximum 5 psi pressure drop at the design refrigerant flow rate.

11.1.2. Units with vertical header arrangements shall have circuiting designed for parallel flow of refrigerant relative to direction of air flow.

11.1.3. Units with horizontal header arrangements shall have circuiting designed for cross flow of refrigerant relative to the direction of air flow.

11.2. Type FL (Gravity Flooded)

11.2.1. Units with vertical header arrangements shall have circuiting designed for parallel flow of refrigerant relative to direction of air flow.

11.2.2. Units with horizontal header arrangements shall have circuiting designed for cross flow of refrigerant relative to the direction of air flow..

11.3. Type DX (Direct Expansion)

11.3.1. Units with vertical header arrangements shall have circuiting designed for counter flow of refrigerant relative to direction of air flow to maximize suction gas superheat for best operation of thermostatic expansion valves.

11.3.2. Units with horizontal header arrangements shall have circuiting designed for cross flow of refrigerant relative to direction of air flow. Circuits must have crossover circuiting to equalize circuit loading.

11.4. Type BW (Single Phase Liquids)

11.4.1. Units with vertical header arrangements shall have circuiting designed for counter flow of refrigerant relative to direction.

11.4.2. Units with horizontal header arrangements shall have circuiting designed for cross flow of refrigerant relative to direction of air flow. Circuits must have crossover circuiting to equalize circuit loading.

12. Galvanizing

12.1. Carbon steel coil core to be hot-dip galvanized per ASTM A-123 for corrosion protection.

13. Fans

13.1. Construction.

13.1.1. Propeller fans shall be constructed of cast aluminum or non-ferrous polymer, as required by the contract.

13.1.2. Hub shall be removable type for ease of service. Integral fan/motor combinations with non-removable fans shall not be allowed.

13.1.3. Fans shall be true airfoil shape and shall be non-overloading type

13.2. Fan Guards.

13.2.1. Fans shall be fully guarded with OSHA approved wire guards.

13.3. Direction of Air Flow

13.3.1. Fans and motors shall be mounted on the air leaving side of the coil for draw through operation.

14. Fan Motors

14.1. Fan motors shall be standard NEMA frame size, inverter ready, integral horsepower, induction three phase, totally enclosed severe duty, with sealed ball bearings.

14.2. Motor service factor shall be no less than 1.15.

14.3. Motors shall have internal rotor construction. External rotor construction motors shall not be allowed.

14.4. Fan motors shall be individually wired by the manufacturer to individual junction boxes on the exterior of the unit cabinet.

15. Cabinet

15.1. General

15.1.1. Standard construction shall be of G90 mill Galvanized Steel, Alloy 5052 Aluminum, or 304L Stainless Steel as required in the contract. Painted or coated cabinet parts shall not be allowed.

15.2. Optional Smart Hanger System

15.2.1. When specified, units shall be provided with Colmac Smart Hanger brackets that will allow the unit to be suspended from pre-mounted structural channels provided by the manufacturer.

15.2.2. Hanger brackets shall be adjustable in the vertical direction to allow for various mounting heights.

15.3. Standard Air Section

15.3.1. Fans and motors shall be arranged for horizontal air discharge, mounted on the air leaving side of the coil section (draw through).

15.4. 45 Degree Down Discharge Air Section

15.4.1. Fans and motors shall be arranged for 45 degree down air discharge when required by contract.

15.4.2. Air discharge section to be factory mounted on the air leaving side and tilted down at 45 degree angle from the vertical plane.

15.5. Penthouse Air Section

15.5.1. Fan and motors shall be arranged for vertical down air discharge when required by the contract. Penthouse air section shall be factory mounted on the air leaving side of the coil section (draw through).

15.5.2. Access doors shall be provided to allow access to each individual fan and motor for service.

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16. Drainpans

16.1. The inner drainpan shall be constructed of Alloy 5052 Aluminum.

16.2. Drainpan shall be designed to cover the coil section of the cooler cabinet.

16.3. Drainpan to be triple pitch, V-bottom design, such that water flows front to center, rear to center, and end to end to a single drain.

16.4. Drain outlet shall be constructed as a full radius, formed directly into the drain pan to eliminate the possibility of water pooling around the drain connection.

16.5. When required by the contract, drainpan shall be insulated with a minimum of 1" thick insulation.

16.5.1. The insulation shall be fully covered with a sheet metal insulation shield of mill galvanized steel, aluminum, or 304L stainless steel as required by the contract.

17. Defrost

17.1. Hot Gas Defrost

17.1.1. General

17.1.1.1. Coil shall be arranged for hot gas defrosting.

17.1.2. Pan Loop

17.1.2.1. A hot gas pan loop of round Alloy 3003 aluminum tubing shall be provided to warm the inner drainpan during defrost. Pan loop designs using square tubing or cross-sections other than round shall not be allowed.

17.1.2.1.1. Pan loop headers are to be held outside the ends of the drain pan to allow for full contact of the tubes with the pan.

17.1.2.1.2. The pan loop shall be attached to the underside of the inner drainpan by means of full length clips designed to keep the pan loop in tight contact with the pan by spring force. The pan loop shall not be mounted in the drainpan where it can contact the defrost water.

17.1.2.1.3. The pan loop outlet pipe shall be arranged such that a liquid seal is formed below the lowest hot gas pan tube.

17.1.3. Pan Loop Check Valve

17.1.3.1. When defrost condensate is being lifted into an overhead condensate return line, a properly sized in-line check valve shall be installed by the manufacturer. Check valve is to be installed between the outlet of the pan loop and the coil per the piping diagram provided by the manufacturer.

17.1.3.2. All portions of the check valve and piping shall be held within the footprint of the drainpan.

17.2. Water Defrost.

17.2.1. General

17.2.1.1. Coil shall be arranged for water defrosting.

17.2.2. Water Distribution Pans

17.2.2.1. Water shall be distributed evenly over the coil fin surfaces by means of water distribution pans.

17.2.2.2. Individual water distribution pans shall be provided one per fan section in the cooler.

17.2.2.3. Water distribution pans shall be removable for inspection and cleaning.

17.2.2.4. Defrost water flow shall be thermodynamically calculated and specified by coil manufacturer such that the flow rate is the minimum needed to heat the mass of coil metal and melt the frost.

17.3. Air Defrost.
17.3.1. Coil shall be arranged for air (off cycle) defrosting.
17.4. Electric Defrost.
17.4.1. General
17.4.1.1. Coil shall be arranged for electric defrosting.
17.4.2. Heating elements
17.4.2.1. Heating elements shall be tubular type, UL listed, with stainless steel sheath.
17.4.2.2. Elements shall be inserted into the fin collars, and spaced throughout the coil core such that the coil core is completely clear of frost and ice at the end of each defrost.

17.4.2.3. Heating elements shall be wired to a common NEMA 3R (minimum) panel.
17.4.2.4. Heated elements shall be attached to coil core by means of a self-centering spring that acts to reset the heater's position during each defrost (US Patent No. 7,712,327).

18. Packaging
18.1. Units shall be crated on a wooden skid constructed of no less than 2" x 8" timbers.
18.2. Units shall be crated fully assembled (including drainpan) in an upright position ready for mounting in the field.
18.3. Crating shall support the full weight of the evaporator.
18.4. Crating shall be removable by means of gravity only.

19. IOM Manuals
19.1. Installation, Operation, and Maintenance Manuals shall be provided. Number of copies and routings shall be provided per the requirements of the contract.

20. Approved Vendor
20.1. Approved Vendor: Colmac Coil Manufacturing, Inc. Model: A+S Series

21. Ordering Information
21.1. Please Specify:
21.1.1. Complete model number.
21.1.2. Saturated suction temperature.
21.1.3. Room temperature.
21.1.4. Overfeed ratio (if pump recirculated).
21.1.5. Options or special features.

22. Optional Features
1.1. Variable Fin Spacing
1.1.1. Coil core fins shall be arranged for highest frost capacity by varying the fin spacing for the air entering rows of tubes.
1.1.2. Fin spacing in fins per inch shall be specified according to contract.

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A+S Air Cooler (SST Tube) Engineering Specifications

1. **General**
   1.1. This specification covers “A+S” type air coolers having stainless steel tubes and aluminum fins intended for use in refrigeration systems.

2. **Selection / Rating Method**
   2.1. Evaporators shall be selected using DT1 rating method.
   2.2. DTM rating method shall not be used.
   2.3. Evaporators shall be selected on the basis of room relative humidity as shown in the drawing.

3. **Tubing**
   3.1. Coil block shall be constructed with 304L stainless steel tubing.
   3.2. Calculated working pressure of the coil tubing (per ASME Pressure Vessel Code Sec. VIII) shall be no less than 300 psig.
   3.3. Tubing shall be constructed from raw material that is made in the USA, as defined by material test reports, which are to be supplied upon customer request.

4. **Tube Pattern**
   4.1. Tube pattern shall be selected for optimum performance and defrost efficiency from one of the three patterns below:
      4.1.1. 5/8” OD - 1.5” x 1.299” equilateral staggered
      4.1.2. 5/8” OD – 1.97” (50 mm) inline
      4.1.3. 7/8” OD - 2.25” x 1.949” equilateral staggered

5. **Fins**
   5.1. Fins shall be selected from one of the four materials below based on optimum performance and the environment in which the cooler will operate.
      5.1.1. Aluminum 1100 alloy, no less than 0.010” (0.25 mm) thick.
      5.1.2. 304L stainless steel, no less than 0.010” ” (0.25 mm) thick.
      5.1.3. Colmac Anti-Microbial alloy, no less than 0.010” ” (0.25 mm) thick.
         5.1.3.1. Coil core fins shall be constructed of a metal alloy that exhibits anti-microbial properties.
         5.1.3.2. Fins shall completely cover the coil tube surfaces exposed to the airstream by means of a full-length self-spacing fin collar.
         5.1.3.3. Coil coatings are not allowed. All surfaces to be a base metal alloy.
   5.2. Fins shall be continuous flat or configured plate type with full length, self-spacing collars. Spiral, “L-foot”, or wrap-on type fins shall not be allowed.
   5.3. Tubes shall be expanded into fin collars to form a tight mechanical bond between tube and fin.

6. **Headers**
   6.1. Headers shall be made of 304L stainless steel pipe certified to ASME SA-240/304L, no less than ANSI schedule 40.

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7. Connections

7.1. Liquid, suction, and hot gas connections shall be carbon steel pipe no less than schedule 40, certified to ASME SA-240/304L. Bolted type flange union connections shall not be allowed.

7.2. In the case of pumped bottom feed, liquid and hot gas connections shall be oriented vertically up.

7.3. In the case of pumped bottom feed, liquid connection to coil header pipe shall be below the level of the lowest tube in the coil to effectively trap condensate during defrost.

7.4. Coil connections shall be terminated with a welded steel head at the factory. One "Schrader" type valve shall be provided by the manufacturer mounted at the factory in one of the coil connection terminations for the purpose of measuring the shipping charge upon arrival at the jobsite.

7.5. The manufacturer shall charge each coil with a shipping charge of 5-20 psig dry air or nitrogen. A label on the coil connection near the Schrader valve shall be provided indicating the factory charge pressure.

8. Cleanliness

8.1. The manufacturer shall insure that the coils are free from internal dirt, scale, and water.

9. Welding/QC

9.1. All tube and header welds shall be made by Tungsten Inert Gas (TIG) welding process.

9.2. All welds shall be performed by ASME certified welders per the requirements of the manufacturer's WPS documents. Copies of all WPS, PQR, and Welder Qualification documents used in the fabrication of the coil shall be made available to the engineer upon request.

9.3. Copies of the manufacturer's Quality Control Manual shall be made available to the engineer upon request.

10. Leak Testing

10.1. Coils shall be tested for leaks after welding at no less than 500 psig (35 bar), dry air under water.

10.2. Test certificates for each coil shall be provided by the manufacturer to the engineer upon request.

11. Circuiting

11.1. <u>Types RT and RB (Recirc Top Feed and Recirc Bottom Feed)</u>

11.1.1. Liquid overfeed orifices shall be installed at the entrance to each coil circuit, sized for a maximum 5 psi pressure drop at the design refrigerant flow rate.

11.1.2. Units with vertical header arrangements shall have circuiting designed for parallel flow of refrigerant relative to direction of air flow.

11.1.3. Units with horizontal header arrangements shall have circuiting designed for cross flow of refrigerant relative to the direction of air flow.

11.2. <u>Type FL (Gravity Flooded)</u>

11.2.1. Units with vertical header arrangements shall have circuiting designed for parallel flow of refrigerant relative to direction of air flow.

11.2.2. Units with horizontal header arrangements shall have circuiting designed for cross flow of refrigerant relative to the direction of air flow..

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11.3. Type DX (Direct Expansion)

11.3.1. Units with vertical header arrangements shall have circuiting designed for counter flow of refrigerant relative to direction of air flow to maximize suction gas superheat for best operation of thermostatic expansion valves.

11.3.2. Units with horizontal header arrangements shall have circuiting designed for cross flow of refrigerant relative to direction of air flow. Circuits must have crossover circuiting to equalize circuit loading.

11.4. Type BW (Single Phase Liquids)

11.4.1. Units with vertical header arrangements shall have circuiting designed for counter flow of refrigerant relative to direction.

11.4.2. Units with horizontal header arrangements shall have circuiting designed for cross flow of refrigerant relative to direction of air flow. Circuits must have crossover circuiting to equalize circuit loading.

12. Fans

12.1. Construction.

12.1.1. Propeller fans shall be constructed of cast aluminum or non-ferrous polymer, as required by the contract.

12.1.2. Hub shall be removable type for ease of service. Integral fan/motor combinations with non-removable fans shall not be allowed.

12.1.3. Fans shall be true airfoil shape and shall be non-overloading type

12.2. Fan Guards.

12.2.1. Fans shall be fully guarded with OSHA approved wire guards.

12.3. Direction of Air Flow

12.3.1. Fans and motors shall be mounted on the air leaving side of the coil for draw through operation.

13. Fan Motors

13.1. Fan motors shall be standard NEMA frame size, inverter ready, integral horsepower, induction three phase, totally enclosed severe duty, with sealed ball bearings.

13.2. Motor service factor shall be no less than 1.15.

13.3. Motors shall have internal rotor construction. External rotor construction motors shall not be allowed.

13.4. Fan motors shall be individually wired by the manufacturer to individual junction boxes on the exterior of the unit cabinet.

14. Cabinet

14.1. General

14.1.1. Standard construction shall be of G90 mill Galvanized Steel, Alloy 5052 Aluminum, or 304L Stainless Steel as required in the contract. Painted or coated cabinet parts shall not be allowed.

14.2. Optional Smart Hanger System

14.2.1. When specified, units shall be provided with Colmac Smart Hanger brackets that will allow the unit to be suspended from pre-mounted structural channels provided by the manufacturer.

14.2.2. Hanger brackets shall be adjustable in the vertical direction to allow for various mounting heights.

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14.3. Standard Air Section

14.3.1. Fans and motors shall be arranged for horizontal air discharge, mounted on the air leaving side of the coil section (draw through).

14.4. 45 Degree Down Discharge Air Section

14.4.1. Fans and motors shall be arranged for 45 degree down air discharge when required by contract.

14.4.2. Air discharge section to be factory mounted on the air leaving side and tilted down at 45 degree angle from the vertical plane.

14.5. Penthouse Air Section

14.5.1. Fan and motors shall be arranged for vertical down air discharge when required by the contract. Penthouse air section shall be factory mounted on the air leaving side of the coil section (draw through).

14.5.2. Access doors shall be provided to allow access to each individual fan and motor for service.

15. Drainpans

15.1. The inner drainpan shall be constructed of Alloy 5052 Aluminum.

15.2. Drainpan shall be designed to cover the coil section of the cooler cabinet.

15.3. Drainpan to be triple pitch, V-bottom design, such that water flows front to center, rear to center, and end to end to a single drain.

15.4. Drain outlet shall be constructed as a full radius, formed directly into the drain pan to eliminate the possibility of water pooling around the drain connection.

15.5. When required by the contract, drainpan shall be insulated with a minimum of 1” thick insulation.

15.5.1. The insulation shall be fully covered with a sheet metal insulation shield of mill galvanized steel, aluminum, or 304L stainless steel as required by the contract.

16. Defrost

16.1. Hot Gas Defrost

16.1.1. General

16.1.1.1. Coil shall be arranged for hot gas defrosting.

16.1.2. Pan Loop

16.1.2.1. A hot gas pan loop of round Alloy 3003 aluminum tubing shall be provided to warm the inner drainpan during defrost. Pan loop designs using square tubing or cross-sections other than round shall not be allowed.

16.1.2.1.1. Pan loop headers are to be held outside the ends of the drain pan to allow for full contact of the tubes with the pan.

16.1.2.1.2. The pan loop shall be attached to the underside of the inner drainpan by means of full length clips designed to keep the pan loop in tight contact with the pan by spring force. The pan loop shall not be mounted in the drainpan where it can contact the defrost water.

16.1.2.1.3. The pan loop outlet pipe shall be arranged such that a liquid seal is formed below the lowest hot gas pan tube.

16.1.3. Pan Loop Check Valve

16.1.3.1. When defrost condensate is being lifted into an overhead condensate return line, a properly sized in-line check valve shall be installed by the manufacturer. Check valve is to be installed between the outlet of the pan loop and the coil per the piping diagram provided by the manufacturer.

16.1.3.2. All portions of the check valve and piping shall be held within the footprint of the drainpan.

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16.2. Water Defrost.

16.2.1. General

16.2.1.1. Coil shall be arranged for water defrosting.

16.2.2. Water Distribution Pans

16.2.2.1. Water shall be distributed evenly over the coil fin surfaces by means of water distribution pans.

16.2.2.2. Individual water distribution pans shall be provided one per fan section in the cooler.

16.2.2.3. Water distribution pans shall be removable for inspection and cleaning.

16.2.2.4. Defrost water flow shall be thermodynamically calculated and specified by coil manufacturer such that the flow rate is the minimum needed to heat the mass of coil metal and melt the frost.

16.3. Air Defrost.

16.3.1. Coil shall be arranged for air (off cycle) defrosting.

16.4. Electric Defrost.

16.4.1. General

16.4.1.1. Coil shall be arranged for electric defrosting.

16.4.2. Heating elements

16.4.2.1. Heating elements shall be tubular type, UL listed, with stainless steel sheath.

16.4.2.2. Elements shall be inserted into the fin collars, and spaced throughout the coil core such that the coil core is completely clear of frost and ice at the end of each defrost.

16.4.2.3. Heating elements shall be wired to a common NEMA 3R (minimum) panel.

16.4.2.4. Heated elements shall be attached to coil core by means of a self-centering spring that acts to reset the heater's position during each defrost (US Patent No. 7,712,327).

17. Packaging

17.1. Units shall be crated on a wooden skid constructed of no less than 2" x 8" timbers.

17.2. Units shall be crated fully assembled (including drainpan) in an upright position ready for mounting in the field.

17.3. Crating shall support the full weight of the evaporator.

17.4. Crating shall be removable by means of gravity only.

18. IOM Manuals

18.1. Installation, Operation, and Maintenance Manuals shall be provided. Number of copies and routings shall be provided per the requirements of the contract.

19. Approved Vendor

19.1. Approved Vendor: Colmac Coil Manufacturing, Inc.   Model: A+S Series

20. Ordering Information

20.1. Please Specify:

20.1.1. Complete model number.

20.1.2. Saturated suction temperature.

20.1.3. Room temperature.

20.1.4. Overfeed ratio (if pump recirculated).

20.1.5. Options or special features.

21. Optional Features

1.1. <u>Variable Fin Spacing</u>

1.1.1. Coil core fins shall be arranged for highest frost capacity by varying the fin spacing for the air entering rows of tubes.

1.1.2. Fin spacing in fins per inch shall be specified according to contract.

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A+R Air Cooler (AL Tube) Engineering Specifications

1. **General**
   1.1. This specification covers "A+R" type air coolers having aluminum tubes and aluminum fins intended for use in ammonia refrigeration systems.

2. **Selection / Rating Method**
   2.1. Evaporators shall be selected using DT1 rating method.
   2.2. DTM rating method shall not be used.
   2.3. Evaporators shall be selected on the basis of room relative humidity as shown in the drawing.

3. **Tubing**
   3.1. Coil block shall be constructed with alloy 3003 aluminum tubing.
   3.2. Calculated working pressure of the coil tubing (per ASME Pressure Vessel Code Sec. VIII) shall be no less than 300 psig.
   3.3. Tubing shall be constructed from raw material that is made in the USA, as defined by material test reports, which are to be supplied upon customer request.

4. **Tube Pattern**
   4.1. Tube pattern shall be selected for optimum performance and defrost efficiency from one of the three patterns below:
      4.1.1. 5/8" OD - 1.5" x 1.299" equilateral staggered
      4.1.2. 5/8" OD – 1.97" (50 mm) inline
      4.1.3. 7/8" OD - 2.25" x 1.949" equilateral staggered

5. **Fins**
   5.1. Shall be aluminum 1100 alloy, no less than 0.010" (0.25 mm) thick.
   5.2. Fins shall be continuous flat or configured plate type with full length, self-spacing collars. Spiral, "L-foot", or wrap-on type fins shall not be allowed.
   5.3. Tubes shall be expanded into fin collars to form a tight mechanical bond between tube and fin.

6. **Headers**
   6.1. Headers shall be made of ASME B241, Alloy 6061 aluminum no less than ANSI schedule 40 pipes.

7. **Connections**
   7.1. Liquid, suction, and hot gas connections shall be carbon steel pipe no less than schedule 40, certified to ASME SA-106/B. Bolted type flange union connections shall not be allowed.
   7.2. In the case of pumped bottom feed, liquid and hot gas connections shall be oriented vertically up.
   7.3. In the case of pumped bottom feed, liquid connection to coil header pipe shall be below the level of the lowest tube in the coil to effectively trap condensate during defrost.
   7.4. Coil connections shall be terminated with a welded steel head at the factory. One "Schrader" type valve shall be provided by the manufacturer mounted at the factory in one of the coil connection terminations for the purpose of measuring the shipping

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charge upon arrival at the jobsite.

7.5. The manufacturer shall charge each coil with a shipping charge of 5-20 psig dry air or nitrogen. A label on the coil connection near the Schrader valve shall be provided indicating the factory charge pressure.

8. Cleanliness

8.1. The manufacturer shall insure that the coils are free from internal dirt, scale, and water.

9. Welding/QC

9.1. All tube welds shall be made by Tungsten Inert Gas (TIG) welding process.

9.2. All welds shall be performed by ASME certified welders per the requirements of the manufacturer's WPS documents. Copies of all WPS, PQR, and Welder Qualification documents used in the fabrication of the coil shall be made available to the engineer upon request.

9.3. Copies of the manufacturer's Quality Control Manual shall be made available to the engineer upon request.

10. Leak Testing

10.1. Coils shall be tested for leaks after welding at no less than 500 psig (35 bar), dry air under water.

10.2. Test certificates for each coil shall be provided by the manufacturer to the engineer upon request.

11. Circuiting

11.1. <u>Type RTA (Recirc Top Feed) and Type RBA (Recirc Bottom Feed)</u>

11.1.1. Liquid overfeed orifices shall be installed at the entrance to each coil circuit, sized for 5 psi pressure drop at the design ammonia flow rate.

12. Fans

12.1. <u>Construction.</u>

12.1.1. Propeller fans shall be constructed of cast aluminum or non-ferrous polymer, as required by the contract.

12.1.2. Hub shall be removable type for ease of service. Integral fan/motor combinations with non-removable fans shall not be allowed.

12.1.3. Fans shall be true airfoil shape and shall be non-overloading type

12.2. <u>Fan Guards.</u>

12.2.1. Fans shall be fully guarded with OSHA approved wire guards.

12.3. <u>Direction of Air Flow</u>

12.3.1. Fans and motors shall be mounted on the air leaving side of the coil for draw through operation.

13. Fan Motors

13.1. Fan motors shall be standard NEMA frame size, inverter ready, integral horsepower, induction three phase, totally enclosed severe duty, with sealed ball bearings.

13.2. Motor service factor shall be no less than 1.15.

13.3. Motors shall have internal rotor construction. External rotor construction motors shall not be allowed.

13.4. Fan motors shall be individually wired by the manufacturer to individual junction boxes on the exterior of the unit cabinet.

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14. Cabinet

14.1. General

14.1.1. Standard construction shall be of G90 mill Galvanized Steel, Alloy 5052 Aluminum, or 304L Stainless Steel as required in the contract. Painted or coated cabinet parts shall not be allowed.

14.2. Optional Smart Hanger System

14.2.1. When specified, units shall be provided with Colmac Smart Hanger brackets that will allow the unit to be suspended from pre-mounted structural channels provided by the manufacturer.

14.2.2. Hanger brackets shall be adjustable in the vertical direction to allow for various mounting heights.

14.3. Standard Air Section

14.3.1. Fans and motors shall be arranged for horizontal air discharge, mounted on the air leaving side of the coil section (draw through).

14.4. 45 Degree Down Discharge Air Section

14.4.1. Fans and motors shall be arranged for 45 degree down air discharge when required by contract.

14.4.2. Air discharge section to be factory mounted on the air leaving side and tilted down at 45 degree angle from the vertical plane.

14.5. Penthouse Air Section

14.5.1. Fan and motors shall be arranged for vertical down air discharge when required by the contract. Penthouse air section shall be factory mounted on the air leaving side of the coil section (draw through).

14.5.2. Access doors shall be provided to allow access to each individual fan and motor for service.

15. Drainpans

15.1. The inner drainpan shall be constructed of Alloy 5052 Aluminum.

15.2. Drainpan shall be designed to cover the coil section of the cooler cabinet.

15.3. Drainpan to be triple pitch, V-bottom design, such that water flows front to center, rear to center, and end to end to a single drain.

15.4. Drain outlet shall be constructed as a full radius, formed directly into the drain pan to eliminate the possibility of water pooling around the drain connection.

15.5. When required by the contract, drainpan shall be insulated with a minimum of 1" thick insulation.

15.5.1. The insulation shall be fully covered with a sheet metal insulation shield of mill galvanized steel, aluminum, or 304L stainless steel as required by the contract.

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16. Defrost

16.1. Hot Gas Defrost

16.1.1. General

16.1.1.1. Coil shall be arranged for hot gas defrosting.

16.1.2. Pan Loop

16.1.2.1. A hot gas pan loop of round Alloy 3003 aluminum tubing shall be provided to warm the inner drainpan during defrost. Pan loop designs using square tubing or cross-sections other than round shall not be allowed.

16.1.2.1.1. Pan loop headers are to be held outside the ends of the drain pan to allow for full contact of the tubes with the pan.

16.1.2.1.2. The pan loop shall be attached to the underside of the inner drainpan by means of full length clips designed to keep the pan loop in tight contact with the pan by spring force. The pan loop shall not be mounted in the drainpan where it can contact the defrost water.

16.1.2.1.3. The pan loop outlet pipe shall be arranged such that a liquid seal is formed below the lowest hot gas pan tube.

16.1.3. Pan Loop Check Valve

16.1.3.1. When defrost condensate is being lifted into an overhead condensate return line, a properly sized in-line check valve shall be installed by the manufacturer. Check valve is to be installed between the outlet of the pan loop and the coil per the piping diagram provided by the manufacturer.

16.1.3.2. All portions of the check valve and piping shall be held within the footprint of the drainpan.

16.2. Water Defrost.

16.2.1. General

16.2.1.1. Coil shall be arranged for water defrosting.

16.2.2. Water Distribution Pans

16.2.2.1. Water shall be distributed evenly over the coil fin surfaces by means of water distribution pans.

16.2.2.2. Individual water distribution pans shall be provided one per fan section in the cooler.

16.2.2.3. Water distribution pans shall be removable for inspection and cleaning.

16.2.2.4. Defrost water flow shall be thermodynamically calculated and specified by coil manufacturer such that the flow rate is the minimum needed to heat the mass of coil metal and melt the frost.

16.3. Air Defrost.

16.3.1. Coil shall be arranged for air (off cycle) defrosting.

16.4. Electric Defrost.

16.4.1. General

16.4.1.1. Coil shall be arranged for electric defrosting.

16.4.2. Heating elements

16.4.2.1. Heating elements shall be tubular type, UL listed, with stainless steel sheath.

16.4.2.2. Elements shall be inserted into the fin collars, and spaced throughout the coil core such that the coil core is completely clear of frost and ice at the end of each defrost.

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16.4.2.3. Heating elements shall be wired to a common NEMA 3R (minimum) panel.

16.4.2.4. Heated elements shall be attached to coil core by means of a self-centering spring that acts to reset the heater's position during each defrost (US Patent No. 7,712,327).

17. Packaging

17.1. Units shall be crated on a wooden skid constructed of no less than 2" x 8" timbers.

17.2. Units shall be crated fully assembled (including drainpan) in an upright position ready for mounting in the field.

17.3. Crating shall support the full weight of the evaporator.

17.4. Crating shall be removable by means of gravity only.

18. IOM Manuals

18.1. Installation, Operation, and Maintenance Manuals shall be provided. Number of copies and routings shall be provided per the requirements of the contract.

19. Approved Vendor

19.1. Approved Vendor: Colmac Coil Manufacturing, Inc.   Model: A+R Series

20. Ordering Information

20.1. Please Specify:

20.1.1. Complete model number.

20.1.2. Saturated suction temperature.

20.1.3. Room temperature.

20.1.4. Overfeed ratio (if pump recirculated).

20.1.5. Options or special features.

21. Optional Features

1.1. <u>Variable Fin Spacing</u>

1.1.1. Coil core fins shall be arranged for highest frost capacity by varying the fin spacing for the air entering rows of tubes.

1.1.2. Fin spacing in fins per inch shall be specified according to contract.

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A+R Air Cooler (Cu Tube) Engineering Specifications

1. **General**
   1.1. This specification covers “A+R” type air coolers having copper tubes and aluminum fins intended for use in halocarbon refrigeration systems.

2. **Selection / Rating Method**
   2.1. Evaporators shall be selected using DT1 rating method.
   2.2. DTM rating method shall not be used.
   2.3. Evaporators shall be selected on the basis of room relative humidity as shown in the drawing.

3. **Tubing**
   3.1. Coil block shall be constructed with UNS C12200 copper tubing certified to ASTM B-75.
   3.2. Calculated working pressure of the coil tubing (per ASME Pressure Vessel Code Sec. VIII) shall be no less than 300 psig.
   3.3. Tubing shall be constructed from raw material that is made in the USA, as defined by material test reports, which are to be supplied upon customer request.

4. **Tube Pattern**
   4.1. Tube pattern shall be selected for optimum performance and defrost efficiency from one of the three patterns below:
      4.1.1. 5/8” OD - 1.5” x 1.299” equilateral staggered
      4.1.2. 5/8” OD – 1.97” (50 mm) inline
      4.1.3. 7/8” OD - 2.25” x 1.949” equilateral staggered

5. **Fins**
   5.1. Fins shall be selected from one of the four materials below based on optimum performance and the environment in which the cooler will operate.
      5.1.1. Aluminum 1100 alloy, no less than 0.010” (0.25 mm) thick.
      5.1.2. 304L stainless steel, no less than 0.010” ” (0.25 mm) thick.
      5.1.3. Copper, no less than no less than 0.010” ” (0.25 mm) thick.
   5.2. Fins shall be continuous flat or configured plate type with full length, self-spacing collars. Spiral, “L-foot”, or wrap-on type fins shall not be allowed.
   5.3. Tubes shall be expanded into fin collars to form a tight mechanical bond between tube and fin.

6. **Headers**
   6.1. Headers shall be made of UNS C12200 Type L copper tubing certified to ASTM B-88.

7. **Connections**
   7.1. Liquid, suction, and hot gas connections shall be UNS C12200 Type L copper tubing certified to ASTM B-88. Bolted type flange union connections shall not be allowed.
   7.2. In the case of pumped bottom feed, liquid and hot gas connections shall be oriented vertically up.
   7.3. In the case of pumped bottom feed, liquid connection to coil header pipe shall be below the level of the lowest tube in the coil to effectively trap condensate during defrost.
   7.4. Coil connections shall be terminated with a brazed copper head at the factory. One

"Schrader" type valve shall be provided by the manufacturer mounted at the factory in one of the coil connection terminations for the purpose of measuring the shipping charge upon arrival at the jobsite.

7.5. The manufacturer shall charge each coil with a shipping charge of 5-20 psig dry air or nitrogen. A label on the coil connection near the Schrader valve shall be provided indicating the factory charge pressure.

8. Cleanliness

8.1. The manufacturer shall insure that the coils are free from internal dirt, scale, and water.

9. Brazing/QC

9.1. All tube and header joints shall be made with high temperature brazing filler metal certified to no less than BCuP-3 (5% Silver Solder).

9.2. All brazing shall be performed by ASME certified brazers per the requirements of the manufacturer's BPS documents. Copies of all BPS, PQR, and Brazer Qualification documents used in the fabrication of the coil shall be made available to the engineer upon request.

9.3. Copies of the manufacturer's Quality Control Manual shall be made available to the engineer upon request.

10. Leak Testing

10.1. Coils shall be tested for leaks after brazing at no less than 350 psig (25 bar), dry air under water.

10.2. Test certificates for each coil shall be provided by the manufacturer to the engineer upon request.

11. Circuiting

11.1. <u>Type RTA (Recirc Top Feed) and Type RBA (Recirc Bottom Feed)</u>

11.1.1. Liquid overfeed orifices shall be installed at the entrance to each coil circuit, sized for 5 psi pressure drop at the design ammonia flow rate.

12. Fans

12.1. <u>Construction.</u>

12.1.1. Propeller fans shall be constructed of cast aluminum or non-ferrous polymer, as required by the contract.

12.1.2. Hub shall be removable type for ease of service. Integral fan/motor combinations with non-removable fans shall not be allowed.

12.1.3. Fans shall be true airfoil shape and shall be non-overloading type

12.2. <u>Fan Guards.</u>

12.2.1. Fans shall be fully guarded with OSHA approved wire guards.

12.3. <u>Direction of Air Flow</u>

12.3.1. Fans and motors shall be mounted on the air leaving side of the coil for draw through operation.

13. Fan Motors

13.1. Fan motors shall be standard NEMA frame size, inverter ready, integral horsepower, induction three phase, totally enclosed severe duty, with sealed ball bearings.

13.2. Motor service factor shall be no less than 1.15.

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13.3. Motors shall have internal rotor construction. External rotor construction motors shall not be allowed.

13.4. Fan motors shall be individually wired by the manufacturer to individual junction boxes on the exterior of the unit cabinet.

14. Cabinet

14.1. General

14.1.1. Standard construction shall be of G90 mill Galvanized Steel, Alloy 5052 Aluminum, or 304L Stainless Steel as required in the contract. Painted or coated cabinet parts shall not be allowed.

14.2. Optional Smart Hanger System

14.2.1. When specified, units shall be provided with Colmac Smart Hanger brackets that will allow the unit to be suspended from pre-mounted structural channels provided by the manufacturer.

14.2.2. Hanger brackets shall be adjustable in the vertical direction to allow for various mounting heights.

14.3. Standard Air Section

14.3.1. Fans and motors shall be arranged for horizontal air discharge, mounted on the air leaving side of the coil section (draw through).

14.4. 45 Degree Down Discharge Air Section

14.4.1. Fans and motors shall be arranged for 45 degree down air discharge when required by contract.

14.4.2. Air discharge section to be factory mounted on the air leaving side and tilted down at 45 degree angle from the vertical plane.

14.5. Penthouse Air Section

14.5.1. Fan and motors shall be arranged for vertical down air discharge when required by the contract. Penthouse air section shall be factory mounted on the air leaving side of the coil section (draw through).

14.5.2. Access doors shall be provided to allow access to each individual fan and motor for service.

15. Drainpans

15.1. The inner drainpan shall be constructed of Alloy 5052 Aluminum.

15.2. Drainpan shall be designed to cover the coil section of the cooler cabinet.

15.3. Drainpan to be triple pitch, V-bottom design, such that water flows front to center, rear to center, and end to end to a single drain.

15.4. Drain outlet shall be constructed as a full radius, formed directly into the drain pan to eliminate the possibility of water pooling around the drain connection.

15.5. When required by the contract, drainpan shall be insulated with a minimum of 1" thick insulation.

15.5.1. The insulation shall be fully covered with a sheet metal insulation shield of mill galvanized steel, aluminum, or 304L stainless steel as required by the contract.

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16. Defrost

16.1. Hot Gas Defrost

16.1.1. General

16.1.1.1. Coil shall be arranged for hot gas defrosting.

16.1.2. Pan Loop

16.1.2.1. A hot gas pan loop of round Alloy 3003 aluminum tubing shall be provided to warm the inner drainpan during defrost. Pan loop designs using square tubing or cross-sections other than round shall not be allowed.

16.1.2.1.1. Pan loop headers are to be held outside the ends of the drain pan to allow for full contact of the tubes with the pan.

16.1.2.1.2. The pan loop shall be attached to the underside of the inner drainpan by means of full length clips designed to keep the pan loop in tight contact with the pan by spring force. The pan loop shall not be mounted in the drainpan where it can contact the defrost water.

16.1.2.1.3. The pan loop outlet pipe shall be arranged such that a liquid seal is formed below the lowest hot gas pan tube.

16.1.3. Pan Loop Check Valve

16.1.3.1. When defrost condensate is being lifted into an overhead condensate return line, a properly sized in-line check valve shall be installed by the manufacturer. Check valve is to be installed between the outlet of the pan loop and the coil per the piping diagram provided by the manufacturer.

16.1.3.2. All portions of the check valve and piping shall be held within the footprint of the drainpan.

16.2. Water Defrost.

16.2.1. General

16.2.1.1. Coil shall be arranged for water defrosting.

16.2.2. Water Distribution Pans

16.2.2.1. Water shall be distributed evenly over the coil fin surfaces by means of water distribution pans.

16.2.2.2. Individual water distribution pans shall be provided one per fan section in the cooler.

16.2.2.3. Water distribution pans shall be removable for inspection and cleaning.

16.2.2.4. Defrost water flow shall be thermodynamically calculated and specified by coil manufacturer such that the flow rate is the minimum needed to heat the mass of coil metal and melt the frost.

16.3. Air Defrost.

16.3.1. Coil shall be arranged for air (off cycle) defrosting.

16.4. Electric Defrost.

16.4.1. General

16.4.1.1. Coil shall be arranged for electric defrosting.

16.4.2. Heating elements

16.4.2.1. Heating elements shall be tubular type, UL listed, with stainless steel sheath.

16.4.2.2. Elements shall be inserted into the fin collars, and spaced throughout the coil core such that the coil core is completely clear of frost and ice at the end of each defrost.

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16.4.2.3. Heating elements shall be wired to a common NEMA 3R (minimum) panel.

16.4.2.4. Heated elements shall be attached to coil core by means of a self-centering spring that acts to reset the heater's position during each defrost (US Patent No. 7,712,327).

17. Packaging

17.1. Units shall be crated on a wooden skid constructed of no less than 2" x 8" timbers.

17.2. Units shall be crated fully assembled (including drainpan) in an upright position ready for mounting in the field.

17.3. Crating shall support the full weight of the evaporator.

17.4. Crating shall be removable by means of gravity only.

18. IOM Manuals

18.1. Installation, Operation, and Maintenance Manuals shall be provided. Number of copies and routings shall be provided per the requirements of the contract.

19. Approved Vendor

19.1. Approved Vendor: Colmac Coil Manufacturing, Inc. Model: A+R Series

20. Ordering Information

20.1. Please Specify:

20.1.1. Complete model number.
20.1.2. Saturated suction temperature.
20.1.3. Room temperature.
20.1.4. Overfeed ratio (if pump recirculated).
20.1.5. Options or special features.

21. Optional Features

1.1. <u>Variable Fin Spacing</u>

1.1.1. Coil core fins shall be arranged for highest frost capacity by varying the fin spacing for the air entering rows of tubes.

1.1.2. Fin spacing in fins per inch shall be specified according to contract.

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A+R Air Cooler (Galvanized) Engineering Specifications

1. **General**
   1.1. This specification covers “A+R” type air coolers having galvanized steel tubes and fins intended for use in ammonia refrigeration systems.

2. **Selection / Rating Method**
   2.1. Evaporators shall be selected using DT1 rating method.
   2.2. DTM rating method shall not be used.
   2.3. Evaporators shall be selected on the basis of room relative humidity as shown in the drawing.

3. **Tubing**
   3.1. Coil block shall be constructed with ASME SA-214 carbon steel tubing.
   3.2. Calculated working pressure of the coil tubing (per ASME Pressure Vessel Code Sec. VIII) shall be no less than 300 psig.
   3.3. Tubing shall be constructed from raw material that is made in the USA, as defined by material test reports, which are to be supplied upon customer request.

4. **Tube Pattern**
   4.1.1. Tube pattern shall be 7/8” OD - 2.25” x 1.949” equilateral staggered

5. **Fins**
   5.1. Shall be carbon steel, no less than 0.010” (0.25 mm) thick.
   5.2. Fins shall be continuous flat or configured plate type with full length, self-spacing collars. Spiral, “L-foot”, or wrap-on type fins shall not be allowed.
   5.3. Fin collars shall be configured so that molten zinc completely bonds the tubes and fins.

6. **Headers**
   6.1. Headers shall be made of carbon steel pipe certified to ASME SA-106/B, no less than ANSI schedule 40.

7. **Connections**
   7.1. Liquid, suction, and hot gas connections shall be carbon steel pipe no less than schedule 40, certified to ASME SA-106/B. Bolted type flange union connections shall not be allowed.
   7.2. In the case of pumped bottom feed, liquid and hot gas connections shall be oriented vertically up.
   7.3. In the case of pumped bottom feed, liquid connection to coil header pipe shall be below the level of the lowest tube in the coil to effectively trap condensate during defrost.
   7.4. Coil connections shall be terminated with a welded steel head at the factory. One “Schrader” type valve shall be provided by the manufacturer mounted at the factory in one of the coil connection terminations for the purpose of measuring the shipping charge upon arrival at the jobsite.
   7.5. The manufacturer shall charge each coil with a shipping charge of 5-20 psig dry air or nitrogen. A label on the coil connection near the Schrader valve shall be provided indicating the factory charge pressure.

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8. Cleanliness

8.1. The manufacturer shall insure that the coils are free from internal dirt, scale, and water.

9. Welding/QC

9.1. All tube and header welds shall be made by Tungsten Inert Gas (TIG) welding process.

9.2. All welds shall be performed by ASME certified welders per the requirements of the manufacturer's WPS documents. Copies of all WPS, PQR, and Welder Qualification documents used in the fabrication of the coil shall be made available to the engineer upon request.

9.3. Copies of the manufacturer's Quality Control Manual shall be made available to the engineer upon request.

10. Leak Testing

10.1. Coils shall be tested for leaks after welding at no less than 500 psig (35 bar), dry air under water.

10.2. Test certificates for each coil shall be provided by the manufacturer to the engineer upon request.

11. Circuiting

11.1. Type RTA (Recirc Top Feed) and Type RBA (Recirc Bottom Feed)

11.1.1. Liquid overfeed orifices shall be installed at the entrance to each coil circuit, sized for 5 psi pressure drop at the design ammonia flow rate.

12. Galvanizing

12.1. Carbon steel coil core to be hot-dip galvanized per ASTM A-123 for corrosion protection.

13. Fans

13.1. Construction.

13.1.1. Propeller fans shall be constructed of cast aluminum or non-ferrous polymer, as required by the contract.

13.1.2. Hub shall be removable type for ease of service. Integral fan/motor combinations with non-removable fans shall not be allowed.

13.1.3. Fans shall be true airfoil shape and shall be non-overloading type

13.2. Fan Guards.

13.2.1. Fans shall be fully guarded with OSHA approved wire guards.

13.3. Direction of Air Flow

13.3.1. Fans and motors shall be mounted on the air leaving side of the coil for draw through operation.

14. Fan Motors

14.1. Fan motors shall be standard NEMA frame size, inverter ready, integral horsepower, induction three phase, totally enclosed severe duty, with sealed ball bearings.

14.2. Motor service factor shall be no less than 1.15.

14.3. Motors shall have internal rotor construction. External rotor construction motors shall not be allowed.

14.4. Fan motors shall be individually wired by the manufacturer to individual junction boxes on the exterior of the unit cabinet.

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15. Cabinet

15.1. General

15.1.1. Standard construction shall be of G90 mill Galvanized Steel, Alloy 5052 Aluminum, or 304L Stainless Steel as required in the contract. Painted or coated cabinet parts shall not be allowed.

15.2. Optional Smart Hanger System

15.2.1. When specified, units shall be provided with Colmac Smart Hanger brackets that will allow the unit to be suspended from pre-mounted structural channels provided by the manufacturer.

15.2.2. Hanger brackets shall be adjustable in the vertical direction to allow for various mounting heights.

15.3. Standard Air Section

15.3.1. Fans and motors shall be arranged for horizontal air discharge, mounted on the air leaving side of the coil section (draw through).

15.4. 45 Degree Down Discharge Air Section

15.4.1. Fans and motors shall be arranged for 45 degree down air discharge when required by contract.

15.4.2. Air discharge section to be factory mounted on the air leaving side and tilted down at 45 degree angle from the vertical plane.

15.5. Penthouse Air Section

15.5.1. Fan and motors shall be arranged for vertical down air discharge when required by the contract. Penthouse air section shall be factory mounted on the air leaving side of the coil section (draw through).

15.5.2. Access doors shall be provided to allow access to each individual fan and motor for service.

16. Drainpans

16.1. The inner drainpan shall be constructed of Alloy 5052 Aluminum.

16.2. Drainpan shall be designed to cover the coil section of the cooler cabinet.

16.3. Drainpan to be triple pitch, V-bottom design, such that water flows front to center, rear to center, and end to end to a single drain.

16.4. Drain outlet shall be constructed as a full radius, formed directly into the drain pan to eliminate the possibility of water pooling around the drain connection.

16.5. When required by the contract, drainpan shall be insulated with a minimum of 1" thick insulation.

16.5.1. The insulation shall be fully covered with a sheet metal insulation shield of mill galvanized steel, aluminum, or 304L stainless steel as required by the contract.

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17. Defrost

17.1. Hot Gas Defrost

17.1.1. General

17.1.1.1. Coil shall be arranged for hot gas defrosting.

17.1.2. Pan Loop

17.1.2.1. A hot gas pan loop of round Alloy 3003 aluminum tubing shall be provided to warm the inner drainpan during defrost. Pan loop designs using square tubing or cross-sections other than round shall not be allowed.

17.1.2.1.1. Pan loop headers are to be held outside the ends of the drain pan to allow for full contact of the tubes with the pan.

17.1.2.1.2. The pan loop shall be attached to the underside of the inner drainpan by means of full length clips designed to keep the pan loop in tight contact with the pan by spring force. The pan loop shall not be mounted in the drainpan where it can contact the defrost water.

17.1.2.1.3. The pan loop outlet pipe shall be arranged such that a liquid seal is formed below the lowest hot gas pan tube.

17.1.3. Pan Loop Check Valve

17.1.3.1. When defrost condensate is being lifted into an overhead condensate return line, a properly sized in-line check valve shall be installed by the manufacturer. Check valve is to be installed between the outlet of the pan loop and the coil per the piping diagram provided by the manufacturer.

17.1.3.2. All portions of the check valve and piping shall be held within the footprint of the drainpan.

17.2. Water Defrost.

17.2.1. General

17.2.1.1. Coil shall be arranged for water defrosting.

17.2.2. Water Distribution Pans

17.2.2.1. Water shall be distributed evenly over the coil fin surfaces by means of water distribution pans.

17.2.2.2. Individual water distribution pans shall be provided one per fan section in the cooler.

17.2.2.3. Water distribution pans shall be removable for inspection and cleaning.

17.2.2.4. Defrost water flow shall be thermodynamically calculated and specified by coil manufacturer such that the flow rate is the minimum needed to heat the mass of coil metal and melt the frost.

17.3. Air Defrost.

17.3.1. Coil shall be arranged for air (off cycle) defrosting.

17.4. Electric Defrost.

17.4.1. General

17.4.1.1. Coil shall be arranged for electric defrosting.

17.4.2. Heating elements

17.4.2.1. Heating elements shall be tubular type, UL listed, with stainless steel sheath.

17.4.2.2. Elements shall be inserted into the fin collars, and spaced throughout the coil core such that the coil core is completely clear of frost and ice at the end of each defrost.

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17.4.2.3. Heating elements shall be wired to a common NEMA 3R (minimum) panel.

17.4.2.4. Heated elements shall be attached to coil core by means of a self-centering spring that acts to reset the heater's position during each defrost (US Patent No. 7,712,327).

18. Packaging

18.1. Units shall be crated on a wooden skid constructed of no less than 2" x 8" timbers.

18.2. Units shall be crated fully assembled (including drainpan) in an upright position ready for mounting in the field.

18.3. Crating shall support the full weight of the evaporator.

18.4. Crating shall be removable by means of gravity only.

19. IOM Manuals

19.1. Installation, Operation, and Maintenance Manuals shall be provided. Number of copies and routings shall be provided per the requirements of the contract.

20. Approved Vendor

20.1. Approved Vendor: Colmac Coil Manufacturing, Inc. Model: A+R Series

21. Ordering Information

21.1. Please Specify:

21.1.1. Complete model number.

21.1.2. Saturated suction temperature.

21.1.3. Room temperature.

21.1.4. Overfeed ratio (if pump recirculated).

21.1.5. Options or special features.

22. Optional Features

1.1. <u>Variable Fin Spacing</u>

1.1.1. Coil core fins shall be arranged for highest frost capacity by varying the fin spacing for the air entering rows of tubes.

1.1.2. Fin spacing in fins per inch shall be specified according to contract.

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A+R Air Cooler (SST Tube) Engineering Specifications

1. **General**
   1.1. This specification covers “A+R” type air coolers having stainless steel tubes and aluminum fins intended for use in refrigeration systems.

2. **Selection / Rating Method**
   2.1. Evaporators shall be selected using DT1 rating method.
   2.2. DTM rating method shall not be used.
   2.3. Evaporators shall be selected on the basis of room relative humidity as shown in the drawing.

3. **Tubing**
   3.1. Coil block shall be constructed with 304L stainless steel tubing.
   3.2. Calculated working pressure of the coil tubing (per ASME Pressure Vessel Code Sec. VIII) shall be no less than 300 psig.
   3.3. Tubing shall be constructed from raw material that is made in the USA, as defined by material test reports, which are to be supplied upon customer request.

4. **Tube Pattern**
   4.1. Tube pattern shall be selected for optimum performance and defrost efficiency from one of the three patterns below:
      4.1.1. 5/8” OD - 1.5” x 1.299” equilateral staggered
      4.1.2. 5/8” OD – 1.97” (50 mm) inline
      4.1.3. 7/8” OD - 2.25” x 1.949” equilateral staggered

5. **Fins**
   5.1. Fins shall be selected from one of the four materials below based on optimum performance and the environment in which the cooler will operate.
      5.1.1. Aluminum 1100 alloy, no less than 0.010” (0.25 mm) thick.
      5.1.2. 304L stainless steel, no less than 0.010” ” (0.25 mm) thick.
      5.1.3. Colmac Anti-Microbial alloy, no less than 0.010” ” (0.25 mm) thick.
         5.1.3.1. Coil core fins shall be constructed of a metal alloy that exhibits anti-microbial properties.
         5.1.3.2. Fins shall completely cover the coil tube surfaces exposed to the airstream by means of a full-length self-spacing fin collar.
         5.1.3.3. Coil coatings are not allowed. All surfaces to be a base metal alloy.
   5.2. Fins shall be continuous flat or configured plate type with full length, self-spacing collars. Spiral, “L-foot”, or wrap-on type fins shall not be allowed.
   5.3. Tubes shall be expanded into fin collars to form a tight mechanical bond between tube and fin.

6. **Headers**
   6.1. Headers shall be made of 304L stainless steel pipe certified to ASME SA-240/304L, no less than ANSI schedule 40.

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7. Connections

7.1. Liquid, suction, and hot gas connections shall be carbon steel pipe no less than schedule 40, certified to ASME SA-240/304L. Bolted type flange union connections shall not be allowed.

7.2. In the case of pumped bottom feed, liquid and hot gas connections shall be oriented vertically up.

7.3. In the case of pumped bottom feed, liquid connection to coil header pipe shall be below the level of the lowest tube in the coil to effectively trap condensate during defrost.

7.4. Coil connections shall be terminated with a welded steel head at the factory. One “Schrader” type valve shall be provided by the manufacturer mounted at the factory in one of the coil connection terminations for the purpose of measuring the shipping charge upon arrival at the jobsite.

7.5. The manufacturer shall charge each coil with a shipping charge of 5-20 psig dry air or nitrogen. A label on the coil connection near the Schrader valve shall be provided indicating the factory charge pressure.

8. Cleanliness

8.1. The manufacturer shall insure that the coils are free from internal dirt, scale, and water.

9. Welding/QC

9.1. All tube and header welds shall be made by Tungsten Inert Gas (TIG) welding process.

9.2. All welds shall be performed by ASME certified welders per the requirements of the manufacturer’s WPS documents. Copies of all WPS, PQR, and Welder Qualification documents used in the fabrication of the coil shall be made available to the engineer upon request.

9.3. Copies of the manufacturer’s Quality Control Manual shall be made available to the engineer upon request.

10. Leak Testing

10.1. Coils shall be tested for leaks after welding at no less than 500 psig (35 bar), dry air under water.

10.2. Test certificates for each coil shall be provided by the manufacturer to the engineer upon request.

11. Circuiting

11.1. <u>Types RT and RB (Recirc Top Feed and Recirc Bottom Feed)</u>

11.1.1. Liquid overfeed orifices shall be installed at the entrance to each coil circuit, sized for a maximum 5 psi pressure drop at the design refrigerant flow rate.

11.1.2. Units with vertical header arrangements shall have circuiting designed for parallel flow of refrigerant relative to direction of air flow.

11.1.3. Units with horizontal header arrangements shall have circuiting designed for cross flow of refrigerant relative to the direction of air flow.

11.2. <u>Type FL (Gravity Flooded)</u>

11.2.1. Units with vertical header arrangements shall have circuiting designed for parallel flow of refrigerant relative to direction of air flow.

11.2.2. Units with horizontal header arrangements shall have circuiting designed for cross flow of refrigerant relative to the direction of air flow..

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11.3. Type DX (Direct Expansion)

11.3.1. Units with vertical header arrangements shall have circuiting designed for counter flow of refrigerant relative to direction of air flow to maximize suction gas superheat for best operation of thermostatic expansion valves.

11.3.2. Units with horizontal header arrangements shall have circuiting designed for cross flow of refrigerant relative to direction of air flow. Circuits must have crossover circuiting to equalize circuit loading.

11.4. Type BW (Single Phase Liquids)

11.4.1. Units with vertical header arrangements shall have circuiting designed for counter flow of refrigerant relative to direction.

11.4.2. Units with horizontal header arrangements shall have circuiting designed for cross flow of refrigerant relative to direction of air flow. Circuits must have crossover circuiting to equalize circuit loading.

12. Fans

12.1. Construction.

12.1.1. Propeller fans shall be constructed of cast aluminum or non-ferrous polymer, as required by the contract.

12.1.2. Hub shall be removable type for ease of service. Integral fan/motor combinations with non-removable fans shall not be allowed.

12.1.3. Fans shall be true airfoil shape and shall be non-overloading type

12.2. Fan Guards.

12.2.1. Fans shall be fully guarded with OSHA approved wire guards.

12.3. Direction of Air Flow

12.3.1. Fans and motors shall be mounted on the air leaving side of the coil for draw through operation.

13. Fan Motors

13.1. Fan motors shall be standard NEMA frame size, inverter ready, integral horsepower, induction three phase, totally enclosed severe duty, with sealed ball bearings.

13.2. Motor service factor shall be no less than 1.15.

13.3. Motors shall have internal rotor construction. External rotor construction motors shall not be allowed.

13.4. Fan motors shall be individually wired by the manufacturer to individual junction boxes on the exterior of the unit cabinet.

14. Cabinet

14.1. General

14.1.1. Standard construction shall be of G90 mill Galvanized Steel, Alloy 5052 Aluminum, or 304L Stainless Steel as required in the contract. Painted or coated cabinet parts shall not be allowed.

14.2. Optional Smart Hanger System

14.2.1. When specified, units shall be provided with Colmac Smart Hanger brackets that will allow the unit to be suspended from pre-mounted structural channels provided by the manufacturer.

14.2.2. Hanger brackets shall be adjustable in the vertical direction to allow for various mounting heights.

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14.3. Standard Air Section

14.3.1. Fans and motors shall be arranged for horizontal air discharge, mounted on the air leaving side of the coil section (draw through).

14.4. 45 Degree Down Discharge Air Section

14.4.1. Fans and motors shall be arranged for 45 degree down air discharge when required by contract.

14.4.2. Air discharge section to be factory mounted on the air leaving side and tilted down at 45 degree angle from the vertical plane.

14.5. Penthouse Air Section

14.5.1. Fan and motors shall be arranged for vertical down air discharge when required by the contract. Penthouse air section shall be factory mounted on the air leaving side of the coil section (draw through).

14.5.2. Access doors shall be provided to allow access to each individual fan and motor for service.

15. Drainpans

15.1. The inner drainpan shall be constructed of Alloy 5052 Aluminum.

15.2. Drainpan shall be designed to cover the coil section of the cooler cabinet.

15.3. Drainpan to be triple pitch, V-bottom design, such that water flows front to center, rear to center, and end to end to a single drain.

15.4. Drain outlet shall be constructed as a full radius, formed directly into the drain pan to eliminate the possibility of water pooling around the drain connection.

15.5. When required by the contract, drainpan shall be insulated with a minimum of 1" thick insulation.

15.5.1. The insulation shall be fully covered with a sheet metal insulation shield of mill galvanized steel, aluminum, or 304L stainless steel as required by the contract.

16. Defrost

16.1. Hot Gas Defrost

16.1.1. General

16.1.1.1. Coil shall be arranged for hot gas defrosting.

16.1.2. Pan Loop

16.1.2.1. A hot gas pan loop of round Alloy 3003 aluminum tubing shall be provided to warm the inner drainpan during defrost. Pan loop designs using square tubing or cross-sections other than round shall not be allowed.

16.1.2.1.1. Pan loop headers are to be held outside the ends of the drain pan to allow for full contact of the tubes with the pan.

16.1.2.1.2. The pan loop shall be attached to the underside of the inner drainpan by means of full length clips designed to keep the pan loop in tight contact with the pan by spring force. The pan loop shall not be mounted in the drainpan where it can contact the defrost water.

16.1.2.1.3. The pan loop outlet pipe shall be arranged such that a liquid seal is formed below the lowest hot gas pan tube.

16.1.3. Pan Loop Check Valve

16.1.3.1. When defrost condensate is being lifted into an overhead condensate return line, a properly sized in-line check valve shall be installed by the manufacturer. Check valve is to be installed between the outlet of the pan loop and the coil per the piping diagram provided by the manufacturer.

16.1.3.2. All portions of the check valve and piping shall be held within the footprint of the drainpan.

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16.2. Water Defrost.

16.2.1. General

16.2.1.1. Coil shall be arranged for water defrosting.

16.2.2. Water Distribution Pans

16.2.2.1. Water shall be distributed evenly over the coil fin surfaces by means of water distribution pans.

16.2.2.2. Individual water distribution pans shall be provided one per fan section in the cooler.

16.2.2.3. Water distribution pans shall be removable for inspection and cleaning.

16.2.2.4. Defrost water flow shall be thermodynamically calculated and specified by coil manufacturer such that the flow rate is the minimum needed to heat the mass of coil metal and melt the frost.

16.3. Air Defrost.

16.3.1. Coil shall be arranged for air (off cycle) defrosting.

16.4. Electric Defrost.

16.4.1. General

16.4.1.1. Coil shall be arranged for electric defrosting.

16.4.2. Heating elements

16.4.2.1. Heating elements shall be tubular type, UL listed, with stainless steel sheath.

16.4.2.2. Elements shall be inserted into the fin collars, and spaced throughout the coil core such that the coil core is completely clear of frost and ice at the end of each defrost.

16.4.2.3. Heating elements shall be wired to a common NEMA 3R (minimum) panel.

16.4.2.4. Heated elements shall be attached to coil core by means of a self-centering spring that acts to reset the heater's position during each defrost (US Patent No. 7,712,327).

17. Packaging

17.1. Units shall be crated on a wooden skid constructed of no less than 2" x 8" timbers.

17.2. Units shall be crated fully assembled (including drainpan) in an upright position ready for mounting in the field.

17.3. Crating shall support the full weight of the evaporator.

17.4. Crating shall be removable by means of gravity only.

18. IOM Manuals

18.1. Installation, Operation, and Maintenance Manuals shall be provided. Number of copies and routings shall be provided per the requirements of the contract.

19. Approved Vendor

19.1. Approved Vendor: Colmac Coil Manufacturing, Inc. Model: A+R Series

20. Ordering Information

20.1. Please Specify:

20.1.1. Complete model number.
20.1.2. Saturated suction temperature.
20.1.3. Room temperature.
20.1.4. Overfeed ratio (if pump recirculated).
20.1.5. Options or special features.

21. **Optional Features**

1.1. Variable Fin Spacing

1.1.1. Coil core fins shall be arranged for highest frost capacity by varying the fin spacing for the air entering rows of tubes.
1.1.2. Fin spacing in fins per inch shall be specified according to contract.

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A+D Air Cooler (AL Tube) Engineering Specifications

1. **General**
   1.1. This specification covers "A+D" type air coolers having aluminum tubes and aluminum fins intended for use in refrigeration systems.

2. **Selection / Rating Method**
   2.1. Evaporators shall be selected using DT1 rating method.
   2.2. DTM rating method shall not be used.
   2.3. Evaporators shall be selected on the basis of room relative humidity as shown in the drawing.

3. **Tubing**
   3.1. Coil block shall be constructed with alloy 3003 aluminum tubing.
   3.2. Calculated working pressure of the coil tubing (per ASME Pressure Vessel Code Sec. VIII) shall be no less than 300 psig.
   3.3. Tubing shall be constructed from raw material that is made in the USA, as defined by material test reports, which are to be supplied upon customer request.

4. **Tube Pattern**
   4.1. Tube pattern shall be selected for optimum performance and defrost efficiency from one of the three patterns below:
      4.1.1. 5/8" OD - 1.5" x 1.299" equilateral staggered
      4.1.2. 5/8" OD – 1.97" (50 mm) inline
      4.1.3. 7/8" OD - 2.25" x 1.949" equilateral staggered

5. **Fins**
   5.1. Shall be aluminum 1100 alloy, no less than 0.010" (0.25 mm) thick.
   5.2. Fins shall be continuous flat or configured plate type with full length, self-spacing collars. Spiral, "L-foot", or wrap-on type fins shall not be allowed.
   5.3. Tubes shall be expanded into fin collars to form a tight mechanical bond between tube and fin.

6. **Headers**
   6.1. Headers shall be made of ASME B241, Alloy 6061 aluminum no less than ANSI schedule 40 pipes.

7. **Connections**
   7.1. Liquid, suction, and hot gas connections shall be carbon steel pipe no less than schedule 40, certified to ASME SA-106/B. Bolted type flange union connections shall not be allowed.
   7.2. In the case of pumped bottom feed, liquid and hot gas connections shall be oriented vertically up.
   7.3. In the case of pumped bottom feed, liquid connection to coil header pipe shall be below the level of the lowest tube in the coil to effectively trap condensate during defrost.

7.4. Coil connections shall be terminated with a welded steel head at the factory. One "Schrader" type valve shall be provided by the manufacturer mounted at the factory in one of the coil connection terminations for the purpose of measuring the shipping charge upon arrival at the jobsite.

7.5. The manufacturer shall charge each coil with a shipping charge of 5-20 psig dry air or nitrogen. A label on the coil connection near the Schrader valve shall be provided indicating the factory charge pressure.

8. Cleanliness

8.1. The manufacturer shall insure that the coils are free from internal dirt, scale, and water.

9. Welding/QC

9.1. All tube welds shall be made by Tungsten Inert Gas (TIG) welding process.

9.2. All welds shall be performed by ASME certified welders per the requirements of the manufacturer's WPS documents. Copies of all WPS, PQR, and Welder Qualification documents used in the fabrication of the coil shall be made available to the engineer upon request.

9.3. Copies of the manufacturer's Quality Control Manual shall be made available to the engineer upon request.

10. Leak Testing

10.1. Coils shall be tested for leaks after welding at no less than 500 psig (35 bar), dry air under water.

10.2. Test certificates for each coil shall be provided by the manufacturer to the engineer upon request.

11. Circuiting

11.1. Type RTA (Recirc Top Feed) and Type RBA (Recirc Bottom Feed)

11.1.1. Liquid overfeed orifices shall be installed at the entrance to each coil circuit, sized for 5 psi pressure drop at the design ammonia flow rate.

12. Fans

12.1. Construction.

12.1.1. Propeller fans shall be constructed of cast aluminum or non-ferrous polymer, as required by the contract.

12.1.2. Hub shall be removable type for ease of service. Integral fan/motor combinations with non-removable fans shall not be allowed.

12.1.3. Fans shall be true airfoil shape and shall be non-overloading type

12.2. Fan Guards.

12.2.1. Fans shall be fully guarded with OSHA approved wire guards.

12.3. Direction of Air Flow

12.3.1. Fans and motors shall be mounted on the air leaving side of the coil for draw through operation.

13. Fan Motors

13.1. Fan motors shall be standard NEMA frame size, inverter ready, integral horsepower, induction three phase, totally enclosed severe duty, with sealed ball bearings.

13.2. Motor service factor shall be no less than 1.15.

13.3. Motors shall have internal rotor construction. External rotor construction motors shall not be allowed.

13.4. Fan motors shall be individually wired by the manufacturer to individual junction boxes on the exterior of the unit cabinet.

14. Cabinet

14.1. General

14.1.1. Standard construction shall be of G90 mill Galvanized Steel, Alloy 5052 Aluminum, or 304L Stainless Steel as required in the contract. Painted or coated cabinet parts shall not be allowed.

14.2. Optional Smart Hanger System

14.2.1. When specified, units shall be provided with Colmac Smart Hanger brackets that will allow the unit to be suspended from pre-mounted structural channels provided by the manufacturer.

14.2.2. Hanger brackets shall be adjustable in the vertical direction to allow for various mounting heights.

14.3. Standard Air Section

14.3.1. Fans and motors shall be arranged for horizontal air discharge, mounted on the air leaving side of the coil section (draw through).

14.4. 45 Degree Down Discharge Air Section

14.4.1. Fans and motors shall be arranged for 45 degree down air discharge when required by contract.

14.4.2. Air discharge section to be factory mounted on the air leaving side and tilted down at 45 degree angle from the vertical plane.

14.5. Penthouse Air Section

14.5.1. Fan and motors shall be arranged for vertical down air discharge when required by the contract. Penthouse air section shall be factory mounted on the air leaving side of the coil section (draw through).

14.5.2. Access doors shall be provided to allow access to each individual fan and motor for service.

15. Drainpans

15.1. The inner drainpan shall be constructed of Alloy 5052 Aluminum.

15.2. Drainpan shall be designed to cover the coil section of the cooler cabinet.

15.3. Drainpan to be triple pitch, V-bottom design, such that water flows front to center, rear to center, and end to end to a single drain.

15.4. Drain outlet shall be constructed as a full radius, formed directly into the drain pan to eliminate the possibility of water pooling around the drain connection.

15.5. When required by the contract, drainpan shall be insulated with a minimum of 1" thick insulation.

15.5.1. The insulation shall be fully covered with a sheet metal insulation shield of mill galvanized steel, aluminum, or 304L stainless steel as required by the contract.

16. Defrost

16.1. Hot Gas Defrost

16.1.1. General

16.1.1.1. Coil shall be arranged for hot gas defrosting.

16.1.2. Pan Loop

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16.1.2.1. A hot gas pan loop of round Alloy 3003 aluminum tubing shall be provided to warm the inner drainpan during defrost. Pan loop designs using square tubing or cross-sections other than round shall not be allowed.

16.1.2.1.1. Pan loop headers are to be held outside the ends of the drain pan to allow for full contact of the tubes with the pan.

16.1.2.1.2. The pan loop shall be attached to the underside of the inner drainpan by means of full length clips designed to keep the pan loop in tight contact with the pan by spring force. The pan loop shall not be mounted in the drainpan where it can contact the defrost water.

16.1.2.1.3. The pan loop outlet pipe shall be arranged such that a liquid seal is formed below the lowest hot gas pan tube.

16.1.3. Pan Loop Check Valve

16.1.3.1. When defrost condensate is being lifted into an overhead condensate return line, a properly sized in-line check valve shall be installed by the manufacturer. Check valve is to be installed between the outlet of the pan loop and the coil per the piping diagram provided by the manufacturer.

16.1.3.2. All portions of the check valve and piping shall be held within the footprint of the drainpan.

16.2. Water Defrost.

16.2.1. General

16.2.1.1. Coil shall be arranged for water defrosting.

16.2.2. Water Distribution Pans

16.2.2.1. Water shall be distributed evenly over the coil fin surfaces by means of water distribution pans.

16.2.2.2. Individual water distribution pans shall be provided one per fan section in the cooler.

16.2.2.3. Water distribution pans shall be removable for inspection and cleaning.

16.2.2.4. Defrost water flow shall be thermodynamically calculated and specified by coil manufacturer such that the flow rate is the minimum needed to heat the mass of coil metal and melt the frost.

16.3. Air Defrost.

16.3.1. Coil shall be arranged for air (off cycle) defrosting.

16.4. Electric Defrost.

16.4.1. General

16.4.1.1. Coil shall be arranged for electric defrosting.

16.4.2. Heating elements

16.4.2.1. Heating elements shall be tubular type, UL listed, with stainless steel sheath.

16.4.2.2. Elements shall be inserted into the fin collars, and spaced throughout the coil core such that the coil core is completely clear of frost and ice at the end of each defrost.

16.4.2.3. Heating elements shall be wired to a common NEMA 3R (minimum) panel.

16.4.2.4. Heated elements shall be attached to coil core by means of a self-centering spring that acts to reset the heater's position during each defrost (US Patent No. 7,712,327).

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17. Packaging

17.1. Units shall be crated on a wooden skid constructed of no less than 2” x 8” timbers.

17.2. Units shall be crated fully assembled (including drainpan) in an upright position ready for mounting in the field.

17.3. Crating shall support the full weight of the evaporator.

17.4. Crating shall be removable by means of gravity only.

18. IOM Manuals

18.1. Installation, Operation, and Maintenance Manuals shall be provided. Number of copies and routings shall be provided per the requirements of the contract.

19. Approved Vendor

19.1. Approved Vendor: Colmac Coil Manufacturing, Inc. Model: A+D Series

20. Ordering Information

20.1. Please Specify:

20.1.1. Complete model number.

20.1.2. Saturated suction temperature.

20.1.3. Room temperature.

20.1.4. Overfeed ratio (if pump recirculated).

20.1.5. Options or special features.

21. Optional Features

1.1. Variable Fin Spacing

1.1.1. Coil core fins shall be arranged for highest frost capacity by varying the fin spacing for the air entering rows of tubes.

1.1.2. Fin spacing in fins per inch shall be specified according to contract.

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A+D Air Cooler (Cu Tube) Engineering Specifications

1. **General**
   1.1. This specification covers "A+D" type air coolers having copper tubes and aluminum fins intended for use in refrigeration systems.

2. **Selection / Rating Method**
   2.1. Evaporators shall be selected using DT1 rating method.
   2.2. DTM rating method shall not be used.
   2.3. Evaporators shall be selected on the basis of room relative humidity as shown in the drawing.

3. **Tubing**
   3.1. Coil block shall be constructed with UNS C12200 copper tubing certified to ASTM B-75.
   3.2. Calculated working pressure of the coil tubing (per ASME Pressure Vessel Code Sec. VIII) shall be no less than 300 psig.
   3.3. Tubing shall be constructed from raw material that is made in the USA, as defined by material test reports, which are to be supplied upon customer request.

4. **Tube Pattern**
   4.1. Tube pattern shall be selected for optimum performance and defrost efficiency from one of the three patterns below:
      4.1.1. 5/8" OD - 1.5" x 1.299" equilateral staggered
      4.1.2. 5/8" OD – 1.97" (50 mm) inline
      4.1.3. 7/8" OD - 2.25" x 1.949" equilateral staggered

5. **Fins**
   5.1. Fins shall be selected from one of the four materials below based on optimum performance and the environment in which the cooler will operate.
      5.1.1. Aluminum 1100 alloy, no less than 0.010" (0.25 mm) thick.
      5.1.2. 304L stainless steel, no less than 0.010" " (0.25 mm) thick.
      5.1.3. Copper, no less than no less than 0.010" " (0.25 mm) thick.
   5.2. Fins shall be continuous flat or configured plate type with full length, self-spacing collars. Spiral, "L-foot", or wrap-on type fins shall not be allowed.
   5.3. Tubes shall be expanded into fin collars to form a tight mechanical bond between tube and fin.

6. **Headers**
   6.1. Headers shall be made of UNS C12200 Type L copper tubing certified to ASTM B-88.

7. **Connections**
   7.1. Liquid, suction, and hot gas connections shall be UNS C12200 Type L copper tubing certified to ASTM B-88. Bolted type flange union connections shall not be allowed.
   7.2. In the case of pumped bottom feed, liquid and hot gas connections shall be oriented vertically up.
   7.3. In the case of pumped bottom feed, liquid connection to coil header pipe shall be below the level of the lowest tube in the coil to effectively trap condensate during defrost.
   7.4. Coil connections shall be terminated with a brazed copper head at the factory. One

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"Schrader" type valve shall be provided by the manufacturer mounted at the factory in one of the coil connection terminations for the purpose of measuring the shipping charge upon arrival at the jobsite.

7.5. The manufacturer shall charge each coil with a shipping charge of 5-20 psig dry air or nitrogen. A label on the coil connection near the Schrader valve shall be provided indicating the factory charge pressure.

8. Cleanliness

8.1. The manufacturer shall insure that the coils are free from internal dirt, scale, and water.

9. Brazing/QC

9.1. All tube and header joints shall be made with high temperature brazing filler metal certified to no less than BCuP-3 (5% Silver Solder).
9.2. All brazing shall be performed by ASME certified brazers per the requirements of the manufacturer's BPS documents. Copies of all BPS, PQR, and Brazer Qualification documents used in the fabrication of the coil shall be made available to the engineer upon request.
9.3. Copies of the manufacturer's Quality Control Manual shall be made available to the engineer upon request.

10. Leak Testing

10.1. Coils shall be tested for leaks after brazing at no less than 350 psig (25 bar), dry air under water.
10.2. Test certificates for each coil shall be provided by the manufacturer to the engineer upon request.

11. Circuiting

11.1. <u>Types RT and RB (Recirc Top Feed and Recirc Bottom Feed)</u>
- 11.1.1. Liquid overfeed orifices shall be installed at the entrance to each coil circuit, sized for a maximum 5 psi pressure drop at the design refrigerant flow rate.
- 11.1.2. Units with vertical header arrangements shall have circuiting designed for parallel flow of refrigerant relative to direction of air flow.
- 11.1.3. Units with horizontal header arrangements shall have circuiting designed for cross flow of refrigerant relative to the direction of air flow.

11.2. <u>Type FL (Gravity Flooded)</u>
- 11.2.1. Units with vertical header arrangements shall have circuiting designed for parallel flow of refrigerant relative to direction of air flow.
- 11.2.2. Units with horizontal header arrangements shall have circuiting designed for cross flow of refrigerant relative to the direction of air flow..

11.3. <u>Type DX (Direct Expansion)</u>
- 11.3.1. Units with vertical header arrangements shall have circuiting designed for counter flow of refrigerant relative to direction of air flow to maximize suction gas superheat for best operation of thermostatic expansion valves.
- 11.3.2. Units with horizontal header arrangements shall have circuiting designed for cross flow of refrigerant relative to direction of air flow. Circuits must have crossover circuiting to equalize circuit loading.

11.4. <u>Type BW (Single Phase Liquids)</u>
- 11.4.1. Units with vertical header arrangements shall have circuiting designed for counter flow of refrigerant relative to direction.

11.4.2. Units with horizontal header arrangements shall have circuiting designed for cross flow of refrigerant relative to direction of air flow. Circuits must have crossover circuiting to equalize circuit loading.

12. Fans

12.1. Construction.

12.1.1. Propeller fans shall be constructed of cast aluminum or non-ferrous polymer, as required by the contract.

12.1.2. Hub shall be removable type for ease of service. Integral fan/motor combinations with non-removable fans shall not be allowed.

12.1.3. Fans shall be true airfoil shape and shall be non-overloading type

12.2. Fan Guards.

12.2.1. Fans shall be fully guarded with OSHA approved wire guards.

12.3. Direction of Air Flow

12.3.1. Fans and motors shall be mounted on the air leaving side of the coil for draw through operation.

13. Fan Motors

13.1. Fan motors shall be standard NEMA frame size, inverter ready, integral horsepower, induction three phase, totally enclosed severe duty, with sealed ball bearings.

13.2. Motor service factor shall be no less than 1.15.

13.3. Motors shall have internal rotor construction. External rotor construction motors shall not be allowed.

13.4. Fan motors shall be individually wired by the manufacturer to individual junction boxes on the exterior of the unit cabinet.

14. Cabinet

14.1. General

14.1.1. Standard construction shall be of G90 mill Galvanized Steel, Alloy 5052 Aluminum, or 304L Stainless Steel as required in the contract. Painted or coated cabinet parts shall not be allowed.

14.2. Optional Smart Hanger System

14.2.1. When specified, units shall be provided with Colmac Smart Hanger brackets that will allow the unit to be suspended from pre-mounted structural channels provided by the manufacturer.

14.2.2. Hanger brackets shall be adjustable in the vertical direction to allow for various mounting heights.

14.3. Standard Air Section

14.3.1. Fans and motors shall be arranged for horizontal air discharge, mounted on the air leaving side of the coil section (draw through).

14.4. 45 Degree Down Discharge Air Section

14.4.1. Fans and motors shall be arranged for 45 degree down air discharge when required by contract.

14.4.2. Air discharge section to be factory mounted on the air leaving side and tilted down at 45 degree angle from the vertical plane.

14.5. Penthouse Air Section

14.5.1. Fan and motors shall be arranged for vertical down air discharge when required by the contract. Penthouse air section shall be factory mounted on the air leaving side of the coil section (draw through).

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14.5.2. Access doors shall be provided to allow access to each individual fan and motor for service.

15. Drainpans

15.1. The inner drainpan shall be constructed of Alloy 5052 Aluminum.

15.2. Drainpan shall be designed to cover the coil section of the cooler cabinet.

15.3. Drainpan to be triple pitch, V-bottom design, such that water flows front to center, rear to center, and end to end to a single drain.

15.4. Drain outlet shall be constructed as a full radius, formed directly into the drain pan to eliminate the possibility of water pooling around the drain connection.

15.5. When required by the contract, drainpan shall be insulated with a minimum of 1” thick insulation.

15.5.1. The insulation shall be fully covered with a sheet metal insulation shield of mill galvanized steel, aluminum, or 304L stainless steel as required by the contract.

16. Defrost

16.1. Hot Gas Defrost

16.1.1. General

16.1.1.1. Coil shall be arranged for hot gas defrosting.

16.1.2. Pan Loop

16.1.2.1. A hot gas pan loop of round Alloy 3003 aluminum tubing shall be provided to warm the inner drainpan during defrost. Pan loop designs using square tubing or cross-sections other than round shall not be allowed.

16.1.2.1.1. Pan loop headers are to be held outside the ends of the drain pan to allow for full contact of the tubes with the pan.

16.1.2.1.2. The pan loop shall be attached to the underside of the inner drainpan by means of full length clips designed to keep the pan loop in tight contact with the pan by spring force. The pan loop shall not be mounted in the drainpan where it can contact the defrost water.

16.1.2.1.3. The pan loop outlet pipe shall be arranged such that a liquid seal is formed below the lowest hot gas pan tube.

16.1.3. Pan Loop Check Valve

16.1.3.1. When defrost condensate is being lifted into an overhead condensate return line, a properly sized in-line check valve shall be installed by the manufacturer. Check valve is to be installed between the outlet of the pan loop and the coil per the piping diagram provided by the manufacturer.

16.1.3.2. All portions of the check valve and piping shall be held within the footprint of the drainpan.

16.2. Water Defrost.

16.2.1. General

16.2.1.1. Coil shall be arranged for water defrosting.

16.2.2. Water Distribution Pans

16.2.2.1. Water shall be distributed evenly over the coil fin surfaces by means of water distribution pans.

16.2.2.2. Individual water distribution pans shall be provided one per fan section in the cooler.

16.2.2.3. Water distribution pans shall be removable for inspection and cleaning.

16.2.2.4. Defrost water flow shall be thermodynamically calculated and specified by coil manufacturer such that the flow rate is the minimum needed to heat the mass of coil metal and melt the frost.

16.3. Air Defrost.
16.3.1. Coil shall be arranged for air (off cycle) defrosting.
16.4. Electric Defrost.
16.4.1. General
16.4.1.1. Coil shall be arranged for electric defrosting.
16.4.2. Heating elements
16.4.2.1. Heating elements shall be tubular type, UL listed, with stainless steel sheath.
16.4.2.2. Elements shall be inserted into the fin collars, and spaced throughout the coil core such that the coil core is completely clear of frost and ice at the end of each defrost.

16.4.2.3. Heating elements shall be wired to a common NEMA 3R (minimum) panel.
16.4.2.4. Heated elements shall be attached to coil core by means of a self-centering spring that acts to reset the heater's position during each defrost (US Patent No. 7,712,327).

17. Packaging
17.1. Units shall be crated on a wooden skid constructed of no less than 2" x 8" timbers.
17.2. Units shall be crated fully assembled (including drainpan) in an upright position ready for mounting in the field.
17.3. Crating shall support the full weight of the evaporator.
17.4. Crating shall be removable by means of gravity only.

18. IOM Manuals
18.1. Installation, Operation, and Maintenance Manuals shall be provided. Number of copies and routings shall be provided per the requirements of the contract.

19. Approved Vendor
19.1. Approved Vendor: Colmac Coil Manufacturing, Inc. Model: A+D Series

20. Ordering Information
20.1. Please Specify:
20.1.1. Complete model number.
20.1.2. Saturated suction temperature.
20.1.3. Room temperature.
20.1.4. Overfeed ratio (if pump recirculated).
20.1.5. Options or special features.

21. Optional Features
1.1. Variable Fin Spacing
1.1.1. Coil core fins shall be arranged for highest frost capacity by varying the fin spacing for the air entering rows of tubes.
1.1.2. Fin spacing in fins per inch shall be specified according to contract.

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A+D Air Cooler (Galvanized) Engineering Specifications

1. General

1.1. This specification covers "A+D" type air coolers having galvanized steel tubes and fins intended for use in refrigeration systems.

2. Selection / Rating Method

2.1. Evaporators shall be selected using DT1 rating method.
2.2. DTM rating method shall not be used.
2.3. Evaporators shall be selected on the basis of room relative humidity as shown in the drawing.

3. Tubing

3.1. Coil block shall be constructed with ASME SA-214 carbon steel tubing.
3.2. Calculated working pressure of the coil tubing (per ASME Pressure Vessel Code Sec. VIII) shall be no less than 300 psig.
3.3. Tubing shall be constructed from raw material that is made in the USA, as defined by material test reports, which are to be supplied upon customer request.

4. Tube Pattern

4.1.1. Tube pattern shall be 7/8" OD - 2.25" x 1.949" equilateral staggered

5. Fins

5.1. Shall be carbon steel, no less than 0.010" (0.25 mm) thick.
5.2. Fins shall be continuous flat or configured plate type with full length, self-spacing collars. Spiral, "L-foot", or wrap-on type fins shall not be allowed.
5.3. Fin collars shall be configured so that molten zinc completely bonds the tubes and fins.

6. Headers

6.1. Headers shall be made of carbon steel pipe certified to ASME SA-106/B, no less than ANSI schedule 40.

7. Connections

7.1. Liquid, suction, and hot gas connections shall be carbon steel pipe no less than schedule 40, certified to ASME SA-106/B. Bolted type flange union connections shall not be allowed.
7.2. In the case of pumped bottom feed, liquid and hot gas connections shall be oriented vertically up.
7.3. In the case of pumped bottom feed, liquid connection to coil header pipe shall be below the level of the lowest tube in the coil to effectively trap condensate during defrost.
7.4. Coil connections shall be terminated with a welded steel head at the factory. One "Schrader" type valve shall be provided by the manufacturer mounted at the factory in one of the coil connection terminations for the purpose of measuring the shipping charge upon arrival at the jobsite.
7.5. The manufacturer shall charge each coil with a shipping charge of 5-20 psig dry air or nitrogen. A label on the coil connection near the Schrader valve shall be provided indicating the factory charge pressure.

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8. Cleanliness

8.1. The manufacturer shall insure that the coils are free from internal dirt, scale, and water.

9. Welding/QC

9.1. All tube and header welds shall be made by Tungsten Inert Gas (TIG) welding process.

9.2. All welds shall be performed by ASME certified welders per the requirements of the manufacturer's WPS documents. Copies of all WPS, PQR, and Welder Qualification documents used in the fabrication of the coil shall be made available to the engineer upon request.

9.3. Copies of the manufacturer's Quality Control Manual shall be made available to the engineer upon request.

10. Leak Testing

10.1. Coils shall be tested for leaks after welding at no less than 500 psig (35 bar), dry air under water.

10.2. Test certificates for each coil shall be provided by the manufacturer to the engineer upon request.

11. Circuiting

11.1. Types RT and RB (Recirc Top Feed and Recirc Bottom Feed)

11.1.1. Liquid overfeed orifices shall be installed at the entrance to each coil circuit, sized for a maximum 5 psi pressure drop at the design refrigerant flow rate.

11.1.2. Units with vertical header arrangements shall have circuiting designed for parallel flow of refrigerant relative to direction of air flow.

11.1.3. Units with horizontal header arrangements shall have circuiting designed for cross flow of refrigerant relative to the direction of air flow.

11.2. Type FL (Gravity Flooded)

11.2.1. Units with vertical header arrangements shall have circuiting designed for parallel flow of refrigerant relative to direction of air flow.

11.2.2. Units with horizontal header arrangements shall have circuiting designed for cross flow of refrigerant relative to the direction of air flow..

11.3. Type DX (Direct Expansion)

11.3.1. Units with vertical header arrangements shall have circuiting designed for counter flow of refrigerant relative to direction of air flow to maximize suction gas superheat for best operation of thermostatic expansion valves.

11.3.2. Units with horizontal header arrangements shall have circuiting designed for cross flow of refrigerant relative to direction of air flow. Circuits must have crossover circuiting to equalize circuit loading.

11.4. Type BW (Single Phase Liquids)

11.4.1. Units with vertical header arrangements shall have circuiting designed for counter flow of refrigerant relative to direction.

11.4.2. Units with horizontal header arrangements shall have circuiting designed for cross flow of refrigerant relative to direction of air flow. Circuits must have crossover circuiting to equalize circuit loading.

12. Galvanizing

12.1. Carbon steel coil core to be hot-dip galvanized per ASTM A-123 for corrosion protection.

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13. Fans

13.1. Construction.

13.1.1. Propeller fans shall be constructed of cast aluminum or non-ferrous polymer, as required by the contract.

13.1.2. Hub shall be removable type for ease of service. Integral fan/motor combinations with non-removable fans shall not be allowed.

13.1.3. Fans shall be true airfoil shape and shall be non-overloading type

13.2. Fan Guards.

13.2.1. Fans shall be fully guarded with OSHA approved wire guards.

13.3. Direction of Air Flow

13.3.1. Fans and motors shall be mounted on the air leaving side of the coil for draw through operation.

14. Fan Motors

14.1. Fan motors shall be standard NEMA frame size, inverter ready, integral horsepower, induction three phase, totally enclosed severe duty, with sealed ball bearings.

14.2. Motor service factor shall be no less than 1.15.

14.3. Motors shall have internal rotor construction. External rotor construction motors shall not be allowed.

14.4. Fan motors shall be individually wired by the manufacturer to individual junction boxes on the exterior of the unit cabinet.

15. Cabinet

15.1. General

15.1.1. Standard construction shall be of G90 mill Galvanized Steel, Alloy 5052 Aluminum, or 304L Stainless Steel as required in the contract. Painted or coated cabinet parts shall not be allowed.

15.2. Optional Smart Hanger System

15.2.1. When specified, units shall be provided with Colmac Smart Hanger brackets that will allow the unit to be suspended from pre-mounted structural channels provided by the manufacturer.

15.2.2. Hanger brackets shall be adjustable in the vertical direction to allow for various mounting heights.

15.3. Standard Air Section

15.3.1. Fans and motors shall be arranged for horizontal air discharge, mounted on the air leaving side of the coil section (draw through).

15.4. 45 Degree Down Discharge Air Section

15.4.1. Fans and motors shall be arranged for 45 degree down air discharge when required by contract.

15.4.2. Air discharge section to be factory mounted on the air leaving side and tilted down at 45 degree angle from the vertical plane.

15.5. Penthouse Air Section

15.5.1. Fan and motors shall be arranged for vertical down air discharge when required by the contract. Penthouse air section shall be factory mounted on the air leaving side of the coil section (draw through).

15.5.2. Access doors shall be provided to allow access to each individual fan and motor for service.

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16. Drainpans

16.1. The inner drainpan shall be constructed of Alloy 5052 Aluminum.

16.2. Drainpan shall be designed to cover the coil section of the cooler cabinet.

16.3. Drainpan to be triple pitch, V-bottom design, such that water flows front to center, rear to center, and end to end to a single drain.

16.4. Drain outlet shall be constructed as a full radius, formed directly into the drain pan to eliminate the possibility of water pooling around the drain connection.

16.5. When required by the contract, drainpan shall be insulated with a minimum of 1" thick insulation.

16.5.1. The insulation shall be fully covered with a sheet metal insulation shield of mill galvanized steel, aluminum, or 304L stainless steel as required by the contract.

17. Defrost

17.1. <u>Hot Gas Defrost</u>

17.1.1. General

17.1.1.1. Coil shall be arranged for hot gas defrosting.

17.1.2. Pan Loop

17.1.2.1. A hot gas pan loop of round Alloy 3003 aluminum tubing shall be provided to warm the inner drainpan during defrost. Pan loop designs using square tubing or cross-sections other than round shall not be allowed.

17.1.2.1.1. Pan loop headers are to be held outside the ends of the drain pan to allow for full contact of the tubes with the pan.

17.1.2.1.2. The pan loop shall be attached to the underside of the inner drainpan by means of full length clips designed to keep the pan loop in tight contact with the pan by spring force. The pan loop shall not be mounted in the drainpan where it can contact the defrost water.

17.1.2.1.3. The pan loop outlet pipe shall be arranged such that a liquid seal is formed below the lowest hot gas pan tube.

17.1.3. Pan Loop Check Valve

17.1.3.1. When defrost condensate is being lifted into an overhead condensate return line, a properly sized in-line check valve shall be installed by the manufacturer. Check valve is to be installed between the outlet of the pan loop and the coil per the piping diagram provided by the manufacturer.

17.1.3.2. All portions of the check valve and piping shall be held within the footprint of the drainpan.

17.2. <u>Water Defrost.</u>

17.2.1. General

17.2.1.1. Coil shall be arranged for water defrosting.

17.2.2. Water Distribution Pans

17.2.2.1. Water shall be distributed evenly over the coil fin surfaces by means of water distribution pans.

17.2.2.2. Individual water distribution pans shall be provided one per fan section in the cooler.

17.2.2.3. Water distribution pans shall be removable for inspection and cleaning.

17.2.2.4. Defrost water flow shall be thermodynamically calculated and specified by coil manufacturer such that the flow rate is the minimum needed to heat the mass of coil metal and melt the frost.

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17.3. Air Defrost.
17.3.1. Coil shall be arranged for air (off cycle) defrosting.
17.4. Electric Defrost.
17.4.1. General
17.4.1.1. Coil shall be arranged for electric defrosting.
17.4.2. Heating elements
17.4.2.1. Heating elements shall be tubular type, UL listed, with stainless steel sheath.
17.4.2.2. Elements shall be inserted into the fin collars, and spaced throughout the coil core such that the coil core is completely clear of frost and ice at the end of each defrost.

17.4.2.3. Heating elements shall be wired to a common NEMA 3R (minimum) panel.
17.4.2.4. Heated elements shall be attached to coil core by means of a self-centering spring that acts to reset the heater's position during each defrost (US Patent No. 7,712,327).

18. Packaging

18.1. Units shall be crated on a wooden skid constructed of no less than 2" x 8" timbers.
18.2. Units shall be crated fully assembled (including drainpan) in an upright position ready for mounting in the field.
18.3. Crating shall support the full weight of the evaporator.
18.4. Crating shall be removable by means of gravity only.

19. IOM Manuals

19.1. Installation, Operation, and Maintenance Manuals shall be provided. Number of copies and routings shall be provided per the requirements of the contract.

20. Approved Vendor

20.1. Approved Vendor: Colmac Coil Manufacturing, Inc. Model: A+D Series

21. Ordering Information

21.1. Please Specify:
21.1.1. Complete model number.
21.1.2. Saturated suction temperature.
21.1.3. Room temperature.
21.1.4. Overfeed ratio (if pump recirculated).
21.1.5. Options or special features.

22. Optional Features

1.1. Variable Fin Spacing
1.1.1. Coil core fins shall be arranged for highest frost capacity by varying the fin spacing for the air entering rows of tubes.
1.1.2. Fin spacing in fins per inch shall be specified according to contract.

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A+D Air Cooler (SST Tube) Engineering Specifications

1. General

1.1. This specification covers “A+D” type air coolers having stainless steel tubes and aluminum fins intended for use in refrigeration systems.

2. Selection / Rating Method

2.1. Evaporators shall be selected using DT1 rating method.
2.2. DTM rating method shall not be used.
2.3. Evaporators shall be selected on the basis of room relative humidity as shown in the drawing.

3. Tubing

3.1. Coil block shall be constructed with 304L stainless steel tubing.
3.2. Calculated working pressure of the coil tubing (per ASME Pressure Vessel Code Sec. VIII) shall be no less than 300 psig.
3.3. Tubing shall be constructed from raw material that is made in the USA, as defined by material test reports, which are to be supplied upon customer request.

4. Tube Pattern

4.1. Tube pattern shall be selected for optimum performance and defrost efficiency from one of the three patterns below:
- 4.1.1. 5/8” OD - 1.5” x 1.299” equilateral staggered
- 4.1.2. 5/8” OD – 1.97” (50 mm) inline
- 4.1.3. 7/8” OD - 2.25” x 1.949” equilateral staggered

5. Fins

5.1. Fins shall be selected from one of the four materials below based on optimum performance and the environment in which the cooler will operate.
- 5.1.1. Aluminum 1100 alloy, no less than 0.010” (0.25 mm) thick.
- 5.1.2. 304L stainless steel, no less than 0.010” ” (0.25 mm) thick.
- 5.1.3. Colmac Anti-Microbial alloy, no less than 0.010” ” (0.25 mm) thick.
  - 5.1.3.1. Coil core fins shall be constructed of a metal alloy that exhibits anti-microbial properties.
  - 5.1.3.2. Fins shall completely cover the coil tube surfaces exposed to the airstream by means of a full-length self-spacing fin collar.
  - 5.1.3.3. Coil coatings are not allowed. All surfaces to be a base metal alloy.

5.2. Fins shall be continuous flat or configured plate type with full length, self-spacing collars. Spiral, “L-foot”, or wrap-on type fins shall not be allowed.
5.3. Tubes shall be expanded into fin collars to form a tight mechanical bond between tube and fin.

6. Headers

6.1. Headers shall be made of 304L stainless steel pipe certified to ASME SA-240/304L, no less than ANSI schedule 40.

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7. Connections

7.1. Liquid, suction, and hot gas connections shall be carbon steel pipe no less than schedule 40, certified to ASME SA-240/304L. Bolted type flange union connections shall not be allowed.

7.2. In the case of pumped bottom feed, liquid and hot gas connections shall be oriented vertically up.

7.3. In the case of pumped bottom feed, liquid connection to coil header pipe shall be below the level of the lowest tube in the coil to effectively trap condensate during defrost.

7.4. Coil connections shall be terminated with a welded steel head at the factory. One "Schrader" type valve shall be provided by the manufacturer mounted at the factory in one of the coil connection terminations for the purpose of measuring the shipping charge upon arrival at the jobsite.

7.5. The manufacturer shall charge each coil with a shipping charge of 5-20 psig dry air or nitrogen. A label on the coil connection near the Schrader valve shall be provided indicating the factory charge pressure.

8. Cleanliness

8.1. The manufacturer shall insure that the coils are free from internal dirt, scale, and water.

9. Welding/QC

9.1. All tube and header welds shall be made by Tungsten Inert Gas (TIG) welding process.

9.2. All welds shall be performed by ASME certified welders per the requirements of the manufacturer's WPS documents. Copies of all WPS, PQR, and Welder Qualification documents used in the fabrication of the coil shall be made available to the engineer upon request.

9.3. Copies of the manufacturer's Quality Control Manual shall be made available to the engineer upon request.

10. Leak Testing

10.1. Coils shall be tested for leaks after welding at no less than 500 psig (35 bar), dry air under water.

10.2. Test certificates for each coil shall be provided by the manufacturer to the engineer upon request.

11. Circuiting

11.1. <u>Types RT and RB (Recirc Top Feed and Recirc Bottom Feed)</u>

11.1.1. Liquid overfeed orifices shall be installed at the entrance to each coil circuit, sized for a maximum 5 psi pressure drop at the design refrigerant flow rate.

11.1.2. Units with vertical header arrangements shall have circuiting designed for parallel flow of refrigerant relative to direction of air flow.

11.1.3. Units with horizontal header arrangements shall have circuiting designed for cross flow of refrigerant relative to the direction of air flow.

11.2. <u>Type FL (Gravity Flooded)</u>

11.2.1. Units with vertical header arrangements shall have circuiting designed for parallel flow of refrigerant relative to direction of air flow.

11.2.2. Units with horizontal header arrangements shall have circuiting designed for cross flow of refrigerant relative to the direction of air flow..

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11.3. Type DX (Direct Expansion)

11.3.1. Units with vertical header arrangements shall have circuiting designed for counter flow of refrigerant relative to direction of air flow to maximize suction gas superheat for best operation of thermostatic expansion valves.

11.3.2. Units with horizontal header arrangements shall have circuiting designed for cross flow of refrigerant relative to direction of air flow. Circuits must have crossover circuiting to equalize circuit loading.

11.4. Type BW (Single Phase Liquids)

11.4.1. Units with vertical header arrangements shall have circuiting designed for counter flow of refrigerant relative to direction.

11.4.2. Units with horizontal header arrangements shall have circuiting designed for cross flow of refrigerant relative to direction of air flow. Circuits must have crossover circuiting to equalize circuit loading.

12. Fans

12.1. Construction.

12.1.1. Propeller fans shall be constructed of cast aluminum or non-ferrous polymer, as required by the contract.

12.1.2. Hub shall be removable type for ease of service. Integral fan/motor combinations with non-removable fans shall not be allowed.

12.1.3. Fans shall be true airfoil shape and shall be non-overloading type

12.2. Fan Guards.

12.2.1. Fans shall be fully guarded with OSHA approved wire guards.

12.3. Direction of Air Flow

12.3.1. Fans and motors shall be mounted on the air leaving side of the coil for draw through operation.

13. Fan Motors

13.1. Fan motors shall be standard NEMA frame size, inverter ready, integral horsepower, induction three phase, totally enclosed severe duty, with sealed ball bearings.

13.2. Motor service factor shall be no less than 1.15.

13.3. Motors shall have internal rotor construction. External rotor construction motors shall not be allowed.

13.4. Fan motors shall be individually wired by the manufacturer to individual junction boxes on the exterior of the unit cabinet.

14. Cabinet

14.1. General

14.1.1. Standard construction shall be of G90 mill Galvanized Steel, Alloy 5052 Aluminum, or 304L Stainless Steel as required in the contract. Painted or coated cabinet parts shall not be allowed.

14.2. Optional Smart Hanger System

14.2.1. When specified, units shall be provided with Colmac Smart Hanger brackets that will allow the unit to be suspended from pre-mounted structural channels provided by the manufacturer.

14.2.2. Hanger brackets shall be adjustable in the vertical direction to allow for various mounting heights.

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14.3. Standard Air Section

14.3.1. Fans and motors shall be arranged for horizontal air discharge, mounted on the air leaving side of the coil section (draw through).

14.4. 45 Degree Down Discharge Air Section

14.4.1. Fans and motors shall be arranged for 45 degree down air discharge when required by contract.

14.4.2. Air discharge section to be factory mounted on the air leaving side and tilted down at 45 degree angle from the vertical plane.

14.5. Penthouse Air Section

14.5.1. Fan and motors shall be arranged for vertical down air discharge when required by the contract. Penthouse air section shall be factory mounted on the air leaving side of the coil section (draw through).

14.5.2. Access doors shall be provided to allow access to each individual fan and motor for service.

15. Drainpans

15.1. The inner drainpan shall be constructed of Alloy 5052 Aluminum.

15.2. Drainpan shall be designed to cover the coil section of the cooler cabinet.

15.3. Drainpan to be triple pitch, V-bottom design, such that water flows front to center, rear to center, and end to end to a single drain.

15.4. Drain outlet shall be constructed as a full radius, formed directly into the drain pan to eliminate the possibility of water pooling around the drain connection.

15.5. When required by the contract, drainpan shall be insulated with a minimum of 1" thick insulation.

15.5.1. The insulation shall be fully covered with a sheet metal insulation shield of mill galvanized steel, aluminum, or 304L stainless steel as required by the contract.

16. Defrost

16.1. Hot Gas Defrost

16.1.1. General

16.1.1.1. Coil shall be arranged for hot gas defrosting.

16.1.2. Pan Loop

16.1.2.1. A hot gas pan loop of round Alloy 3003 aluminum tubing shall be provided to warm the inner drainpan during defrost. Pan loop designs using square tubing or cross-sections other than round shall not be allowed.

16.1.2.1.1. Pan loop headers are to be held outside the ends of the drain pan to allow for full contact of the tubes with the pan.

16.1.2.1.2. The pan loop shall be attached to the underside of the inner drainpan by means of full length clips designed to keep the pan loop in tight contact with the pan by spring force. The pan loop shall not be mounted in the drainpan where it can contact the defrost water.

16.1.2.1.3. The pan loop outlet pipe shall be arranged such that a liquid seal is formed below the lowest hot gas pan tube.

16.1.3. Pan Loop Check Valve

16.1.3.1. When defrost condensate is being lifted into an overhead condensate return line, a properly sized in-line check valve shall be installed by the manufacturer. Check valve is to be installed between the outlet of the pan loop and the coil per the piping diagram provided by the manufacturer.

16.1.3.2. All portions of the check valve and piping shall be held within the footprint of the drainpan.

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16.2. Water Defrost.
16.2.1. General
16.2.1.1. Coil shall be arranged for water defrosting.
16.2.2. Water Distribution Pans
16.2.2.1. Water shall be distributed evenly over the coil fin surfaces by means of water distribution pans.
16.2.2.2. Individual water distribution pans shall be provided one per fan section in the cooler.
16.2.2.3. Water distribution pans shall be removable for inspection and cleaning.
16.2.2.4. Defrost water flow shall be thermodynamically calculated and specified by coil manufacturer such that the flow rate is the minimum needed to heat the mass of coil metal and melt the frost.

16.3. Air Defrost.
16.3.1. Coil shall be arranged for air (off cycle) defrosting.
16.4. Electric Defrost.
16.4.1. General
16.4.1.1. Coil shall be arranged for electric defrosting.
16.4.2. Heating elements
16.4.2.1. Heating elements shall be tubular type, UL listed, with stainless steel sheath.
16.4.2.2. Elements shall be inserted into the fin collars, and spaced throughout the coil core such that the coil core is completely clear of frost and ice at the end of each defrost.

16.4.2.3. Heating elements shall be wired to a common NEMA 3R (minimum) panel.
16.4.2.4. Heated elements shall be attached to coil core by means of a self-centering spring that acts to reset the heater's position during each defrost (US Patent No. 7,712,327).

17. Packaging

17.1. Units shall be crated on a wooden skid constructed of no less than 2" x 8" timbers.
17.2. Units shall be crated fully assembled (including drainpan) in an upright position ready for mounting in the field.
17.3. Crating shall support the full weight of the evaporator.
17.4. Crating shall be removable by means of gravity only.

18. IOM Manuals

18.1. Installation, Operation, and Maintenance Manuals shall be provided. Number of copies and routings shall be provided per the requirements of the contract.

19. Approved Vendor

19.1. Approved Vendor: Colmac Coil Manufacturing, Inc.   Model: A+D Series

20. Ordering Information

20.1. Please Specify:

20.1.1. Complete model number.
20.1.2. Saturated suction temperature.
20.1.3. Room temperature.
20.1.4. Overfeed ratio (if pump recirculated).
20.1.5. Options or special features.

21. Optional Features

1.1. <u>Variable Fin Spacing</u>

1.1.1. Coil core fins shall be arranged for highest frost capacity by varying the fin spacing for the air entering rows of tubes.
1.1.2. Fin spacing in fins per inch shall be specified according to contract.

COLMAC COIL Manufacturing Inc.
P.O. Box 571 | Colville, WA 99114 | USA
T: +1.509.684.2595 | F: +1.509.684.8331
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DX AMMONIA PIPING HANDBOOK
2nd Edition

Bruce I. Nelson, P.E.

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COLMAC COIL
Manufacturing Inc.

P.O. Box 571 | Colville, WA 99114 | USA
T: +1.509.684.2595 | F: +1.509.684.8331
www.colmaccoil.com

I. Background

Ammonia refrigeration systems have traditionally employed evaporators supplied with liquid by either gravity flooding (with surge drums), or pumped overfeed (either with mechanical pumps or discharge gas-driven vessels). Both of these designs typically use bottom feed coil circuiting which feeds liquid ammonia at the lowest point in the coil circuit and causes the ammonia to flow upward and "percolate" through the coil in ascending passes to the outlet at the top of the circuit. These coil designs also typically use large diameter tubing which means relatively large coil internal volume. This combination of refrigerant feed, circuiting, and tube diameter, results in the greatest evaporator charge inventory possible.

End users of ammonia refrigeration systems are increasingly interested in reducing the charge of ammonia in evaporators (and in the overall system) in the interest of minimizing the risk to workers and products associated with ammonia leaks. One very effective way to significantly reduce evaporator ammonia charge is to design and operate the evaporator using dry expansion (DX) circuiting and controls. Using DX ammonia can reduce the evaporator charge by as much as 30 to 50 times compared to bottom feed flooded or pumped designs. The magnitude of this reduction in ammonia charge may also mitigate regulatory requirements (PSM, RMP), and potentially reduce insurance risk and premiums.

DX ammonia has been used for some time in medium and high temperature systems (suction temperatures above +20 degrees F) with some success. However, in spite of the charge reduction advantages mentioned above, to date DX ammonia has not been applied successfully at freezer temperatures. At suction temperatures below about +20F, the following particular characteristics of ammonia result in extremely poor performance of evaporators unless addressed and mitigated:

1. Separation of liquid and vapor phases. The very high ratio of vapor to liquid specific volume of ammonia at low temperatures combined with its very high latent heat of vaporization causes an unavoidable separation of vapor and liquid phases inside evaporator tubes. This separation of phases causes the liquid ammonia present to run along the very bottom of the tubes leaving the top of the tubes completely "dry". The result is extremely poor evaporator performance and lower-than-expected suction temperatures during operation. To solve this problem Colmac has developed (and patented) an enhancement technique, which when applied to the inside of evaporator tubes, causes the liquid ammonia present to coat the entire inside surface of the tubes by capillary action. Performance with Colmac enhanced tube technology results in DX ammonia performance at low temperatures which is as-good or better than performance with bottom feed pumped ammonia circuiting.
2. Refrigerant distributor technology. Traditionally the distribution of expanded refrigerant to multiple parallel evaporator circuits has been done using a refrigerant distributor having a fixed orifice plate. This design depends on a relatively large pressure drop (approximately 40-45 psi) across the fixed orifice to thoroughly mix and equally distributor the liquid and vapor phases before they enter the distributor tubes and evaporator circuits. This relatively high pressure drop across the distributor reduces the

pressure drop available for the expansion valve, and consequently limits how low condensing pressure can be allowed to fall during periods of low ambient temperature. The very high latent heat of vaporization of ammonia results in low refrigerant mass flow rate and consequently a very small orifice diameter for a given cooling load (the orifice can be as small as 1/16" diameter in some cases). This small orifice size is prone to fouling and being blocked by even small size debris. Other disadvantages of this distributor design include:

a. Performance is very sensitive to liquid temperature (subcooling) at the expansion valve.
b. Operating range is small, at most 50% to 125% of rated capacity.
c. The orifice and distributor tubes restrict the flow of hot gas during a hot gas defrost cycle.
d. The maximum number of parallel evaporator circuits available in a single distributor is limited to only 15.

To address these shortcomings Colmac has developed a new (patent pending) refrigerant distributor technology, the Colmac Tank Distributor, having the following characteristics:

a. Refrigerant pressure drop across the Tank Distributor during operation is very low, only 2-4 psi.
b. Any oil or debris entering the Tank Distributor is captured in a drop leg (which is integral to the design) before it can enter the coil and foul tube surfaces.
c. Performance of the Tank Distributor is completely insensitive to liquid temperature (subcooling).
d. Graduated orifices in each distributor tube allow equal distribution of refrigerant to all circuits over an extremely wide operating range of 0% to 700% of rated capacity.
e. Graduated orifices and large diameter distributor tubes allow full flow (minimal restriction) of hot gas during hot gas defrost.
f. The number of parallel evaporator circuits possible in a single Tank Distributor can be as high as 48.

3. <u>Removal of water from ammonia</u>. As described elsewhere (Nelson 2010), even small amounts of water (1-3%) in the ammonia will significantly penalize DX ammonia evaporator performance. Water must be effectively removed during operation, particularly in freezing systems which operate at suction pressures below one atmosphere (in a vacuum). Currently, the only effective way to remove water from ammonia is in a heated distillation vessel (an ammonia "still"). This very negative effect of small amounts of water on evaporator performance has not been fully recognized in the past, but must be addressed during the design of the DX ammonia system. Colmac has developed an effective ammonia distillation vessel design and installation strategy which is described within this Handbook.

Colmac has developed, tested, and patented (Nelson 2011) a new Low Temperature DX Ammonia system which correctly addresses all of the above issues peculiar to ammonia as a refrigerant that have heretofore prevented its use at low suction temperatures. It is now possible to successfully apply DX ammonia at suction temperatures down to -50 degrees F.

P.O. Box 571 | Colville, WA 99114 | USA
T: +1.509.684.2595 | F: +1.509.684.8331
www.colmaccoil.com

This Piping Handbook is intended to guide the reader through the process of successfully designing and implementing DX Ammonia from +50F to -50F and realizing the benefits of:

- Dramatically reduced ammonia charge
- Simplified controls
- Energy efficient dry suction line
- Reduced line sizes
- Elimination of ammonia recirculator pumps

II. System Configuration

Colmac DX Ammonia can be applied to any temperature level and system configuration. P&ID diagrams for various typical systems are shown in Appendix A, simplified for purposes of clarity. Selection and system piping details (relief valves, purgers, isolation valves, vessel designs, etc) should follow industry guidelines as found in the IIAR Ammonia Piping Handbook (IIAR 2004). The diagrams are not intended to present an exhaustive range of configurations – every industrial refrigeration system will have unique features and requirements. This information is presented to illustrate the general system features particular to a successful DX Ammonia design.

a. Figure A1 - Single Stage Single Temperature Level
b. Figure A2 - Single Stage (Economized Screw) Multiple Temperature Level
c. Figure A3 - Two Stage Multiple Temperature Level

III. System Stability

With liquid overfeed and gravity flooded systems, liquid return to the recirculator vessel or the surge drum is normal and expected through the wet suction line. The recirculator vessel or surge drum effectively separates returning liquid from vapor and insures that the dry suction line carries only vapor back to the compressor.

DX systems, on the other hand, are designed to operate with a dry suction line and are by definition more sensitive to liquid floodback. Industrial DX systems should incorporate a suction accumulator vessel to prevent liquid slugging of the compressor during a floodback event, however, excessive floodback from evaporators can cause high level alarming and system shutdown until the excess liquid in the suction accumulator can be transferred back to the high pressure side of the system. Stable and smooth operation of the system and the evaporator expansion valve(s) is critical to avoiding liquid floodback. Instabilities and/or rapid changes in discharge and suction pressures during operation are the typical cause of unstable operation of expansion valves and should be considered carefully by the system designer and operator(s).

Rapid changes in system discharge pressure can cause system instabilities in a number of ways. A sudden reduction in discharge pressure can result in undesirable flashing of liquid refrigerant in liquid lines and will also be accompanied by a sympathetic, albeit smaller, reduction in suction pressure. A sudden increase in discharge pressure will be accompanied by a sympathetic, albeit smaller, increase in suction pressure. An increase in suction pressure, if large enough and rapid enough, will suppress boiling in the evaporators which can directly lead to liquid floodback from the evaporators to the suction accumulator.

Rapid changes in discharge pressure are normally caused by one or more of the following events:

a. Condenser fans cycling on and off,
b. Evaporative condenser pumps cycling on and off,
c. Evaporator(s) initiating hot gas defrost,
d. Compressor(s) cycling on and off

**NOTE: Design the system to limit the rate of change in condensing temperature to no more than 5 deg F/minute.

Rapid changes in system suction pressure can also result in system instability and poor performance. It is a sudden increase in suction pressure that has the highest potential for liquid floodback from DX evaporators. This sudden increase in suction pressure raises the temperature of the evaporator, reduces the imposed load, and results in liquid refrigerant exiting the evaporator before the expansion valve can respond and reduce the flow of refrigerant entering the evaporator accordingly.

Rapid changes in suction pressure are normally caused by:

a. Compressor(s) cycling on and off
b. Multiple liquid feed solenoids cycling on and off
c. Evaporator fans cycling on and off
d. Evaporators starting or finishing defrost
e. Sudden changes in imposed load on evaporators

**NOTE: Design the system to limit the rate of change in suction temperature to no more than 2 deg F/minute.

Following are recommended system design features which will serve to maximize system pressure stability and minimize the potential for liquid floodback from evaporators.

1. <u>Condenser Fans</u>
   a. Use of VFD fan speed control instead of fan cycling for control of head pressure is recommended.

2. <u>Condenser Pumps</u>
   a. It is also recommended that evaporative condenser sump water pumps be operated continuously rather than cycling on and off, provided ambient weather conditions allow.

3. <u>Compressor Capacity Control</u>
   a. Use of VFD speed control for capacity where possible and appropriate.

b. Limit capacity loading/unloading steps (on/off) to no more than 10% of total system capacity.
c. Limit the rate of change of suction temperature (speed of screw compressor slide valve movement) to no greater than 2 deg F/minute.

4. Evaporator Defrost
   a. Defrost the minimum number of evaporators at one time.
   b. Use a bleed line to equalize pressure slowly at the end of defrost.

5. Evaporator Fans
   a. Fan speed and cooling capacity can be controlled by VFD, however the following guidelines must be observed when applied to DX evapaorators:
      - Rate of change in fan speed must be gradual and limited to result in no more than 2 deg F/minute change in suction temperature.
      - Minimum fan speed must be set to produce no less than 250 ft/min face velocity.
   b. If fans are going to be cycled on/off for capacity control, no more than 10% of the total number of evaporator fans should be cycled on or off at the same time.

6. Liquid Feed Solenoids
   a. Avoid cycling multiple liquid feed solenoids all at the same time. i.e. Liquid feed solenoids should be cycled sequentially.

7. Sudden changes in load on Evaporators
   a. Avoid locating evaporator directly above doorways.
   b. Mitigate intermittent process loads located close to evaporators.

IV. Evaporator Selection and Operation

1. DT1 vs DTM ratings

As explained in detail elsewhere (Nelson 2012(a)) evaporator manufacturers typically present their capacity ratings using one of two definitions of temperature difference, DT1 or DTM. Some manufacturers publish ratings based on both DT1 and DTM and allow the designer to choose the preferred definition:

DT1 = Air On Temperature – Evaporator Temperature
DTM = Average (“Room”) Air Temperature – Evaporator Temperature

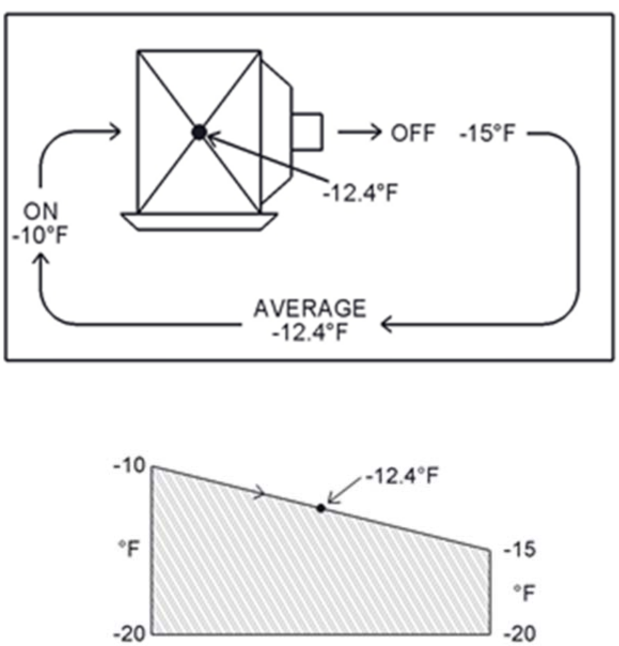
Figure 1 below graphically illustrates these two definitions of temperature difference for the same evaporator and their effect on LMTD (Log Mean Temperature Difference), and hence rated capacity. In this example, the same evaporator having a -20 deg F evaporating temperature rated using DTM “produces” 33.3% (DTM LMTD of 9.6 deg F versus DT1 LMTD of 7.2 deg F) more capacity than the same evaporator rated using DT1!

In short, by using the DTM rating method a manufacturer can show cooling capacities that are much higher (30 to 40% higher), and so offer a lower cost evaporator with much less surface area than the manufacturer using the DT1 rating method.

Unfortunately, one cannot get “something for nothing”. Even though evaporators selected using DTM ratings will be cheaper initially because they have less surface area, they will cause the system to run at a lower suction pressure with higher operating costs than evaporators selected using DT1 ratings. This difference in operating cost between DTM and DT1 evaporators has been calculated and the incremental return on investment shown to dramatically favor selecting evaporators using DT1 ratings (Nelson 2012(b)). Additionally, in the same article the author shows that the basic DTM assumption that the average air temperature within the evaporator equals the average room temperature is a fundamentally flawed and false assumption because of air entrainment and mixing in the room.

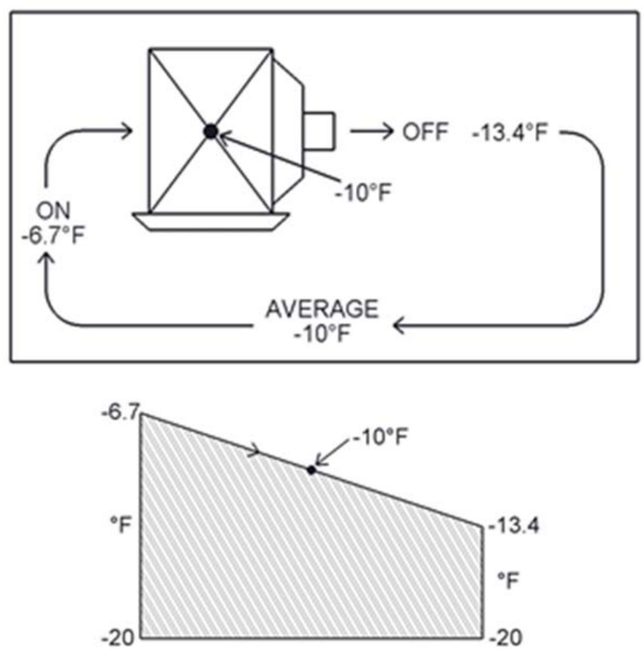
FIGURE 1
Temperature Profiles for DT1 vs DTM

(a) DT1 = 10F (Air On) Temp Difference



DT1 LMTD = 7.2 F

(b) DTM = 10F (Average) Temp Difference



DTM LMTD = 9.6 F

In conclusion, Colmac highly recommends that evaporators be selected using DT1 ratings rather than DTM.

2. Sensible Heat Ratio, Room Relative Humidity (rh%), and Evaporator Ratings

Accurate prediction of the refrigeration load, both sensible and latent components, is important to proper refrigeration system equipment selection and successful operation

(Nelson 2012(a)). Various types of sensible cooling loads must be anticipated and included in the calculation, such as: lighting, electric motors, forklifts, product cooling/freezing, transmission of heat through walls, ceilings, and floors, and cooling of infiltration air. Latent cooling loads are present whenever moisture is added to the air in the refrigerated space. Sources of introduced moisture typically include: infiltration air, respiring food products, surface moisture on products, packaging and other objects entering the space, residual water left on floors after wash down (process rooms), human respiration, and humidification equipment (above freezing).

Room relative humidity (rh%), which is the indication of how nearly the air in the refrigerated space is saturated with water vapor, will be the equilibrium condition resulting from the balance of moisture introduced into the space with the moisture removed from space by the evaporator coils (Cleland 2012).

Whenever evaporator surfaces operate at temperatures below the dew point of the air being cooled, water vapor in the airstream is condensed to liquid (at temperatures above 32F (0C)) or deposited to form frost (below 32F (0C)). The cooling effect associated with this dehumidification of the airstream is termed “latent” cooling. The sum of the sensible cooling load and latent cooling load is termed the “total” load. The ratio of the sensible cooling load divided by the total cooling load is called the Sensible Heat Ratio (SHR) and defines the slope of the air process line on a psychrometric chart.

$$SHR = \frac{Sensible\ Cooling\ Load}{Sensible\ Cooling\ Load + Latent\ Cooling\ Load} \quad (1)$$

Refrigerated spaces with product being transferring in and out through doorways will very typically have a relative humidity in the 85 to 95% range due to infiltration and other sources of moisture. Lower room relative humidity may be found in some exceptional cases where traffic through doorways is very light, product is tightly packaged, dehumidification equipment is used at doorways, etc. The relationship between room relative humidity and SHR is shown in Table 1 below:

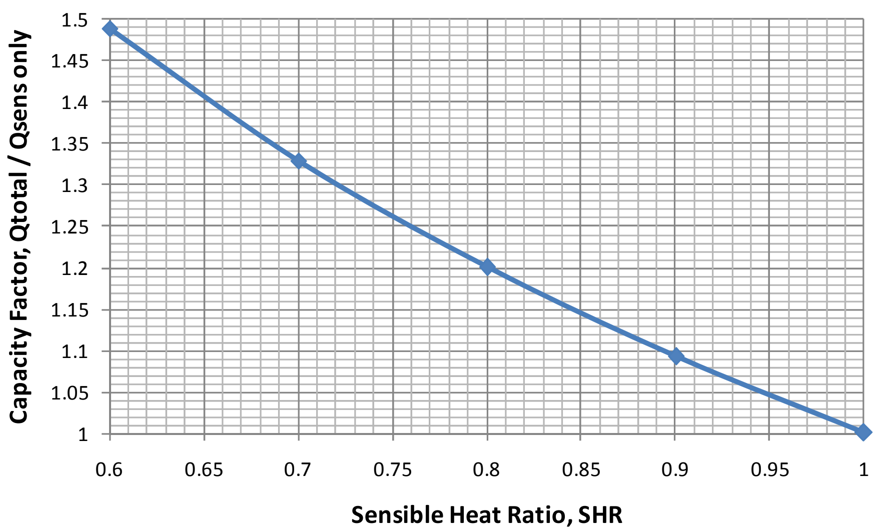
TABLE 1
SHR FOR DT1 = 10 deg F AT VARIOUS TEMPERATURES AND ROOM RH%

	Sensible Heat Ratio, SHR			
Room Temperature, F (C)	**65%rh**	**75%rh**	**85%rh**	**95%rh**
45 (7.2)	1.0	0.84	0.67	0.56
32 (0)	0.98	0.84	0.73	0.64
10 (-12.2)	0.98	0.92	0.87	0.83
0 (-17.8)	0.98	0.95	0.92	0.89
-10 (-23.3)	0.99	0.97	0.95	0.93
-30 (-34.4)	0.99	0.99	0.98	0.97

The room relative humidity and resulting SHR can have a large effect on evaporator cooling capacity, especially at higher room temperatures.

Using a computer model developed to accurately calculate fin efficiency and surface effectiveness for both sensible and combined sensible and latent heat transfer, a prediction of the increase in evaporator coil performance as a function of SHR has been made (Nelson 2012(a)). Results of the predicted capacity increase as a function of SHR for an ammonia refrigeration evaporator coil operating over a wide range of room temperatures (+45F to -30F) and having typical fin spacings and geometry with DT1 = 10F are shown in Figure 2 below.

FIGURE 2
Total Cooling Capacity Factor vs SHR



To make things a bit more complicated, some evaporator manufacturers include the effect of room rh% in their ratings, others do not. As shown in Figure 2, the lower the SHR the greater the total cooling capacity of the evaporator. A manufacturer who shows their evaporator ratings as “all sensible” (SHR = 1) will be more conservative (have more surface area) than the manufacturer who shows their ratings at 85 or 95% rh.

Selecting evaporators using 85 to 95%rh ratings will result in evaporators having less surface area and lower first cost compared to evaporators selected using “all sensible” ratings. The risk in this approach is undersizing the evaporators in the case where the actual operating room rh% is less than the rh% used during the selection process.

Conclusion: The latent load should always be estimated and included in the total calculated refrigeration load. Size evaporators for the design total calculated refrigeration load at the estimated room relative humidity. If room relative humidity is difficult to estimate or cannot be estimated, then a conservation approach is to select evaporators based on a low room relative humidity (i.e. 65 to 75% rh) or using “sensible only” ratings.

3. Optimizing System TD

The product being stored or processed normally determines the room air temperature in a refrigerated facility. Appropriate temperatures for storing and processing various foods and food products can be found elsewhere (ASHRAE 2009).

Once the room temperature is determined, the evaporator temperature must be decided upon by the designer. Compressor power and energy consumption is a strong function of the suction pressure and temperature. The higher the suction pressure the more efficiently the compressor will run and the less power will be consumed. Energy efficiency can be characterized by a ratio termed Coefficient of Performance (COP), defined as:

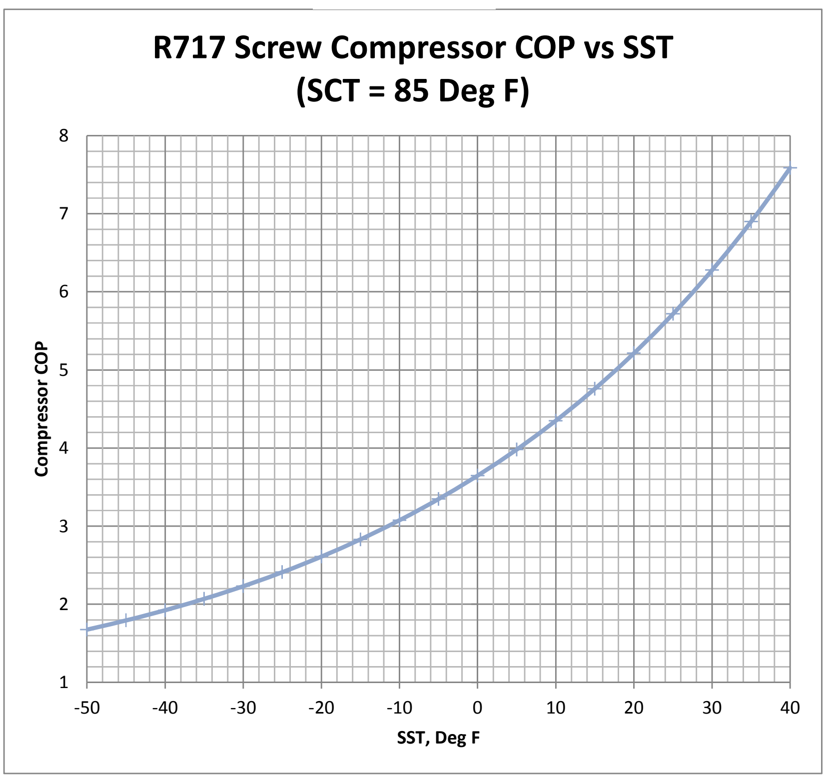
$$COP = \frac{Useful\ Output}{Input} \quad (2)$$

In the case of a refrigeration compressor,

$$COP = \frac{Cooling\ Capacity, kW}{Input\ Power, kW} \quad (3)$$

Figure 3 below shows typical ammonia screw compressor COP vs SST (Saturated Suction Temperature). The figure assumes 2-Stage compression is used below a suction temperature of -20 deg F.

FIGURE 3



It would appear from Figure 3 that a smaller TD (TD = Room Temperature – Evaporator Temperature) would always be desirable from an energy consumption standpoint since the smaller the TD, the higher the evaporator (SST) temperature and compressor COP. This, however, is not the case.

Heat is transferred from the room via the air circulated by the evaporators. The cooling capacity of an evaporator can be characterized by the NTU-effectiveness equation. This equation indicates that for a constant cooling capacity and evaporator effectiveness (an expression of how closely the leaving air temperature approaches the evaporating temperature), the flow rate of the air will be inversely proportional to the TD.

$$\dot{q} = \dot{m} \cdot C_p \cdot \varepsilon \cdot TD \qquad (4)$$

Where:
$\dot{q} = Cooling\ Capacity$
$\dot{m} = Mass\ Flowrate\ of\ Air$
$C_p = Specific\ Heat\ of\ Air$
$\varepsilon = Evaporator\ NTU - Effectiveness$
$TD = Air\ On\ Temperature - Evaporating\ Temperature$

Evaporator effectiveness is, in fact, very nearly constant over the typical narrow operating range of a refrigeration evaporator. The effectiveness equation shows that as TD becomes smaller, the air flowrate must become larger in the same proportion for a given cooling capacity.

Fan power can be calculated using a simple equation as follows:

$$\dot{W}_{fan} = \frac{\dot{Q} \cdot dp}{\emptyset_{tot}} \qquad (5)$$

Where:
$\dot{W}_{fan} = Fan\ Power$
$\dot{Q} = Volumetric\ Flowrate\ of\ Air$
$dp = Total\ Pressure\ Across\ Fan\ (Static + Dynamic)$
$\emptyset_{tot} = Total\ Fan\ Efficiency$

The air pressure drop through the evaporator coil, and therefore fan power, will be affected by:

1. The coil face velocity,
2. Tube diameter, spacing, and pattern,
3. Number of coil rows deep,
4. Fin spacing and pattern
5. Frost thickness

The relationships above indicate that compressor COP will decrease with increasing TD while Fan COP will increase with increasing TD. Figure 4 shows these relationships for an example evaporator coil having 8 rows deep and 3 FPI fin spacing.

FIGURE 4

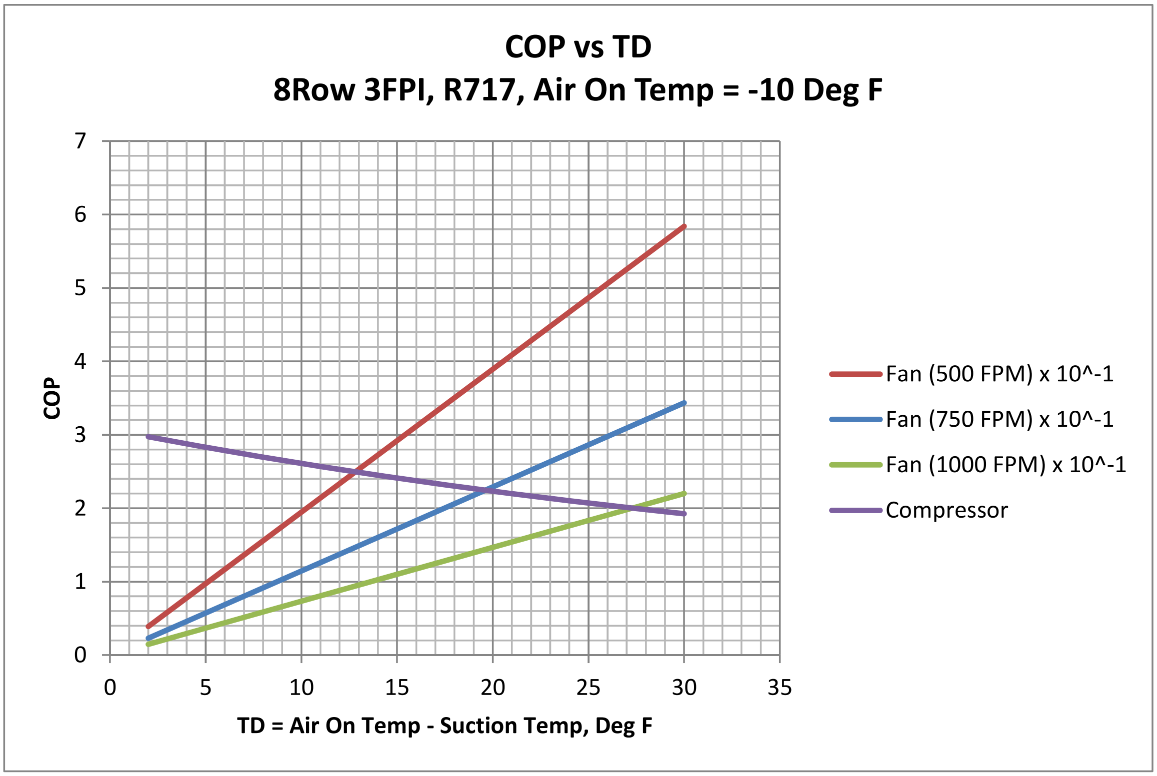


Figure 4 implies there will be some maximum combined COP for compressor and fans which will represent the optimum operating TD in terms of energy efficiency. This combined COP is shown below in Figures 5, 6, and 7, for a typical ammonia evaporator coil having the following characteristics:

Tubing: 7/8" OD Aluminum
Tube Pattern: 2.25" Staggered
Fins: Configured Aluminum Plate Type
Rows Deep: 8
Face Velocity: 500, 750, and 1000 FPM
Fin Spacing: 2, 3, and 4 FPI
Air On Temperature: -10 deg F
Frost Thickness: 0 mm

FIGURE 5

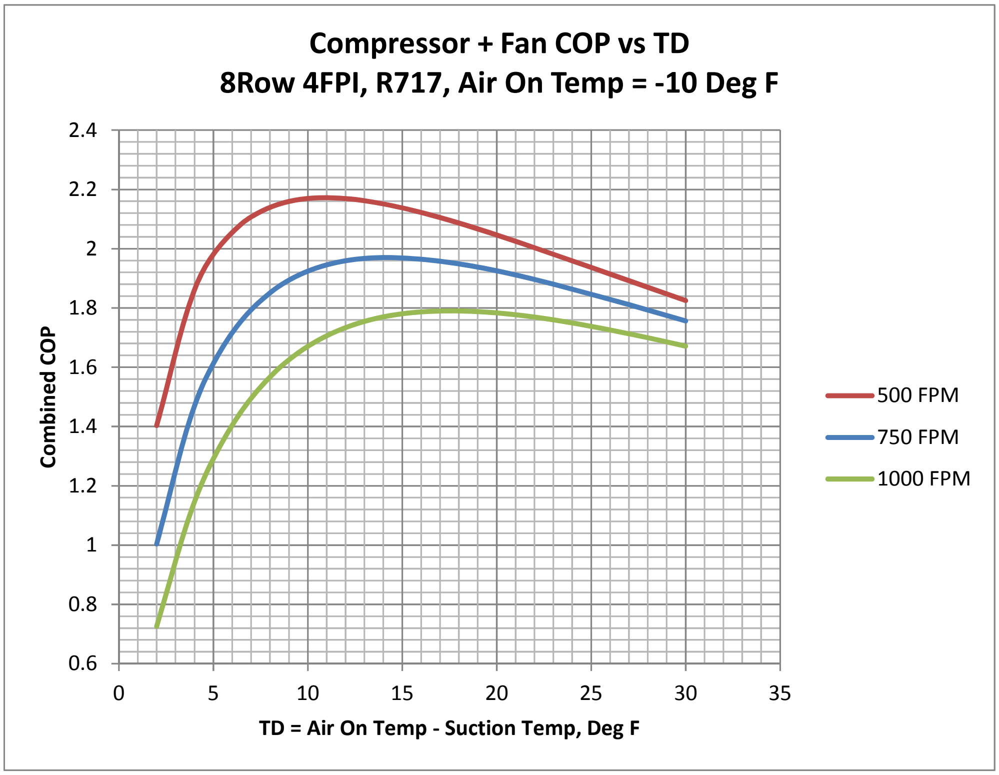
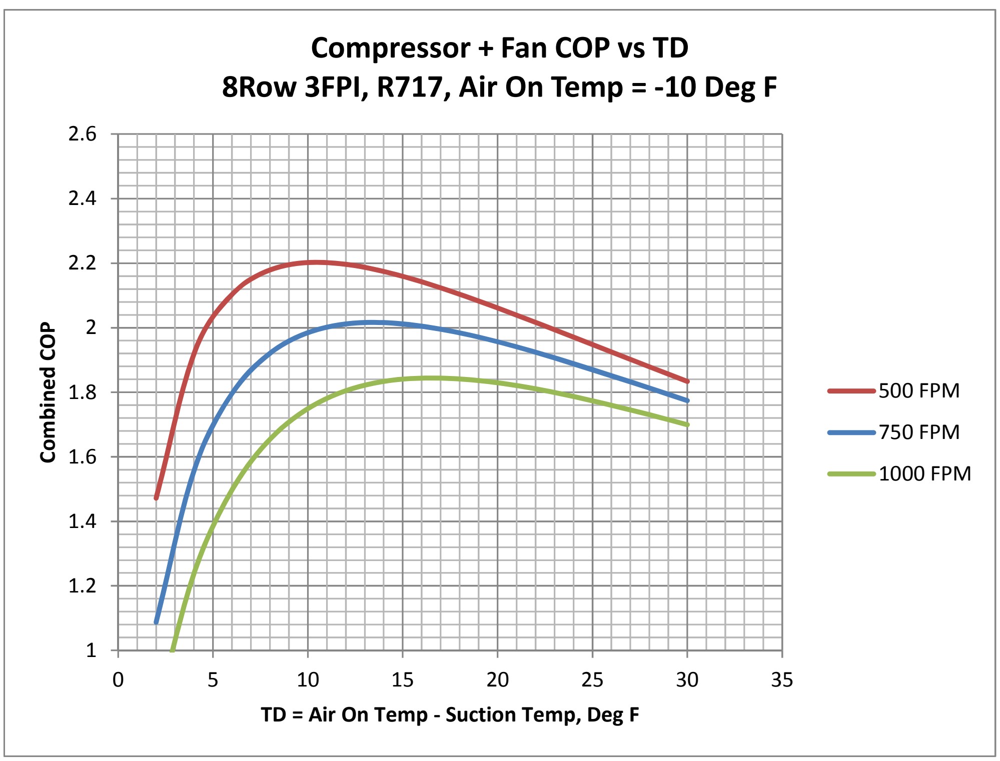


FIGURE 6



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Manufacturing Inc.
P.O. Box 571 | Colville, WA 99114 | USA
T: +1.509.684.2595 | F: +1.509.684.8331
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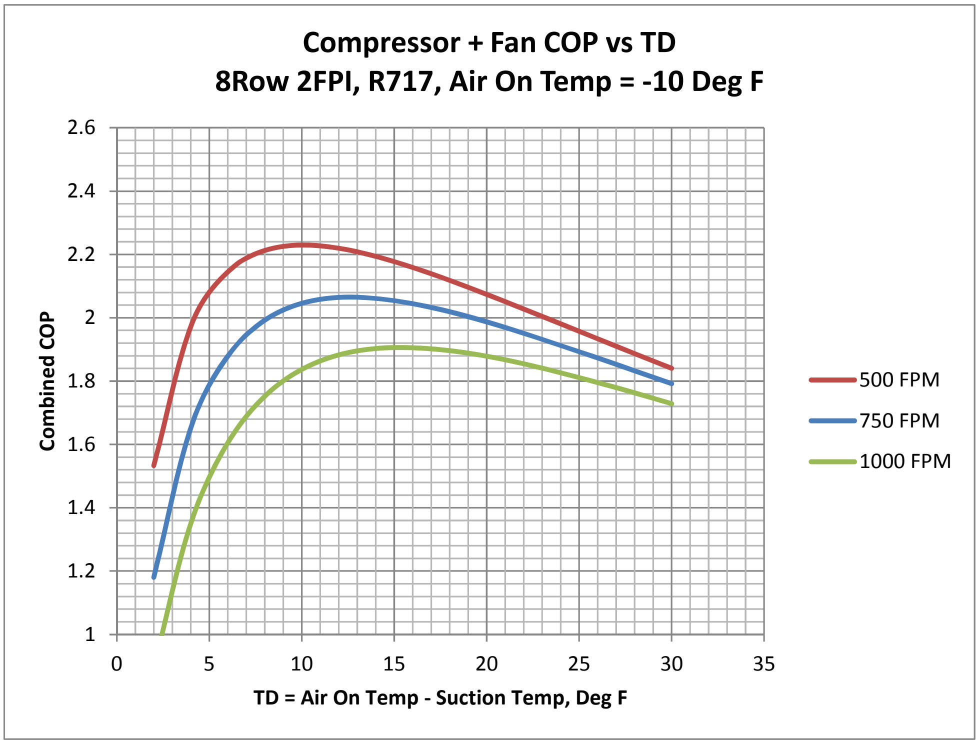
FIGURE 7



The following is observed from Figures 5 through 7:

a. Combined COP is a very strong function of coil face velocity. COP at 500 FPM is approximately 10% higher than COP at 750 FPM and 20% higher than COP at 1000 FPM.
b. Combined COP increases as the distance between fins is increased. Coils with 2FPI spacing will have higher combined COP than coils with 3FPI, which will have higher COP than 4FPI.
c. The optimum (maximum) TD increases with increasing face velocity.
d. In all cases, combined COP decreases very rapidly below about 7 deg F TD.

In order to make the final decision about selecting the optimum TD, the cost of power as well as installed cost of the compressor(s) and evaporators must be known (or estimated). These variables can then be combined to calculate the incremental return on investment comparing different evaporator designs (face velocity and fin spacing) in terms of first cost vs operating cost.

Since these costs are highly variable, the final return on investment calculation must be made on a case-by-case basis and presented to the client in a way which allows the final decision to be made given the project financial constraints and requirements.

Conclusions:

1. *For highest system COP / energy efficiency, select evaporators for the lowest face velocity and widest fin spacing financially practical. Colmac recommends maximum face velocity of 600 FPM and fin spacing of 3 FPI or wider (lower FPI).*
2. *For coil face velocities between 500 and 750 FPM a design TD between 10 deg F and 15 deg F is recommended.*
3. *Final optimized evaporator design and TD must be determined based on specific project financial constraints and acceptable return on investment.*

4. Effect of TD on Expansion Valve (EV) Operation

With direct expansion (DX) evaporators the flow of refrigerant to the evaporator is metered by an automatic expansion valve in response to a control signal measured at the evaporator outlet. The control signal is normally the amount of superheat in the refrigerant suction gas. The theoretical maximum amount of suction gas superheat that can be generated is equal to the operating TD (TD = Air On Temperature – Evaporating Temperature).

The amount of superheat required for stable operation (modulation) of the expansion valve varies with the type of valve employed. Two basic types of expansion valves are currently available on the market, Thermostatic (TEV) and Electronic (EEV). Both use superheat in the suction gas as the control signal.

Thermostatic expansion valves measure and mechanically calculate superheat by means of a temperature sensing bulb and pressure equalizing line. These valves and their operation are described in detail by the valve manufacturers. The advantage of this type of valve is their low cost and compactness. With this type of valve, temperature sensing is accomplished by a refrigerant-filled bulb strapped to the outside of the coil suction connection. A disadvantage of this system is the additional superheat required to overcome the thermal resistance of the pipe wall. This additional superheat forces the operating TD to be approximately 5 deg F greater than for an electronic expansion valve that uses a temperature transducer to measure temperature directly.

Electronic expansion valves operate based on a signal received from a superheat controller which reads suction gas temperature and pressure from a combination of sensors. The expansion valve itself may operate based on an “open/close” (pulsing) principle or on a motorized positioning principle. Advantages of this type of valve include more accurate and responsive sensing of superheat which allows stable operation at smaller TD than thermostatic type valves. PID control parameters can also be adjusted in the controller to “fine tune” operation over a wide range of conditions. The primary disadvantage of electronic expansion valves is the higher first cost compared to thermostatic valves. This, however, is changing as valve manufacturers are finding lower cost solutions and beginning to offer cost competitive electronic valves to the market.

P.O. Box 571 | Colville, WA 99114 | USA
T: +1.509.684.2595 | F: +1.509.684.8331
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Minimum recommended TD and superheat settings for both types of expansion valves are shown in Table 2 below:

TABLE 2
MINIMUM RECOMMENDED DX AMMONIA TD AND SUPERHEAT SETTING

Expansion Valve Type	Minimum Recommended TD, deg F	Recommended Superheat Setting, deg F
Thermostatic	15	12
Electronic	12	10

Note: Colmac offers factory supplied and mounted expansion valves and controllers, both thermostatic and electronic type.

5. Types of Frost and Selection of Fin Spacing

Frost can accumulate on evaporator coil fins by one of two mechanisms:

1. By deposition, and/or
2. As air-borne ice crystals

Designing evaporators to properly handle these two types of frost is described in this section.

1. Deposition:

Whenever the temperature of the evaporator coil surface is below the dewpoint temperature of the room air, moisture will condense and be deposited on the surface either as liquid water (above freezing) or as frost (below freezing). This mass transfer process, when related to the formation of frost is called *deposition,* and is driven by the difference in water vapor pressure between the air and the surface of the coil. The amount of heat associated with this mass transfer process is termed *latent heat* and is quantified by the SHR (see previous definition). Whenever the SHR is less than 1.0, the deposition of frost will take place. The rate at which frost will be deposited on the coil surfaces can easily be calculated as a function of the total cooling load, the SHR, and the surface area of the evaporator.

The surface effectiveness of a refrigeration evaporator is relatively high (usually greater than 80%) due to the typically small TD and low heat flux compared to air conditioning and process evaporators. This high surface effectiveness results in a more or less constant surface temperature and uniform deposition of frost over the entire surface of the evaporator. This assumption of uniform frost deposition is made in the following equation:

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$$\dot{x}_{frost} = \frac{\dot{q}_{tot}(1 - SHR)}{h_{fg} \cdot \rho_{frost} \cdot A_o} \cdot 304.8 \qquad (6)$$

Where:
$\dot{x}_{frost} = Rate\ of\ Frost\ Deposition, mm/h$
$\dot{q}_{tot} = Evaporator\ Cooling\ Capacity, Btu/h$
$SHR = Sensible\ Heat\ Ratio$
$h_{fg} = Latent\ Heat\ of\ Vaporization\ of\ Water, 1068\ Btu/lbm$
$\rho_{frost} = Average\ Density\ of\ Frost, 10.4\ lbm/ft3$
$A_o = Evaporator\ Surface\ Area\ (outside), ft2$

EXAMPLE:
An evaporator having 8 rows deep and fin spacing of 3 FPI is operating with a 10 deg F TD (DT1) in a +10 deg F / 85%rh room. The evaporator has a cooling capacity of 240,000 Btu/h (20 TR) and outside surface area of 4100 ft2. What will be the rate of frost deposition?

Answer:
From Table 1 the expected SHR at this room air temperature and rh% will be 0.87.

$$Rate\ of\ Frost\ Deposition = \frac{240{,}000(1 - 0.87)}{1068 \cdot 10.4 \cdot 4100} \cdot 304.8 = 0.21\ mm/h$$

As frost is deposited on the evaporator coil surfaces the local air velocity between fins will increase and result in increased air pressure drop across the coil. The increase in air pressure drop due to accumulation of frost can be approximated by the following equation:

$$dp' = dp_{clean} \cdot \left(\frac{\frac{1}{\varphi} - t_{fin}}{\frac{1}{\varphi} - \left(t_{fin} + 2 \cdot \frac{\delta_{frost}}{25.4} \right)} \right)^2 \qquad (7)$$

Where:
$dp' = Air\ Pressure\ Drop\ with\ Frost\ Thickness\ of\ \delta_{frost}$
$dp_{clean} = Air\ Pressure\ Drop\ When\ Fins\ are\ Clean\ (no\ frost)$
$\varphi = Fin\ Spacing, Fins\ Per\ Inch\ (FPI)$
$t_{fin} = Fin\ Thickness, inches$
$\delta_{frost} = Frost\ Thickness, mm$

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The rate of blockage of the coil with frost and associated pressure drop will result in a reduction in airflow and cooling capacity. This reduction in cooling capacity will ultimately determine defrost frequency and efficiency, and overall system energy efficiency and power consumption.
Cooling capacity of the evaporator can be characterized as functions of face velocity, SHR, and frost thickness. Knowing how capacity changes with these parameters, combined with the relationships shown in equations 5, 6, and 7 above, allows the construction of a simple model which will predict the change in coil capacity over time. Simplifying assumptions in the model include:

- Frost is deposited uniformly over the surface of the coil
- Frost density is uniform and of a fixed value
- Suction temperature remains constant

Normally, refrigeration loads are calculated based on 16 to 18 hours of run time per day. It is not clear when or why this rule of thumb came into practice. Perhaps it is a corollary to the "2-to-1" rule for hot gas defrosting. That is, two coils must be in operation while the third coil is in hot gas defrost in order to provide a sufficient quantity of hot gas for the defrost cycle. Perhaps it is simply an additional "catch-all" safety factor. One industry historian mentioned that the 16-18 run hours rule came from split system applications where capacity drops out during defrost compared to a central system which would rebalance the TD on the remaining evaporators (Welch 2013). It makes the most sense to the author that the runtime adjustment to the design refrigeration load should be used to account for the degradation in coil performance over time due to accumulation of frost.

In a large refrigeration system having a constant refrigeration load and compressor unloading capability, the compressors will unload to maintain a constant suction temperature as the coil capacity falls off due to frosting. As the compressors unload to maintain system suction pressure, they will run longer to maintain room temperature. This implies that in order to maintain room temperature, defrosting should be initiated when evaporator capacity falls to a level equal to the design runtime ratio (design runtime divided by 24). Table 3 below shows the maximum reduction in evaporator capacity due to frosting that should be allowed before defrost is initiated. Note that this table obviously does not apply to evaporators operating above freezing.

TABLE 3
MINIMUM EVAPORATOR CAPACITY TO INITIATE DEFROST AT VARIOUS DESIGN RUNTIMES

Design Runtime, h/day	Minimum Evaporator Capacity at Initiation of Defrost
14	58%
16	67%
18	75%
20	83%

The evaporator performance model described above was used to examine the effect of fin spacing and SHR on loss of cooling capacity due to frost accumulation. See Figures 8, 9, 10, and 11 below.

From Table 1 it is clear that the highest frost load (lowest SHR) will occur in high temperature (+32F) rooms with high relative humidity. The lowest frost loads (highest SHR) occur at freezer temperatures, even when relative humidity is high.

FIGURE 8

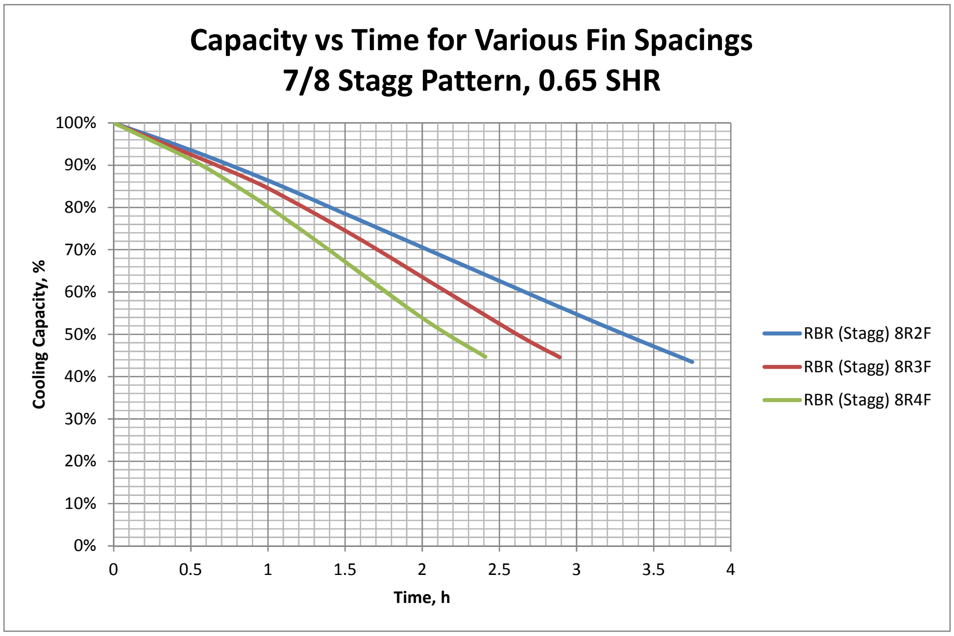

FIGURE 9

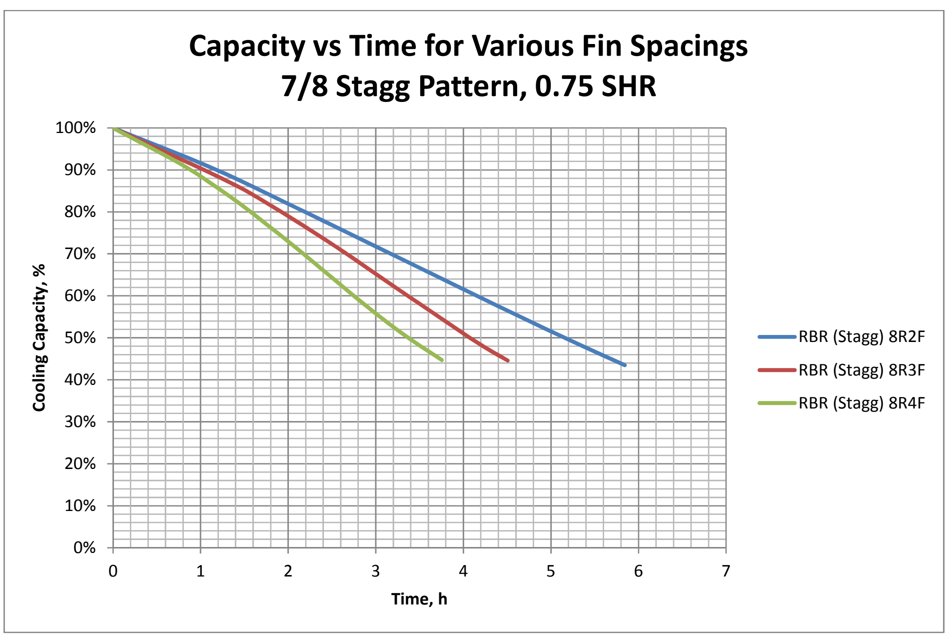

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FIGURE 10

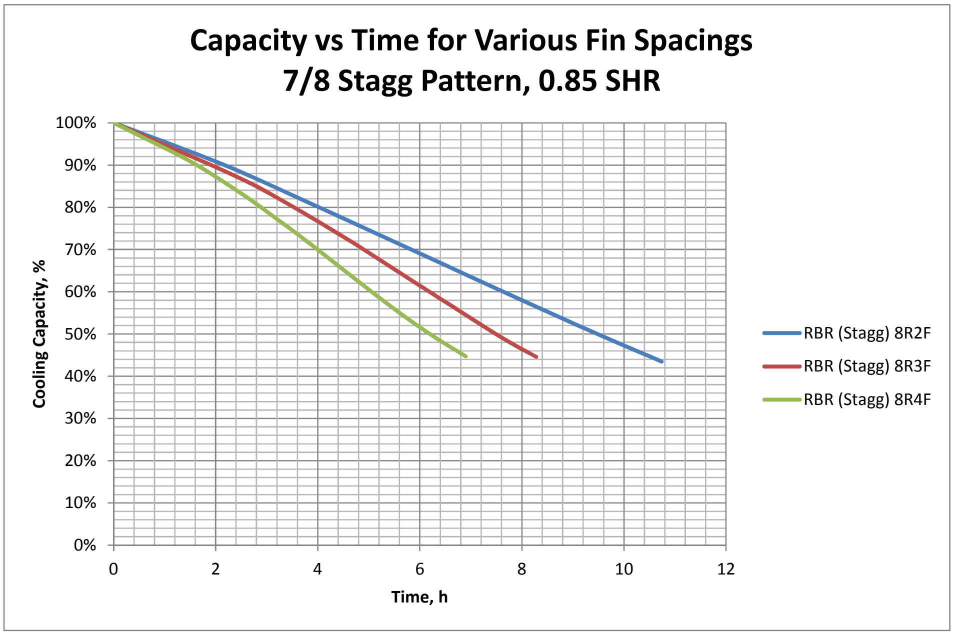
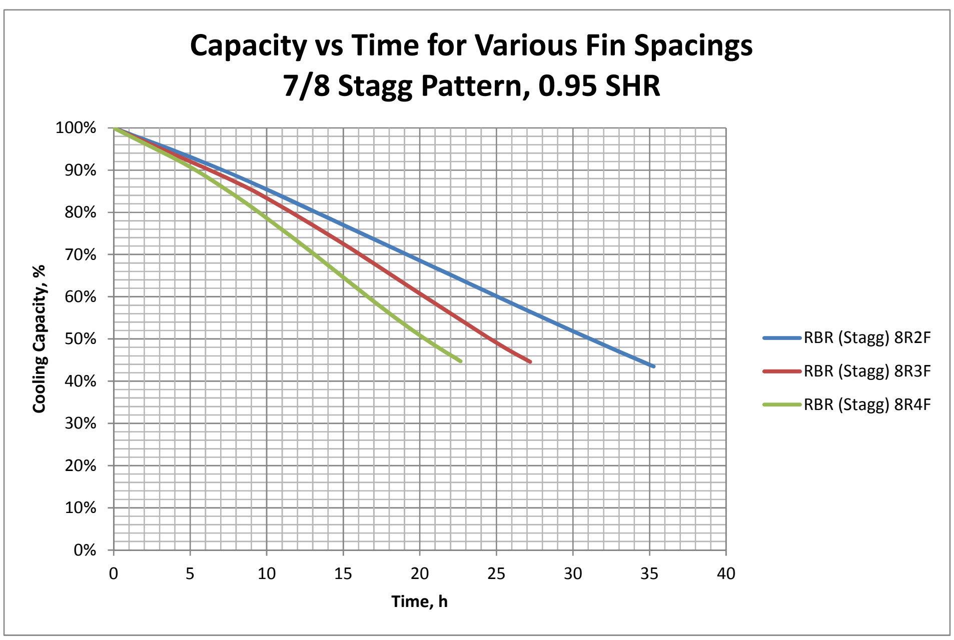


FIGURE 11



A number of observations can be made when considering Figures 8-11, Table 1, and Table 3:

1. The rate at which frost accumulates on an evaporator increases as the room temperature increases for a given room relative humidity. i.e. Frost on an evaporator operating in a room at +32F and 85% rh will accumulate much faster than on the same evaporator operating at -10F and 85% rh. This is due to the higher water vapor pressure in air at higher temperatures and the resulting lower SHR.
2. For a given reduction in evaporator capacity, wider fin spacing always results in longer actual run time between defrosts.
3. As design runtime is increased, the number of defrosts per day required increases. In the case of very high frost load (SHR less than 0.75) using design runtime greater than 14h/day may result in an inability of the refrigeration system to maintain room temperature.
4. Figures 8 through 11 can be used to estimate defrost frequency when room SHR, design runtime, and coil fin spacing are known.
   Example:
   An evaporator has been selected for a +10F/85%rh room based on design runtime of 16 h/day. Fin spacing selected is 3 FPI. Estimate the defrost frequency using Tables 1 and 3, and Figures 8 through 11.
   From Table 1: SHR = 0.87
   From Table 3: Cooling Capacity at Time of Defrost = 67%
   From Figure 10: Time between defrosts = 5.2 h
   Therefore, estimated defrost frequency = 24 h/day / 5.2 h = 5 defrosts per day

Conclusion: Table 4 below shows suggested maximum fin spacing, design runtime, and defrost frequency for various values of SHR. This table is intended to be used as a general guideline in conjunction with Table 1. Note that room relative humidity, and therefore SHR, will likely change throughout the year depending on location and climate conditions. This implies that optimum defrost frequency may be different in summer months vs winter months.

TABLE 4
SUGGESTED FIN SPACING, RUNTIME, AND DEFROST FREQUENCY VS SHR

SHR	*Suggested Maximum Fin Spacing, FPI*	*Recommended Maximum Design Runtime, h/day*	*Suggested Defrost Frequency, No. Defrosts/day*
0.65	*2*	*14*	*9*
0.75	*3*	*16*	*8*
0.85	*4*	*16*	*6*
0.95	*4*	*18*	*2*

The above discussion and recommendations are based on frost accumulation by deposition and do not include the effects of air-borne ice crystals on fin spacing and defrost frequency. The effects of air-borne ice crystals are discussed in the following section.

2. Air-Borne Ice Crystals:

This type of frost is formed quite differently from the frost formed by deposition as explained above. It accumulates on evaporator surfaces by a different mechanism, and is more difficult to quantify and predict.

Air-borne ice crystals as a type of frost that can be deposited on coil surfaces has been recognized and discussed for some time (Cleland 2002, Stoecker 1988). These ice particulates form when infiltration air mixes with refrigerated air to produce a supersaturated condition. On a psychrometric chart, a supersaturated condition is indicated when the mixed air condition falls to the left of the saturation (100% rh) line (think of fog that has frozen in mid-air).

Rather than accumulate relatively uniformly over the entire coil surface as is the case with frost formed by deposition, air-borne ice crystals accumulate on the leading edges of the coil fins and have the primary effect of restricting airflow. This type of frost is more difficult to predict since its formation depends on not only the condition of the air outside the refrigerated space, but also on the condition of doorways and how they are operated.

When evaporators are located directly above doorways where air-borne ice crystals are formed this type of frost can accumulate very quickly and have serious consequences in terms of degraded performance and inability to defrost effectively due to excessive accumulation of hoar frost and ice. In one particular case observed by the author, two identical evaporators were installed in the same refrigerated space (a -10 deg F freezer) along the same wall, one directly over the doorway and the second offset between doorways. The evaporator directly over the doorway had chronic problems with rapid, heavy accumulation of frost, and with defrost issues related to accumulation of ice on the unit cabinet and in the drainpan. The evaporator located only 20 feet away between doorways, operated without accumulating ice on the cabinet and or in the pan and defrosted normally and effectively. *<u>It is therefore recommended that evaporators not be located directly above doorways whenever possible.</u>*

If it is known that the evaporator will be exposed to this type of frost, variable fin spacing is recommended. That is, a fin spacing arrangement which has fins on the first one to two rows on the air entering side of the coil spaced wider than in the remaining rows. Typical arrangements are 1 / 2 fpi (fins per inch), 1.5 / 3 fpi, and 2 / 4 fpi.

V. Condenser Selection and Operation

A number of different types of condensers are available for use with ammonia.

- Water Cooled
- Air Cooled
- Evaporative
- Hybrid (Adiabatic) Air-Evaporative

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In certain cases the type of compression equipment (screw vs reciprocating) selected and the expected maximum ambient temperature will determine whether or not air cooled condensing will be possible. In other cases the availability (or unavailability) of water may require the use of air cooled condensing. The good news is that DX ammonia is compatible with all types of condensing systems!

Proper selection and operation of ammonia condensing equipment is outlined in the condenser manufacturers' literature.

It is recommended that the system designer carefully consider the following points when selecting/designing condensing equipment:

- Energy efficiency
- Part load operation
- Low ambient operation
- Internal volume and ammonia charge
- Gas inlet and liquid outlet piping
- Purging of non-condensible gases
- VFD condenser fan control (highly recommended)

VI. Subcooling

Refrigerant liquid leaving the condenser is typically at or near saturation temperature and pressure. If the liquid has not been subcooled before it enters the liquid line, any drop in pressure, and/or any heat input, will cause the liquid to boil and "flash gas" will be formed. Because of the very large volume occupied by vapor compared to liquid, the flash gas increases the refrigerant velocity and causes an excessive pressure drop in the liquid line, This reduces the capacity and interferes with the operation of the expansion valve, and consequently will reduce system capacity. Adequate subcooling of the liquid will prevent the formation of flash gas in liquid lines.

Subcooling the liquid after it leaves the receiver is therefore a necessity for proper system operation. Note that any subcooling done within the condenser or between the condenser and the receiver will be eliminated in the receiver due to the equalizer line. The amount of subcooling required corresponds to the liquid line pressure drop and heat gain. The pressure drop is the sum of 1) the loss in pressure due to elevation gain in the liquid line, 2) liquid line pressure drop due to friction, and 3) pressure drop through service and control valves.

Table 5 shows the pressure drop in liquid lines produced by elevation gain between the receiver and evaporators with ammonia.

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TABLE 5

Pressure Drop in Ammonia Liquid Lines Due to Elevation Gain			
Elevation Gain		Pressure Drop	
ft	m	psi	kPa
1	0.3	0.3	1.9
5	1.5	1.4	9.3
10	3.0	2.7	18.7
15	4.6	4.1	28.0
20	6.1	5.4	37.3
25	7.6	6.8	46.7
30	9.1	8.1	56.0
35	10.7	9.5	65.4
40	12.2	10.8	74.7
45	13.7	12.2	84.0
50	15.2	13.5	93.4

Once the total liquid line pressure drop (the sum of elevation pressure drop plus frictional pressure drop plus pressure drop through valves) is calculated, the required amount of subcooling to prevent flash gas in the line can be determined from Table 6. Note that the amount of subcooling required for a given pressure drop increases as condensing temperature decreases.

TABLE 6

Total Liquid Line		Required Amount of Subcooling (Ammonia)					
Pressure Drop		120F (49C) SCT		95F (35C) SCT		65F (18C) SCT	
psi	kPa	deg F	deg C	deg F	deg C	deg F	deg C
1	6.9	0.2	0.1	0.3	0.2	0.5	0.3
4	27.6	1.0	0.5	1.3	0.7	1.9	1.0
6	41.4	1.4	0.8	1.9	1.1	2.8	1.6
8	55.2	1.9	1.1	2.6	1.4	3.8	2.1
10	68.9	2.4	1.3	3.2	1.8	4.7	2.6
12	82.7	2.9	1.6	3.8	2.1	5.6	3.1
14	96.5	3.4	1.9	4.5	2.5	6.6	3.7
16	110.3	3.8	2.1	5.1	2.8	7.5	4.2
18	124.1	4.3	2.4	5.8	3.2	8.5	4.7
20	137.9	4.8	2.7	6.4	3.6	9.4	5.2
25	172.4	6.0	3.3	8.0	4.4	11.8	6.5
30	206.8	7.2	4.0	9.6	5.3	14.1	7.8
35	241.3	8.4	4.7	11.2	6.2	16.5	9.2
40	275.8	9.6	5.3	12.8	7.1	18.8	10.5
45	310.3	10.8	6.0	14.4	8.0	21.2	11.8
50	344.7	12.0	6.7	16.0	8.9	23.5	13.1

A commonly used method of subcooling liquid refrigerant is termed Mechanical Subcooling. This is the COLMAC RECOMMENDED method of liquid subcooling and refers to using a portion of liquid refrigerant from the uncooled liquid line to evaporate and cool the remaining liquid. A heat exchanger (typically a plate type exchanger) is installed in the liquid line in such a way as to cool the liquid refrigerant on one side of the exchanger by evaporating a relatively small amount of the refrigerant on the other side of the exchanger. The evaporating side refrigerant is metered by a TXV or motorized valve in response to liquid line temperature and the evaporated refrigerant then returned to the suction line. This method of subcooling produces predictable results under all conditions, and is required to insure proper operation of Colmac DX Ammonia evaporator controls. With mechanical subcooling there is no net loss of refrigerating effect or system energy efficiency.

Alternate methods for subcooling refrigerant liquid can be applied, but have various drawbacks:

Ambient Subcooling. This involves using a separate circuit within the condenser to route liquid refrigerant from the receiver to the system causing the refrigerant to approach the ambient air temperature. This is a relatively simple design, however the amount of subcooling will be limited to the condenser TD. This may not be a sufficient amount of subcooling to avoid formation of flash gas during certain times of the year. Therefore, this method of subcooling is NOT recommended.

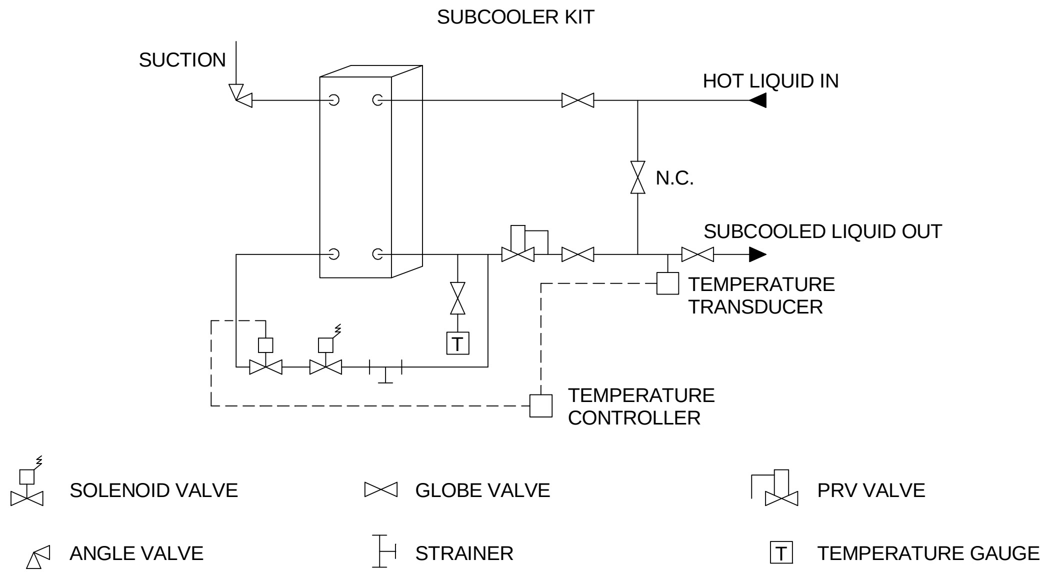
Liquid Pumping. Here a liquid pump is installed at the exit of the receiver to pressurize the liquid line sufficiently to overcome the total pressure drop due to friction and elevation gain. While effective at eliminating flash gas regardless of operating conditions, this method adds complexity and will cause the liquid line to operate at a pressure which is higher than condensing pressure. As with ambient subcooling, this method is NOT recommended.

NOTE: Referring to Figures A1-A3, liquid temperature leaving the mechanical subcooler is shown as 40 deg F. This liquid temperature is conservative and should prevent the formation of flash gas in liquid lines in most if not all cases.

Subcooler Piping:

Figure 12 below illustrates typical mechanical subcooler heat exchanger piping.

FIGURE 12



To insure effective liquid subcooling, be sure to observe the following rules:

1. Size piping and valves for the maximum refrigerant flow condition anticipated, i.e. lowest head pressure / highest suction pressure. This condition typically occurs during winter months.
2. Always insulate liquid lines to prevent heat gain and loss of subcooling.
3. Locate subcooler heat exchanger downstream of the receiver at the entrance to the liquid line, NOT between the condenser and receiver. See P&ID examples above.
4. Use good piping practice, as can be found in the IIAR Ammonia Refrigeration Piping Handbook (IIAR 2004).

Mechanical Subcooler Selection:

Colmac offers pre-engineered Mechanical Subcoolers which are factory piped and packaged in a free-standing frame, and include the following components:

- Stainless steel plate-type subcooling heat exchanger
- Electronic expansion valve and temperature controller
- Service (isolation) valves
- Pressure reducing valve for controlled leaving liquid line pressure
- UL listed and wired control panel

See separate Engineering Bulletin for subcooler selection and specification details.

VII. Piping – General

1. Cleanliness. The small internal passages found in expansion valves (and other control valves) in DX ammonia systems are particularly sensitive to fouling and plugging with

relatively small amounts of dirt and debris. For this reason, particular care needs to be taken during the installation of system piping to insure cleanliness and to minimize the introduction of weld scale and dust, and other types of dirt and debris.

2. Evacuation Prior to Charging the System with Ammonia. Because the performance of DX ammonia evaporators is dramatically affected by even small amounts of water, it is very important to follow good pressure testing and evacuation procedures prior to charging the system with ammonia. Recommended evacuation procedure can be found in the separate Colmac Engineering Bulletin on this topic.

VIII. Liquid Lines

Industry-accepted methods and practice for proper sizing and arrangement of liquid lines can be found in the IIAR Ammonia Refrigeration Piping Handbook (IIAR 2004). Additionally, follow the guidelines explained below.

1. Design mass flowrate. Liquid lines must be sized appropriately for the type of line (condenser to receiver, receiver to expansion valve, etc.) and the expected maximum mass flow rate condition. The maximum mass flow rate condition will occur when discharge pressure is at its minimum, suction pressure is at its maximum, and compressors are running fully loaded. Typically this would occur with floating head pressure systems during winter months. Designing liquid lines for the hottest day of the year (commonly taken as the “design point”) will likely lead to undersized liquid lines and higher-than-expected pressure drop with the potential of forming flash gas in the liquid line.
2. Insulation. Insulation of liquid lines downstream of the liquid subcooler becomes critically important in DX ammonia systems to avoid heat gain and the potential for developing flash gas in the liquid line upstream of the expansion valves. Use good quality insulation systems with adequate insulation value and protection against physical and weather damage.
3. Type of Expansion Valve. Three types of expansion valves are commonly used in DX systems: 1) Thermostatic, 2) Motorized, and 3) Pulse-width Modulating. Thermostatic and motorized valves modulate in response to the imposed load on the coil and so liquid lines should be sized for the maximum expected design mass flow rate (see paragraph V.1. above). Pulse-width modulating (PWM) expansion valves, on the other hand, alternate between wide open and fully closed at a rate which corresponds to the duty called for by the electronic controller. Because the mass flow rate of refrigerant will be determined by the wide open capacity of the PWM valve, the “local” liquid line from the liquid supply main to the individual evaporator must be sized to handle the maximum capacity of the valve. When PWM valves are used, the liquid supply main line must be sized to handle this “wide open capacity” by using a diversity factor based on the number of evaporators expected to be operating at the same time divided by the total number of evaporators.
4. Pressure Regulating Valve. As shown in Figures A1-A3, the liquid line pressure leaving the subcooler assembly is maintained at 75 psig by a pressure regulating valve. When defrost hot gas pressure is regulated to maintain 90 psig (also shown in Figures A1-A3)

this pressure differential allows defrost condensate leaving the evaporators during defrost to be fed directly back into the liquid line and sent to other operating evaporators.

5. Pipe material specifications. Refer to the IIAR Ammonia Refrigeration Piping Handbook (IIAR 2004) and ANSI/IIAR Standard 2-2008 (IIAR 2008) for detailed pipe material specification requirements for ammonia liquid piping.

IX. Suction Lines

Unlike pumped ammonia systems, no wet suction lines are needed for DX ammonia. Although they should be pitched and trapped to accommodate the occasional presence of liquid, suction line pressure drop should be calculated to reflect dry operation. Refer to the IIAR Ammonia Refrigeration Piping Handbook (IIAR 2004) for proper sizing and arrangement of dry suction lines. Additionally, follow the guidelines explained below.

1. Design mass flowrate. As with liquid lines, dry suction lines should be sized for the expected maximum mass flow rate condition. Again, the maximum mass flow rate condition will occur when discharge pressure is at its minimum, suction pressure is at its maximum, and compressors are running fully loaded.
2. Trapped vertical risers. Suction lines with vertical upflow (suction “risers”) must be installed with a p-trap at the bottom (entrance) of the riser and discharge into the top of the overhead suction main pipe. When varying loads on the evaporator are expected, a double riser design should be used. Refer to the IIAR Ammonia Refrigeration Piping Handbook (IIAR 2004) for examples of double suction riser designs.
3. Pitched suction lines. Suction lines must be pitched a minimum of 1/8” per foot toward the suction accumulator to facilitate good drainage of any liquid refrigerant and/or oil that enters the suction line.
4. Pipe material specifications. Particular attention must be paid to carbon steel pipe material specifications in low temperature (suction temperatures below -20 deg F), which may require impact testing. Refer to the IIAR Ammonia Refrigeration Piping Handbook (IIAR 2004) and ANSI/IIAR Standard 2 (IIAR 2008) for detailed pipe material specifications and requirements.

X. Hot Gas Lines

Industry-accepted methods and practice for proper sizing and arrangement of hot gas lines can be found in the IIAR Ammonia Refrigeration Piping Handbook (IIAR 2004). Additionally, follow the guidelines explained below.

1. Design mass flowrate. Hot gas (defrost) lines should be sized for the mass flow rate corresponding to the maximum number and size of evaporators expected to defrost at the same time. Conventional wisdom maintains that each individual evaporator requires a flow of hot gas equal to 2 x times the flow required during cooling, and so this would limit the number of evaporators being defrosted at the same time to a maximum of 1/3 the total number of evaporators in the facility (the “two-to-one rule”). However, evaporators equipped with Colmac Smart Hot Gas™ controls can effectively defrost an

evaporator with hot gas flowing to the evaporator for only 8 to 10 minutes. With an effective building management control system, and depending on the frost load and frequency of defrosting, it is possible to limit the amount of defrost hot gas flowing at any given time to only that required for the largest single evaporator in the facility. This approach obviously has the potential to reduce the hot gas line and PRV size and cost. Expected mass flow rate of hot gas for defrost of a given sized evaporator can be calculated using the method described below in the Hot Gas Defrost section.

2. Insulation. Insulation of hot gas lines is critically important to insure fast defrosting. Use good quality insulation systems with adequate insulation value and protection against physical and weather damage.
3. Pressure Regulating Valve. As shown in Figures A1-A3, the hot gas line coming from the compressor discharge line is maintained at 90 psig by a pressure regulating valve. When defrost hot gas pressure is regulated to maintain 90 psig and the liquid line is maintained at 75 psig (also shown in Figures A1-A3) this pressure differential allows defrost condensate leaving the evaporators during defrost to be fed directly back into the liquid line and sent to other operating evaporators. Maintaining the hot gas line pressure at the reduced 90 psig also minimizes heat loss to the surrounding ambient.
4. Pitched hot gas lines and drip legs. Hot gas lines must be pitched a minimum of 1/8" per foot toward the evaporators to facilitate good drainage of any condensed refrigerant ("condensate") to drip legs installed ahead of the evaporator control valve group(s).
5. Liquid drainers. As hot gas for defrost travels from the engine room to the evaporators some of its energy will be released to heat up the piping itself, and some released due to heat loss through insulation. Condensate will therefore form in the hot gas piping which must then be effectively trapped and drained before it reaches the evaporators. Unless it is effectively removed, accumulating condensed liquid upstream of hot gas solenoid valves will cause cavitation on the seats of the solenoid valves when the valve is closed (Jensen 2013). Condensate will collect in drip legs (described above) and must be returned to either a nearby suction line, or a condensate return line. Use a liquid drainer or an appropriately sized steam trap to allow only liquid to leave the drip leg. Using liquid drainers also effectively keeps hot gas lines continually heated and ready to supply full flow of hot gas to evaporators immediately on demand for defrosting.
6. Pipe material specifications. Refer to the IIAR Ammonia Refrigeration Piping Handbook (IIAR 2004) and ANSI/IIAR Standard 2-2008 (IIAR 2008) for detailed pipe material specification requirements for ammonia hot gas piping.

XI. Effects of Water in Ammonia and Its Removal

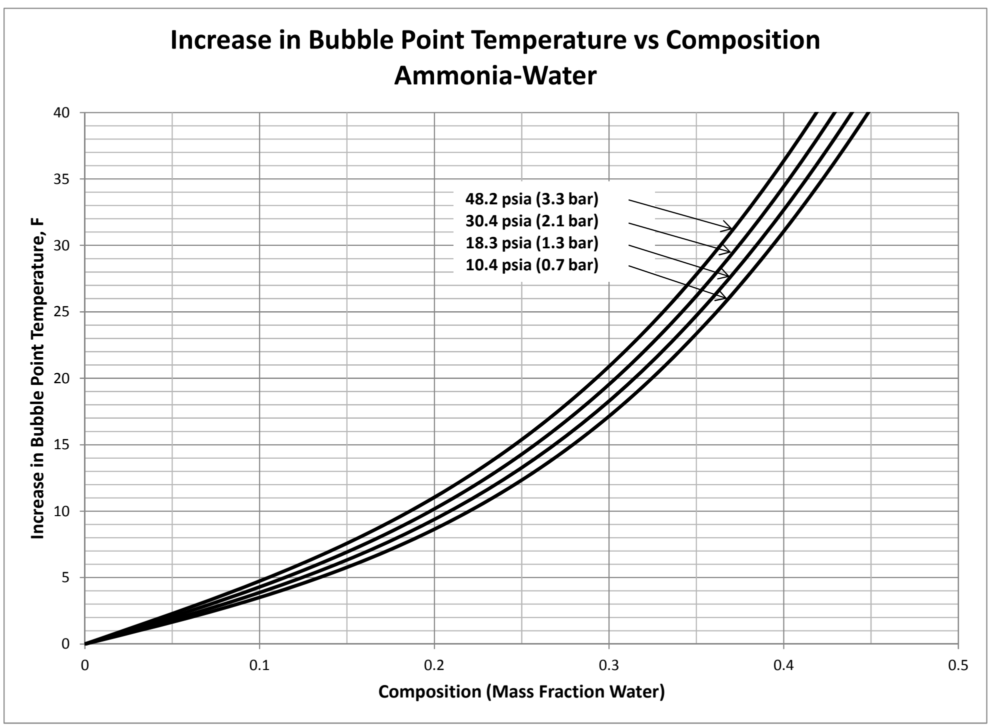
As explained in detail elsewhere (Nelson 2010), the presence of even small amounts of water in ammonia has a significant negative effect on DX evaporator performance. Unfortunately, water is difficult to entirely keep out of industrial ammonia refrigeration systems for a number of reasons: Residual water in pressure vessels left from hydro-testing, incomplete evacuation of the system prior to startup, leaks in parts of the system which normally operate in a vacuum, etc.

This residual water goes into solution with the ammonia and increases and the boiling point (bubble point) temperature. At a concentration of 20% (by mass) water in ammonia, the boiling point rises to approximately 10 deg F above the boiling point of pure ammonia at the same pressure. See Figure 13 below.

As the ammonia-water liquid enters the evaporator circuit it begins to boil. Because of the large difference in vapor pressures of ammonia and water, only ammonia vapor is generated during the evaporation process, leaving the water behind in the remaining liquid. So the evaporation process results in an increase in water concentration and a corresponding increase in the boiling point of the refrigerant as it passes through the coil circuit. In the case of an evaporator operating with a 10 deg F TD, the refrigerant will stop boiling once the water concentration reaches about 20% since the boiling point will have risen by 10 deg F. This cessation of boiling will occur at some point along the length of the evaporator circuit, the point at which boiling stops depending on the initial concentration of water and suction pressure. At the point where the increase in the water concentration has caused an increase in the boiling point equal to the coil TD, liquid refrigerant will exit the evaporator and enter the suction line.

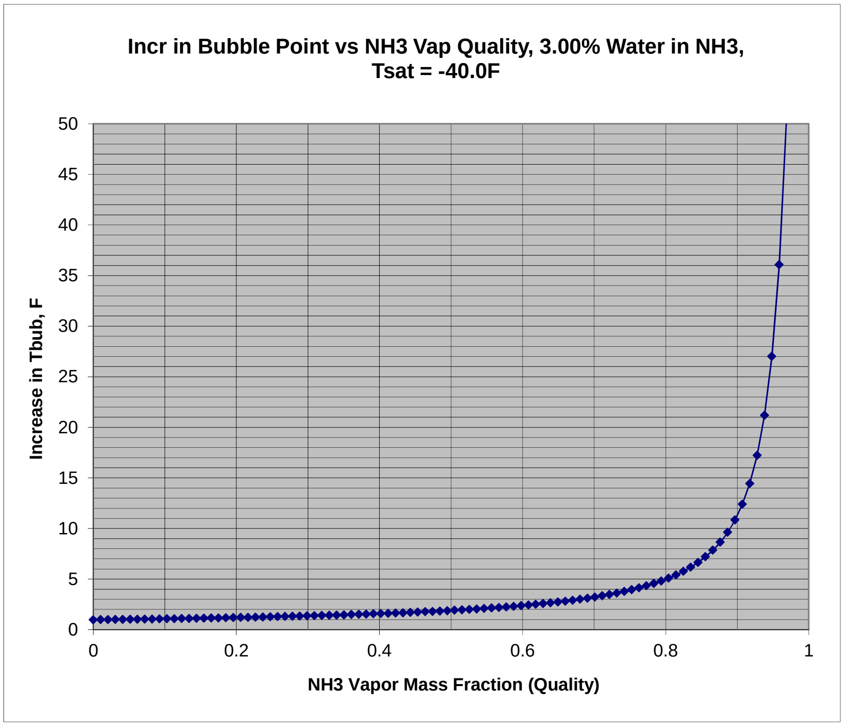
Figure 13 below shows the increase in boiling point (bubble point) for various initial water concentration in ammonia at various pressures.

FIGURE 13



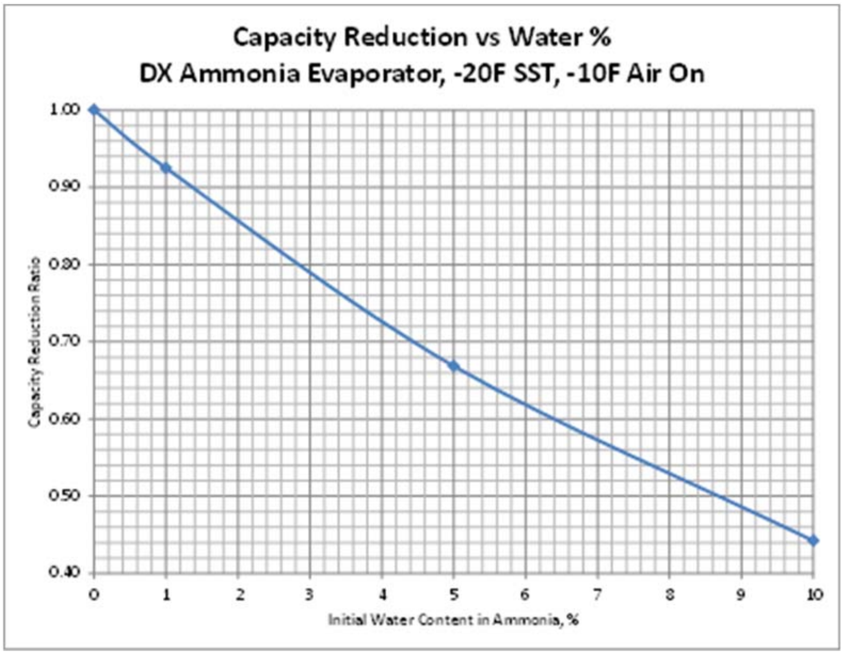
An example of the increase in bubble point temperature over the circuit length of an evaporator, represented by the change in vapor quality, is shown in Figure 14 below for an initial water concentration in ammonia of 3% at a pressure of 10.4 psia (-40 deg F SST). In this example the bubble point (Tbub) has increased by 10 deg F at a vapor quality of approx. 0.89.

FIGURE 14



This increase in bubble point significantly reduces the mean temperature difference and therefore the cooling capacity of the evaporator is reduced as illustrated in Figure 15.

FIGURE 15



In addition to the performance penalty seen when relatively small amounts of water are present in the ammonia, this also means that the mass fraction (1 – 0.89) = 0.11, or 11% of the mass of refrigerant exiting the evaporator as liquid will have to be captured downstream in the suction accumulator.

Knowing that ammonia-water liquid of approximately 20% water concentration will unavoidably leave the evaporators whenever even small amounts of water are present in the ammonia is important for the designer to understand. The suction accumulator must therefore be properly designed to perform the following functions:

i. Separate liquid and vapor refrigerant and allow only vapor to return to the compressor,
ii. Capture and distill (by heating) ammonia-water liquid to a concentration that can safely be removed from the system for disposal.
iii. Transfer excess trapped liquid to the high pressure receiver, or into the reduced pressure liquid line.

1. Separation

Liquid-vapor separation in suction accumulator vessels is well understood and design methods well documented. Refer to recognized published sizing and design methods (Stoecker 1988, Wiencke 2002).

Colmac offers a range of pre-engineered factory assembled suction accumulator packages specifically suited to operation with DX ammonia. See separate Engineering Bulletin for selection and specification details.

2. Distillation and Disposal of Ammonia-Water Solution (Ammonium Hydroxide)

Distillation:

Ammonia is highly soluble in water due to the polarity of NH3 molecules and their ability to form very strong hydrogen bonds (Nelson 2010). This high solubility makes ammonia-water a good working fluid pair in absorption refrigeration machines, taking advantage of the large vapor pressure differences between the ammonia vapor and weak solution. However, this same behavior makes water removal from ammonia refrigeration systems somewhat challenging.

As mentioned above, ammonia-water solution concentrated to approximately 20% water will return from evaporators via the suction line to be trapped in the suction accumulator. This aqueous ammonia solution, called Ammonium Hydroxide, at a concentration of 80% ammonia (20% water) would be very difficult to safely remove from the system for disposal. Further distillation of the solution is needed to bring the ammonia concentration in the solution down to the practical minimum before it is removed.

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The only practical way to distill the Ammonium Hydroxide is by heating in a separate distillation vessel, called a "still". Ammonium Hydroxide trapped in the suction accumulator drains by gravity into the still where it is heated to a temperature corresponding to the point on a Phase Equilibrium diagram where the slope of the dew point line changes rapidly from nearly vertical to more nearly flat. This point is shown on Figure 16 as 'Point A'. Below this temperature (between 100 and 120 deg F), nearly pure ammonia vapor will leave the still and travel through the vent line back to the suction accumulator where it will then be taken back to the compressor. Above this temperature, water vapor will begin to leave the Ammonium Hydroxide solution and exit the still vent line where it will go back into solution with any ammonia liquid present in the suction accumulator. Based on this, the heating element in the still must be controlled to bring the solution temperature up to a maximum of 100 to 120 deg F, at which point it is ready to be removed safely to a storage container for further processing and/or disposal.

FIGURE 16

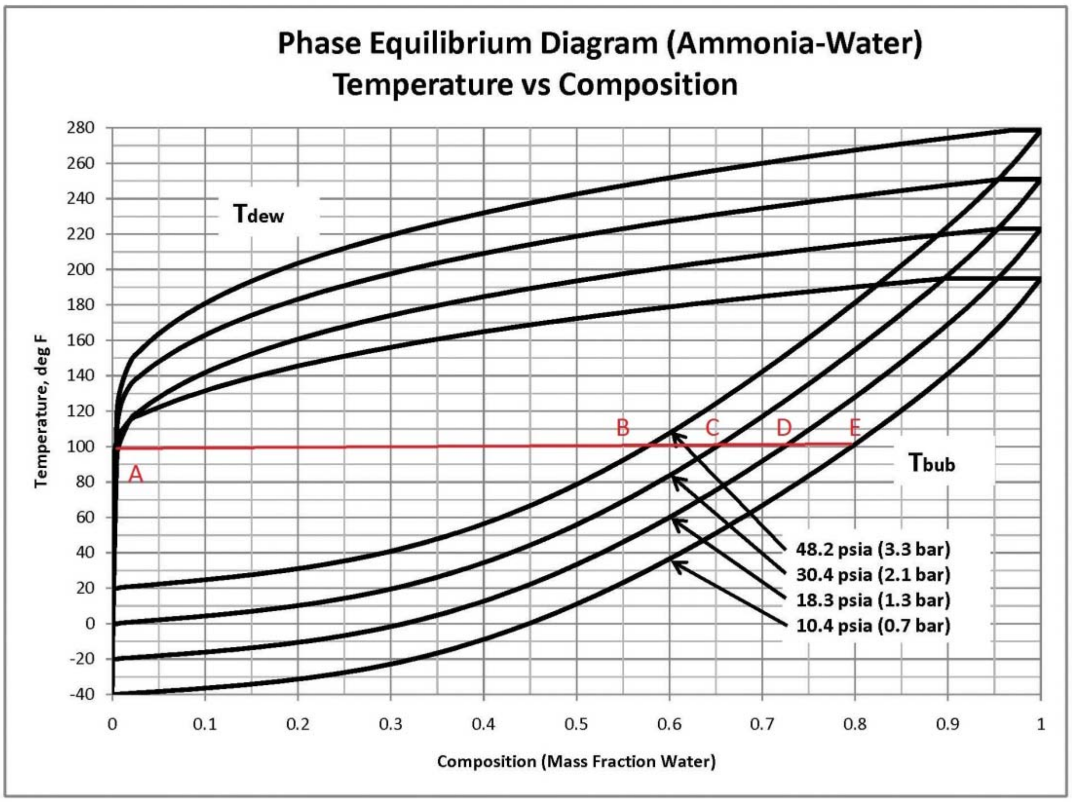

Figure 16 also shows that the maximum water concentration in the Ammonium Hydroxide solution heated to 100 deg F varies with suction pressure. The maximum water concentrations possible are shown as Points B, C, D, and E, in Figure 16, and are listed in Table 7 below. It is apparent from the figure and the table that the still is able to achieve higher water concentrations at lower suction pressures.

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TABLE 7
AMMONIA-WATER CONCENTRATIONS @ 100 deg F vs SUCTION PRESSURE

Suction Pressure, psia (Saturation Temp, F)	Water Concentration, % by mass	Ammonia Concentration, % by mass
48.2 (+20 F)	57.5	42.5
30.4 (0 F)	65.0	35.0
18.3 (-20 F)	72.5	27.5
10.4 (-40 F)	80.0	20.0

Using the above information, an estimate can now be made of the volume of Ammonium Hydroxide solution that will be generated by the still for a given system ammonia charge having a given initial water content. Table 8 below shows the expected volume of Ammonium Hydroxide solution per pound of initial ammonia charge that will have to be removed by the still (and disposed of) in order to completely remove the water from refrigeration system.

TABLE 8
EXPECTED VOLUME OF DISTILLED SOLUTION AMMONIUM HYDROXIDE @ 100F
(GALLONS per POUND INITIAL AMMONIA CHARGE)

Initial Water	Saturated Suction Pressure, psia (Saturated Temp, F)			
Content, %	48.2 (+20 F)	30.4 (0 F)	18.3 (-20 F)	10.4 (-40 F)
0	0.00000	0.00000	0.00000	0.00000
1	0.00246	0.00211	0.00183	0.00161
3	0.00738	0.00633	0.00550	0.00484
5	0.01230	0.01055	0.00917	0.00807
10	0.02460	0.02109	0.01835	0.01614
20	0.04920	0.04218	0.03669	0.03229

EXAMPLE:
A system has an initial ammonia charge of 5,000 lbs with 3% water content. The still is installed on the -20 deg F suction accumulator. What will be the total volume of distilled Ammonium Hydroxide solution drained from the still?

Answer:
Final Distilled Solution Ammonia Concentration for Disposal (from Table 7): 27.5%
Expected Volume of Distilled Solution per Pound (from Table 8): 0.0055 gal/lbs

Total Expected Volume of 27.5% Ammonium Hydroxide for Disposal:
5,000 lbs x 0.0055 gal/lbs = 27.5 gallons

Storage and Disposal:

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Ammonium Hydroxide is listed as a hazardous substance under CWA (40 CFR 1164.40 CFR 117.3 Reportable Quantity Category C. 1000lbs/454 kg). As such, it is important to comply with all local and national regulations for safe handling and disposal of the solution removed from the system still (Smith 2010).

It is interesting to note that suitably diluted Ammonium Hydroxide may be disposed of on agricultural land as fertilizer. However, the material should be kept from entering streams and lakes as it is harmful to aquatic life and can cause environmental damage.

Ammonium Hydroxide will react exothermically (heat is generated) with acids, and so neutralizing of the solution by unqualified personnel is not recommended.

It is important to prevent contact of the Ammonium Hydroxide solution with chemicals such as mercury, chlorine, iodine, bromine, silver oxide, and hypochlorites, as they can form explosive compounds. Contact with chlorine forms chloramine gas which is a primary skin irritant and sensitizer.

Figure 16 in combination with Table 7 can be used to predict the temperature above which ammonia vapor will be generated when the distilled solution is stored in an open container. This “vapor neutral” temperature is found using the ammonia concentrations shown in Table 7 for various suction pressures, intersecting a line of constant bubble point temperature (Tbub) at atmospheric pressure (14.7 psia) on Figure 16. Table 9 below shows the ambient (storage) temperatures below which ammonia vapor will not be generated from the Ammonium Hydroxide solution discharged from the still.

TABLE 9
RECOMMENDED MAXIMUM AMMONIUM HYDROXIDE STORAGE TEMPERATURES

Suction Pressure, psia (Suction Temp, F)	Ammonia Concentration, % by mass	Storage Temperature, Deg F
48.2 (+20 F)	42.5	42
30.4 (0 F)	35.0	64
18.3 (-20 F)	27.5	90
10.4 (-40 F)	20.0	108

Ammonium Hydroxide solution has a corrosive reaction with the following materials which should not be used to store the distilled Ammonium Hydroxide solution (LaRoche Industries 1987):

- Galvanized (zinc coated) surfaces
- Copper
- Brass and bronze alloys
- Certain types of elastomers

The distilled Ammonium Hydroxide solution can be safely stored in containers made of the following materials:

- Carbon steel
- Stainless steel
- Aluminum
- Cast Iron

Generally speaking, aluminum alloys are not recommended for exposure to aqueous solutions having a pH greater than 9.0 due to accelerated corrosion and metal loss. Ammonium Hydroxide however, even in high concentrations, is an exception to this rule. (Davis 1999).

In conclusion, Ammonium Hydroxide solution collected from the still should be stored in an appropriately constructed container located in a cool space out of direct sunlight. It is recommended that the distilled solution be disposed of using a local qualified waste disposal vendor.

More detailed handling and safety information can be found on MSDS sheets published by suppliers of Ammonium Hydroxide (Tanner Industries 2000, LaRoche Industries 1998).

3. Liquid Transfer

Liquid refrigerant will leave the evaporator(s) and accumulate in the suction accumulator vessel during operation for a number of reasons:

a. Liquid floodback due to water in the ammonia (see above explanation),
b. Liquid floodback due to a rapid change in system pressure and/or load,
c. Liquid condensate from hot gas defrost.

A liquid transfer system capable of handling the total anticipated volume of liquid refrigerant reaching the suction accumulator vessel must be included in the system design. In order to properly size the transfer system, estimates of the amount of liquid returning from evaporators for the reasons stated above must be made.

i. Liquid Floodback Due to Water in Ammonia

The anticipated volume of ammonia-water liquid leaving the evaporator(s) based on an average 20% water concentration at the evaporator exit has been calculated and shown in Table 10 below. Multiply the value shown in the table by the total capacity of the system in tons (TR) to determine the volume of ammonia-water liquid returning to the suction accumulator.

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TABLE 10
Volume of Ammonia-Water Liquid Leaving DX Evaporators

Water Content in Ammonia, %	Volumetric Flowrate of Ammonia-Water (20% water concentration) Leaving DX Evaporators, ft3/h/TR
0.5	0.01
1.0	0.02
3.0	0.07
5.0	0.12
10.0	0.24

Example:
It has been determined that the ammonia fed to evaporators with total capacity of 200 tons (TR) has a water content of 3%. If the evaporators are operated as direct expansion (DX), how much ammonia-water liquid is expected to return from the evaporators to the suction accumulator?

Answer:
Volume of Floodback Due to Water = 200 TR x 0.07 ft3/h/TR = 14 ft3/h = 1.8 gal/min

In a properly designed and operated system, this type of liquid floodback should only occur initially during startup since water in the system will be captured in the still and then removed.

ii. Liquid Floodback Due to Rapid Changes in Pressure or Load

This type of floodback is difficult to predict, but fortunately is (or should be) relatively small. A 'worst-case' rule of thumb might be to assume that an average 10% of the mass of refrigerant leaves as liquid from 25% of the evaporators. In that case, the transfer system would need to handle a volume of liquid approximated by the following formula:

$$Volume\ of\ Floodback, ft3/h = \frac{\dot{q} \cdot 12{,}000}{h_{fg} \cdot dx} \cdot v \cdot 0.10 \cdot 0.25 \qquad (8)$$

Where:
$\dot{q} = Total\ Evaporator\ Capacity, TR$
$h_{fg} = Latent\ Heat\ of\ Vaporization, Btu/lbm$
$dx = Change\ in\ Vapor\ Quality\ Through\ the\ Evaporator$
$v = Specific\ Volume\ (liquid), ft3/lbm$

Example:
200 TR of ammonia evaporator capacity at -25 deg F suction temperature is connected to the suction accumulator. What is the expected average volume of liquid returning to the accumulator due to liquid floodback?

Answer:
Latent Heat of Vaporization, hfg = 550 Btu/lbm
Change in Vapor Quality Through the Evaporator, dx = 0.8
Specific Volume (liquid), v = 0.024 ft3/lbm

$$Volume\ of\ Floodback = \frac{200 \cdot 12{,}000}{550 \cdot 0.8} \cdot 0.024 \cdot 0.10 \cdot 0.25 = 3.3 ft3/h = 0.4\ gal/min$$

iii. Defrost Condensate from Hot Gas Defrost

If there is any water present in the ammonia entering the evaporator during low temperature operation, it will be held and distilled in the pores of the proprietary wicking structure on the ID of the Colmac evaporator tubes. This local distillation process degrades the performance of the evaporator by reducing the local mean temperature difference (MTD). Hot gas defrost is critical to removing this "water-rich" liquid from the wicking structure. The ammonia hot gas coming from the high pressure receiver (see Figures A1 thru A3) is essentially water-free and oil-free ammonia. This pure ammonia vapor condenses on the tube ID, dilutes the "water-rich" liquid, and sends it to either the intercooler vessel or the low pressure suction accumulator where it can be distilled in the ammonia still and removed from the system.

This process of "flushing" the evaporators and the system of water during hot gas defrosting should only happen initially during the startup phase for systems which operate with a low suction pressure above one atmosphere (0 psig) and then only periodically for systems with a low suction pressure operating in a vacuum (blast freezing). During system startup, a valve in the defrost condensate return line on each evaporator is opened to admit the condensate to the suction line and accumulator (see Figures A1 through A3). In the accumulator the water-laden ammonia is captured in the water still, distilled, and removed from the system. After the water in the initial ammonia charge has been completely removed (after a number of defrost cycles) and the ammonia is "dry", the valve in the condensate return line to suction is closed and the valve in the condensate return line to the liquid line is opened.

During startup, excess defrost condensate which is not captured in the water still must be transferred to the high pressure side of the system. The volume of defrost condensate leaving the evaporators can be estimated using the following formula:

$$Volume\ of\ Condensate, ft3/h = \frac{\dot{q} \cdot 12{,}000}{h_{fg}} \cdot v \cdot \frac{(1 - SHR)}{\emptyset} \qquad (9)$$

Where:
$\dot{q} = Total\ evaporator\ cooling\ capacity, Btu/lbm$
$h_{fg} = Latent\ heat\ of\ vaporization, Btu/lbm$

$SHR = Sensible\ Heat\ Ratio$
$v = Specific\ Volume\ (liquid), ft3/lbm$
$\emptyset = Defrost\ Efficiency\ (typically\ 0.15)$

Example:
200 TR of ammonia evaporator capacity at +10 deg F room temperature / 85% rh is connected to the suction accumulator. What is the expected average volume of defrost condensate (liquid) returning to the accumulator?

Answer:
Latent Heat of Vaporization, hfg = 550 Btu/lbm
Sensible Heat Ratio (SHR) from Table 1 = 0.87
Specific Volume (liquid), v = 0.024 ft3/lbm
Defrost Efficiency = 0.15

$$Volume\ of\ Condensate, ft3/h = \frac{200 \cdot 12{,}000}{550} \cdot 0.024 \cdot \frac{(1-0.87)}{0.15} = 90.8 ft3/h = 11.3\ gal/min$$

The suction accumulator(s) and the liquid transfer vessel must therefore be designed to handle the total amount of liquid returning from evaporators due to water + normal floodback, + defrost condensate.

A liquid transfer vessel is incorporated into the Colmac Pre-Engineered Suction Accumulator Skid package (see separate Engineering Bulletin). The transfer vessel is designed to handle up to 5% initial water content in the system ammonia charge. Note that Industrial Refrigeration grade anhydrous ammonia is certified to be 99.95% pure ammonia.

XII. Effects of Oil on Evaporator Performance and Oil Separation

Immiscible lubricants are recommended over miscible lubricants for large industrial DX ammonia refrigeration systems for a number of reasons:

- Lower cost
- Ease of separation
- Relative insensitivity to contaminants (water, dirt)

Even though immiscible oils are preferred over miscible types for the reasons stated above, any oil reaching the evaporator can potentially coat the inside of the tubes and severely degrade heat transfer performance due to:

1. Added resistance to heat transfer as explained below and shown in Figure 17, and
2. Fouling of the proprietary wicking structure preventing liquid ammonia from coating the inside of the tubes by capillary action.

Even a thin layer of oil coating the inside of evaporator tubes adds resistance to heat flow as shown below.

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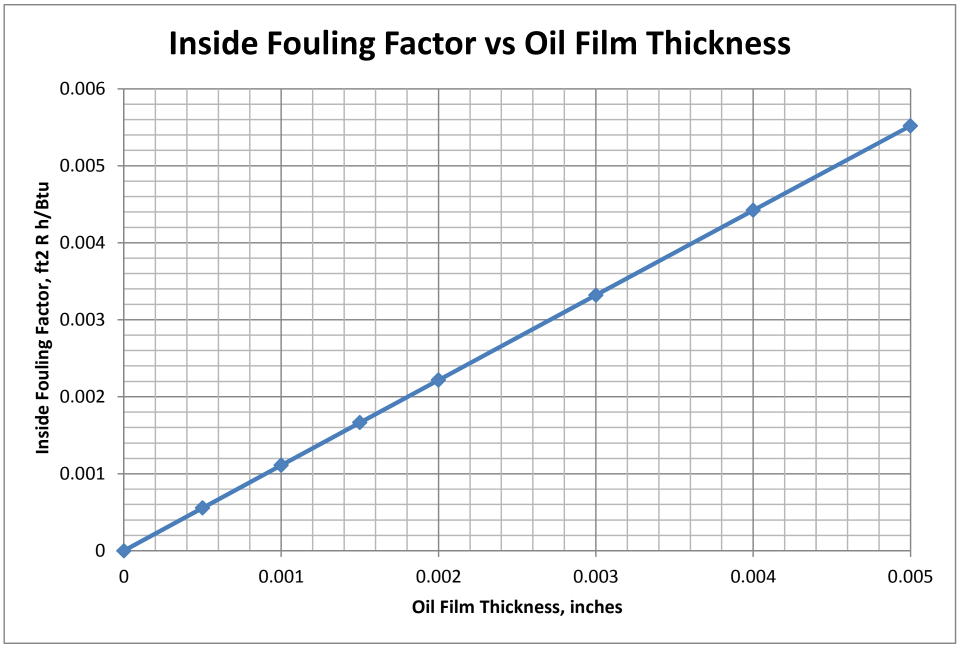
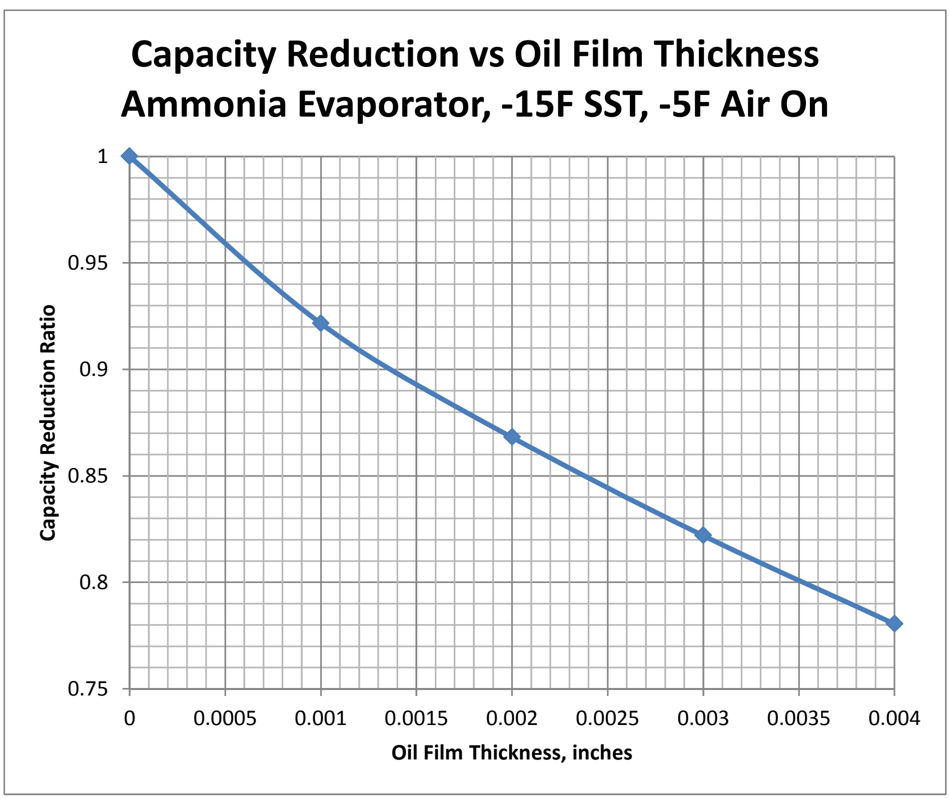
FIGURE 17



In a typical DX ammonia evaporator, this fouling factor causes a significant reduction in cooling capacity as is shown below in Figure 18.

FIGURE 18



It is apparent from Figures 17 and 18 above that it is highly desirable from an energy efficiency standpoint to prevent compressor lubricating oil from reaching the evaporators. To achieve this, the following should be carefully considered and specified in the system design:

a. Type of compressor lubricating oil
b. Compressor oil separator design and efficiency
c. Oil capture and management at the outlet of the condenser
d. Oil capture in the suction accumulator(s)
e. Oil capture at the evaporator

Type of Oil:

Depending on the type of compressor used (reciprocating or rotary screw), varying amounts of lubricating oil will unavoidably be discharged with the ammonia vapor. Oil will leave the compressor both in liquid droplet form and as oil vapor. The liquid droplets can be captured mechanically in the oil separator vessel by controlling velocity and by incorporating coalescing elements. The oil which is combined with the ammonia in vapor form is more difficult to capture. Generally speaking, as volatility and solubility of the oil increase, separation becomes more difficult. The amount of oil which is not captured in the separator and returned to the compressor is referred to as “oil carryover”.

All lubricating oils used in the ammonia refrigeration industry are blends of a base fluid(s) with additives (Wierbosch 2010). The base fluid controls volatility and solubilty of the oil. Today, commonly used base fluids include:

- Napthenic
- Solvent Refined Paraffinic
- Alkyl Benzene
- 2-Stage Hydrocracked
- PAO/AB

The aromatic content of the base fluid has a large effect on vapor pressure (volatility) and solubility. The higher the vapor pressure of the oil, the more oil vapor will leave the compressor with the ammonia in the discharge gas (Briley 1984). Since this oil vapor is difficult to capture in the separator, it is desirable to select an oil which has the lowest vapor pressure possible. Alkyl Benzene and Naphthenic bases have the highest aromatic content, vapor pressure, and solubility. 2-Stage Hydrocracked bases have lowest aromatic content, vapor pressure, and the lowest solubility.

It is therefore recommended that ammonia refrigeration oil having a 2-Stage Hydrocracked base fluid be used in the DX ammonia compression system design. 2-Stage Hydrocracked mineral oil manufactured by CPI (“CPI-1009-68”) is recommended for application in reciprocating and screw type ammonia compressors for temperatures above -40.

Another factor affecting oil vapor pressure is the oil temperature. The higher the oil temperature, the higher the vapor pressure. Reducing the discharge gas (and oil vapor)

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temperature before it enters the separator will therefore reduce overall oil carryover and increase the efficiency of the separator. For example, desuperheating the discharge gas from 80 deg C to 35 deg C reduces the oil vapor pressure, and therefore carryover of oil vapor, by approximately 85% (Wiencke 2012).

Oil Separator;

For successful DX ammonia system operation, an oil separator with coalescing elements capable of guaranteeing 5-7 ppm carryover should be specified and installed.

For reasons mentioned above, it is also recommended that the discharge gas be desuperheated as much as practical prior to entering the oil separator.

NOTE: "Mesh Pad" oil separators as found on older screw compressor packages and reciprocating compressors will not have the required separation efficiency and are not recommended!

Oil capture and management at the outlet of the condenser;

As mentioned above, reducing the temperature of the discharge gas down to the saturated condensing temperature (i.e. fully desuperheating) significantly reduces the vapor pressure of the oil in the discharge gas. This reduction of the oil vapor pressure increases the amount of oil available for capture.

Consequently, most of the oil vapor which has escaped the oil separator vessel will be condensed and held in the liquid ammonia leaving the condenser. It is possible to design the high pressure receiver to collect and separate this oil, now in the liquid phase, and then automatically return it automatically to the compressors. It is also desirable to take the "de-oiled" ammonia vapor from the top of the high pressure receiver rather than using oil-laden discharge gas for hot gas defrost. These features are shown in Figures A1 thru A3 in the appendix.

Oil capture in the suction accumulator(s);

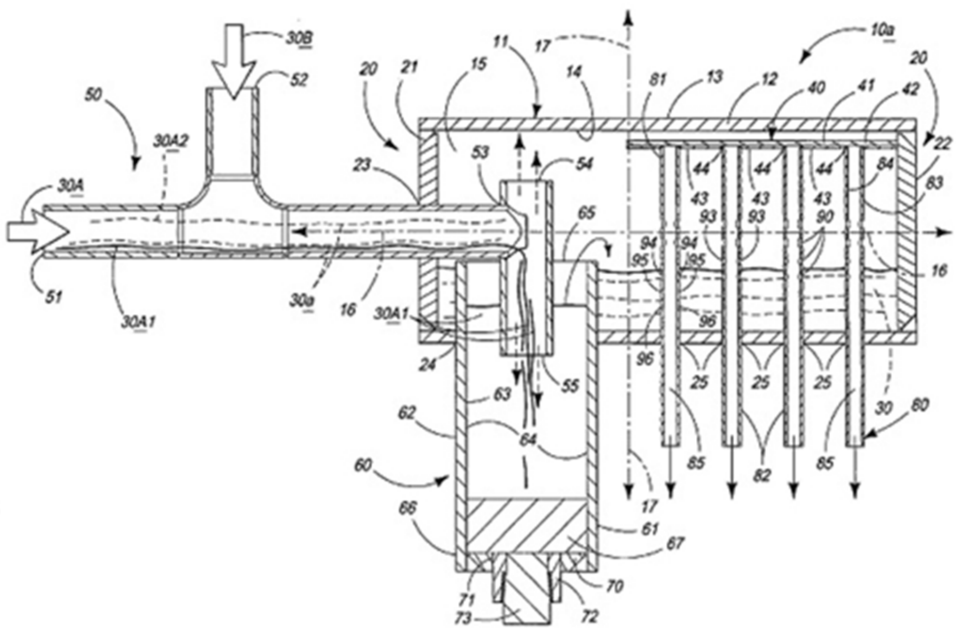
Properly designed suction accumulators should include accompanying oil pots to collect and remove any small amount of oil that has made it as far as the evaporators. See Figures A1 thru A3 in the appendix.

Oil Capture at the Evaporator:

As explained above, it is important to prevent fouling of evaporator tubes with oil particularly at low temperatures. To this end, Colmac has developed a proprietary DX ammonia distributor which effectively separates any oil which has escaped the oil separator and high pressure receiver and prevents it from entering the evaporator. The Colmac Tank Distributor (patented) incorporates a drop leg into the body of the distributor tank which serves to collect oil and debris where it can be periodically drained and removed from the system at the evaporator.

Figure 19 below shows a cross section of the Colmac Tank Distributor with its integral drop leg feature for capturing and removing oil.

FIGURE 19
COLMAC TANK DISTRIBUTOR (CROSS SECTION)



Unlike conventional orifice plate type distributors, the Colmac Tank Distributor operates with very low pressure drop and is well suited to the following applications:

- DX ammonia utilizing motorized expansion valves
- Floating head pressure systems
- Evaporators designed for operation with more than one refrigerant

XIII. Estimating DX Evaporator Refrigerant Charge Inventory

In order to properly size the volume of the system vessels (high pressure receiver and low pressure accumulator), an estimate of the refrigerant charge held in the evaporators must be made. Designers normally calculate the evaporator charge as a percentage of the evaporator internal volume times the liquid density of ammonia.

One of the main advantages of DX operation is the significantly reduced evaporator ammonia charge compared to pumped ammonia. Many system designers estimate evaporator charge for bottom feed pumped ammonia evaporators to be as much as 80% of the internal volume times the liquid density to account for low load and idle conditions. DX ammonia evaporator charge can be estimated using two phase void fraction equations. Table 11 below shows DX ammonia evaporator charge as a percentage of internal volume.

TABLE 11
COLMAC DX AMMONIA CHARGE INVENTORY

Suction Pressure, psia (Saturation Temp, F)	Colmac DX Ammonia Evaporator Charge Inventory, lbs/ft3 of Internal Volume
48.2 (+20 F)	1.01
30.4 (0 F)	0.83
18.3 (-20 F)	0.63
10.4 (-40 F)	0.52

This significantly reduced system charge not only reduces the required size of the receiver (and/or other system vessels), it also greatly reduces pump out time for the evaporators prior to defrosting. This serves to shorten total defrost time and increase the effectiveness of hot gas defrosting, reducing energy consumption and operating costs.

EXAMPLE:
A Colmac DX ammonia evaporator operating at a suction temperature of -20 deg F has an internal volume of 12 ft3. What is the expected DX ammonia operating charge? What would the operating charge be for pumped ammonia operation using the “80%” rule?

Answer:
Colmac DX ammonia charge = 12 ft3 x 0.63 = 7.6 lbs
Pumped ammonia charge = 12 ft3 x 0.8 x 42.2 lbs/ft3 = 405 lbs

XIV. DX Sequence of Operations

Following are important sequence of operations steps specific to DX ammonia systems. Other general system startup procedures should comply with safe, best practice, and with established standard operating procedures.

- Startup:
  - Run with defrost condensate-to-suction return valves open (close the condensate-to-liquid line return valves) at each evaporator. This puts all defrost condensate into suction accumulators and actively flushes evaporators and the internal tube wicking structure with pure ammonia. Sends all water-laden ammonia to low pressure suction accumulator.
  - Actively run the water still and remove distilled aqua ammonia solution when the still temperature reaches 110 deg F. Continue to operate the still until the system is completely dried out (still temperature never comes up to 110 deg F).
- After startup and pull down stages, after the system ammonia change is completely dried out:

- Close the condensate-to-suction return valves and open condensate-to-liquid line return valves on each evaporator.
- Disconnect power to the ammonia still.

XV. Colmac Smart Hot Gas Defrost

The energy efficiency of hot gas defrosting evaporators depends on the following (Nelson 2011(1)):

1. Minimizing convective heat loss.
    - Use lowest practical defrost regulator setting. 75 to 90 psig (50 to 60F) should be adequate. Note: If higher pressures are needed, look for problems elsewhere.
2. Shorten defrost duration.
    - Use top feed or DX (direct expansion) evaporator feed to reduce time required for pump out.
    - Open the hot gas solenoid only long enough to clear coil (6-8 minutes).
    - Install a separate hot gas solenoid and defrost regulator for pre and post-heating of the pan loop. Alternately, install electric resistance drainpan heating.
3. Reduce the number of defrosts per day.
    - Reduce the number of defrosts per day to match the frost load.
    - Choose evaporators with wide fin spacing (3 fpi instead of 4 fpi) to maximize frost carrying capacity.
    - Mitigate infiltration of humid air into the refrigerated space by:
        - Proper design and operation of doorways, and
        - Keep loading docks at the lowest practical dewpoint temperature.

Calculating the Cost of Defrost

As mentioned above defrost efficiency can be significantly improved by reducing the amount of energy lost to the room by convection during defrost. The operating cost savings due to a reduction in defrost duration has been calculated and presented below based on:

1. Reducing defrost duration from 30 minutes to 10 minutes, and
2. Increasing frost thickness from 1mm to 2mm (reducing the number of defrosts per day by half).

The calculations assume:

- Evaporator capacity: 100 TR
- Compressor runtime: 16 h/day
- Cost of Electricity: $0.10/kWh

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Table 12 shows calculated cost savings for four different room temperatures.

TABLE 12

CALCULATED COST SAVINGS ($/y/100 TR) FOR OPTIMIZED VS CONVENTIONAL DEFROST

	Room Temp, C (F)			
	0 (+32)	**-18 (0)**	**-23 (-10)**	**-34 (-30)**
SHR	0.66	0.89	0.93	0.97
System COP:	3.2	2.5	2.2	2
Frost Removed, kg/day:	2,778	899	572	245
Frost Removed, kg/y:	1,014,096	328,090	208,784	89,479
I. Baseline (30 min, 1 mm)				
Defrost Efficiency, %	32%	18%	17%	14%
Defrost Convective Losses, %:	46%	61%	63%	65%
Defrost Convective Losses, kWh/y:	1,012,438	753,334	545,922	283,071
Baseline Cost of Defrost (Convective), $/y:	**$31,639**	**$30,133**	**$24,815**	**$14,154**
II. Optimized (10 min, 2 mm)				
Defrost Efficiency, %	61%	46%	43%	40%
Defrost Convective Losses, %:	15%	26%	27%	30%
Defrost Convective Losses, kWh/y:	168,740	125,556	90,987	47,178
Optimized Cost of Defrost (Convective), $/y:	**$5,273**	**$5,022**	**$4,136**	**$2,359**
Savings Optimized vs Baseline, $/y:	**$26,366**	**$25,111**	**$20,679**	**$11,795**

Conventional ammonia evaporators are typically arranged for bottom feed with the hot gas pan loop piped in series with the coil. The Colmac Smart Hot Gas Defrost system (Nelson 2011(2)) results in the highest possible defrost efficiency and lowest operating cost by utilizing top feed DX circuiting with the hot gas pan loop piped separately from the coil. This results in:

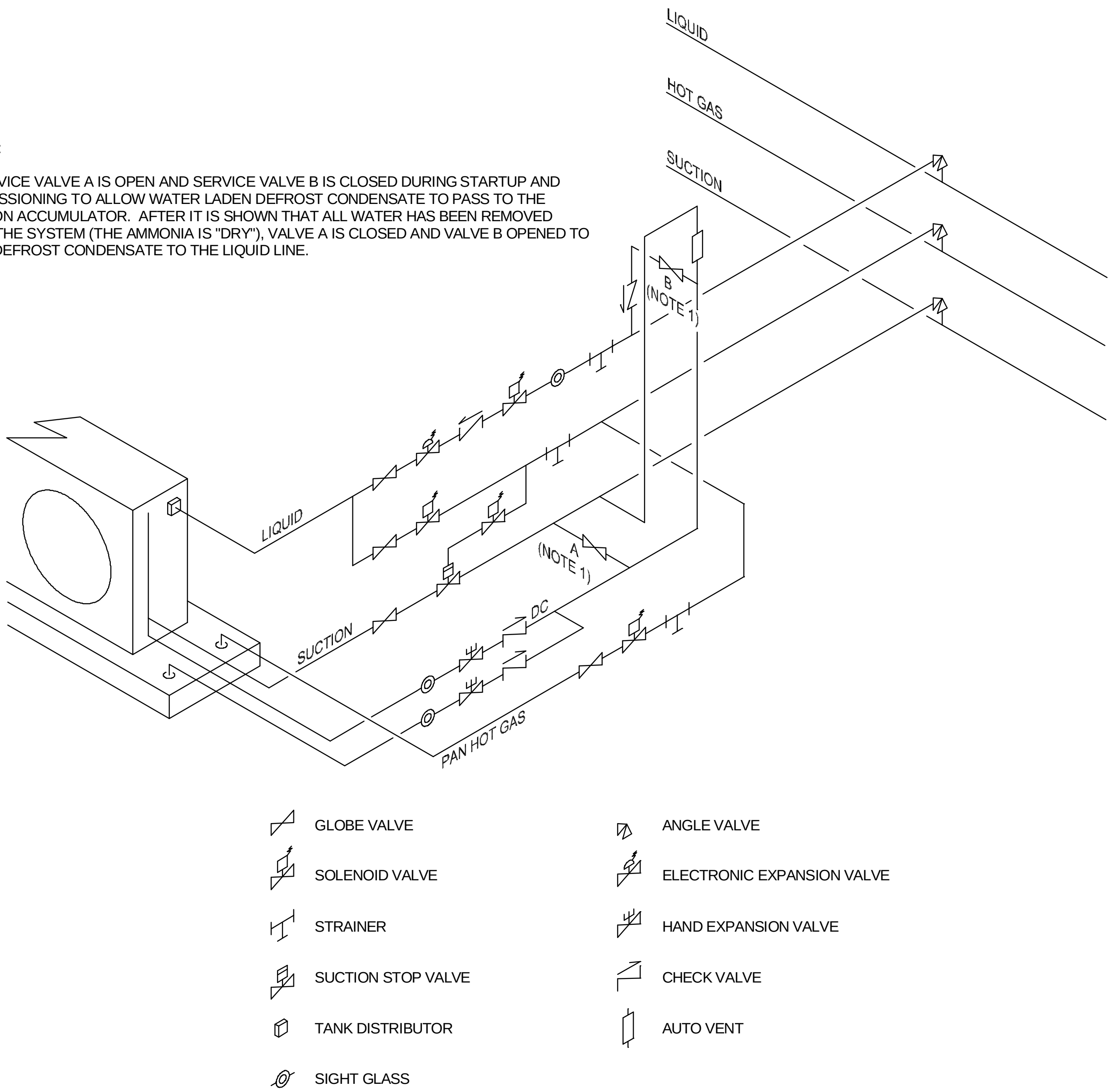
- Shorter pump out period
- Defrost duration (time coil hot gas solenoid is open) of only 6-8 minutes

A typical Colmac Smart Hot Gas Defrost control valve group is shown in Figure 20 below.

FIGURE 20
COLMAC DX SMART HOT GAS DEFROST CONTROL VALVE GROUP
HIGH PRESSURE LIQUID (HPL) FEED

NOTES:

1. SERVICE VALVE A IS OPEN AND SERVICE VALVE B IS CLOSED DURING STARTUP AND COMMISSIONING TO ALLOW WATER LADEN DEFROST CONDENSATE TO PASS TO THE SUCTION ACCUMULATOR. AFTER IT IS SHOWN THAT ALL WATER HAS BEEN REMOVED FROM THE SYSTEM (THE AMMONIA IS "DRY"), VALVE A IS CLOSED AND VALVE B OPENED TO SEND DEFROST CONDENSATE TO THE LIQUID LINE.



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With a conventional bottom feed and hot gas defrost piping arrangement, hot gas is first sent through the drainpan loop and then in series through the coil block. This commonly used arrangement is effective and simple, however, it requires that the hot gas solenoid remains open to keep the drainpan heated long enough for all water to completely drain and exit through the drain piping. Convective heat loss to the room continues after the coil is clear of frost while the pan is draining.

A more efficient arrangement is to control hot gas to the coil block and to the drainpan loop separately through two separately timed hot gas solenoid valves. This arrangement shortens the amount of time hot gas is flowing through the coil block, minimizing the convective heat loss and maximizing defrost efficiency.

A properly sized control valve group for the Colmac Smart Hot Gas Defrost piping arrangement is less expensive than a conventional bottom feed hot gas defrost piping arrangement with defrost regulator.

Colmac DX Smart Hot Gas Defrost Sequence of Operation

1. Defrost is initiated.
2. Liquid Line Solenoid (LLS) closes
3. Pump out period (15 – 20 minutes)
4. Fan(s) stop
5. Pan loop solenoid energized for timed pan preheat (2-3 minutes)
6. Coil hot gas solenoid and pilot solenoid (closes suction stop valve) open
7. Timed defrost (6-8 minutes)
8. Coil hot gas solenoid closes
9. After coil pressure is equalized to suction pressure (3-5 minutes), Suction Stop Valve opens
10. Open LLS
11. Pan loop solenoid de-energized
12. After 5 minute cool down delay fans restart

Diversity and Defrost Timing

As with all hot gas defrost systems, the "two to one" rule must be observed in the execution of defrosts. That is, a minimum of two evaporators in the same temperature zone must be running (liquid line solenoids open) at the same time one evaporator is defrosting. This strategy is needed to provide enough load to balance evaporating to condensing (defrosting) capacity in the refrigeration system.

Hot Gas Flowrate and Valve Selection

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Colmac provides to its representatives and selected customers a calculation tool for estimating hot gas flow rate given operating temperatures and evaporator dimensional data.

The complete Colmac DX Smart Hot Gas Defrost evaporator control valve is also offered from Colmac as a kit or factory mounted on the evaporator.

XVI. Defrost Water Volume and Drain Line Sizing

Following is a simple method to calculate the amount of moisture removed by the air coolers from air in the refrigerated spaces in order to determine:

A) Total sewerage requirements for the facility, and
B) Proper drain piping sizes to handle peak flowrates during defrost.

This section will present two simple calculation methods for determining these important design parameters (Nelson 2008).

Determining Total Volume of Moisture Removed:

In order to estimate the volume of water generated from defrosting (or wet fin) air coolers, the hours per day the cooler(s) operate along with the Sensible Heat Ratio (SHR) must be known. Assuming a room relative humidity of 90%, the SHR for an air cooler operating at various temperatures will be as shown in Table 13 below:

Table 13
SHR for 90%rh Air at Various Temperatures

Room Temp, F	Air SHR
45	0.59
32	0.70
10	0.85
-10	0.93
-30	0.98

The amount of moisture accumulated on the surfaces of the air cooler(s) that will be drained as condensed water in high temp rooms or as melted frost in medium and low temp rooms, can be estimated using the following formula:

$$Gal/day = 1.35t(1 - SHR)Q \quad (9)$$

where:
t = Operating Time, hours/day
SHR = Air Sensible Heat Ratio
Q = System Cooling Capacity, tons (note: 1 ton = 12,000 Btuh)
1.35 (constant) = 12,000 Btuh/ton / (8.33 lbs/gal x 1,068 Btu/lbs)

8.33 lbs/gal = liquid density of water
1,068 Btu/lbs = latent heat of vaporization of water

Example 1:
Room Temp: 45F
Operating Time: 12 hours/day
Room SHR (from Table 1): 0.59
System Cooling Capacity: 50 tons
Condensed Water Volume = 1.35 x 12 x (1-.59) x 50 = 332 gal/day

Example 2:
Room Temp: -10F
Operating Time: 16 hours/day
Room SHR (from Table 1): 0.93
System Cooling Capacity: 100 tons
Defrost Water Volume = 1.35 x 16 x (1 - 0.93) x 100 = 151 gal/day

Determining Peak Defrost Water Flowrate

To determine the peak defrost water flowrate leaving a frosted coil surface, first calculate the volume of water yielded by a cooling coil during defrost using the following equation:

$$V_{def} = 0.0937 \times A_{surf} \times \left[\frac{\left(\frac{1}{S_{fin}} - t_{fin} \right)}{2} \right] \times \varepsilon \qquad (10)$$

where:
V_{def} = *Volume of Defrost Water, gallons*
A_{surf} = *Total Frosted Surface Area, sq ft*
S_{fin} = *Fin Spacing, fins per inch*
t_{fin} = *Fin Thickness, inches*
ε = *Fraction of Frost Blockage (50% = 0.5)*

Note: This equation assumes frost has average density of 150 kg/m3 (Besant 1999), approx. 1/6th that of liquid water.

Example 1:
Total Surface Area = 4,500 sq ft
Fin Spacing = 4 fins per inch

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Fin Thickness = 0.012 inches
Fraction of Frost Blockage = 0.5
Volume of Defrost Water = 0.0937 x 4,500 x (1/4-0.012)/2 x 0.5 = 25 gallons

In order to then determine the peak flowrate, an estimate of the length of defrost time must be made. For hot gas defrosting, the majority of defrost water flows to the drain in a relatively short period of time. To estimate peak flow rate of defrost water an estimated duration of defrost of 5 minutes can reasonably be made (Stoecker 1983).

To calculate peak flowrate, simply divide the volume of defrost water by the estimated duration of defrost. For the example:

Estimated peak defrost flowrate = 25 gal/ 5 min = 5 gpm

Drain lines can now be sized based on the calculated peak defrost flowrate. The maximum peak flowrate for a facility will be the combined flowrates for the maximum number of cooling coils expected to defrost simultaneously.

Colmac provides to its representatives and selected customers a calculation tool for estimating defrost flow rate given operating temperatures and evaporator dimensional data.

Sizing Sloping Drain Lines

The American Society of Plumbing Engineers (ASPE) publishes sizing methods for vertical and sloping drains (ASPE 1999). The following table is taken from the ASPE Data Book Volume 2, page 8.

Table 14
Approximate Discharge Rates and Velocities in Sloping Drains, n = 0.015*

Actual Inside Diameter of Pipe, inches	½-Full Flow Discharge Rate and Velocity Based on ¼ inch/ft Slope	
	Discharge, gpm	Velocity, fps
1 3/8	3.13	1.34
1 ½	3.91	1.42
1 5/8	4.81	1.50
2	8.42	1.72
2 ½	15.3	1.99
3	24.8	2.25
4	53.4	2.73
5	96.6	3.16
6	157	3.57
8	340	4.34
10	616	5.04
12	999	5.67

* n = Manning coefficient, which varies with the roughness of the pipe.

Horizontal drain lines must be pitched at least ¼" per foot to insure positive drainage.

Drain lines running through freezing spaces should be actively heated with heat trace cable and then well insulated.

Drain lines should also have p-traps installed just outside the refrigerated space to prevent back flow of warm humid ambient air through the drain line into the refrigerated space.

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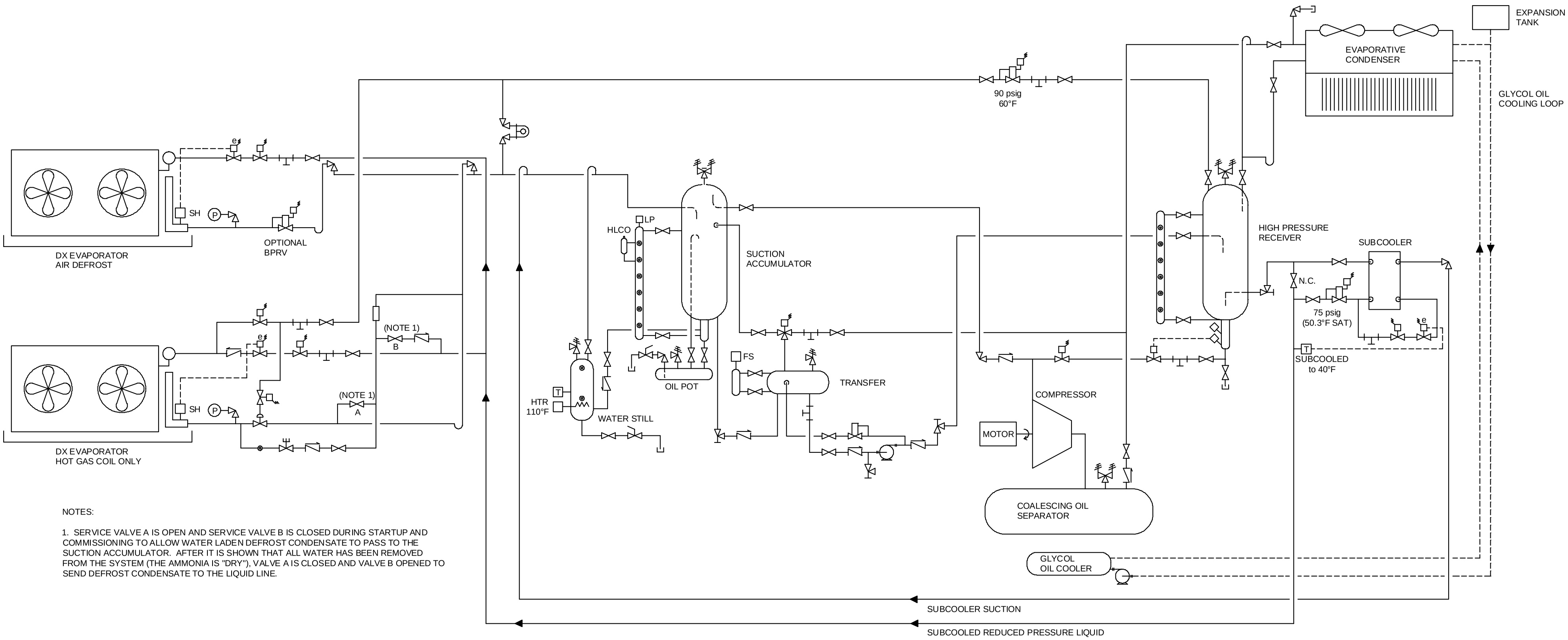
XVIII. APPENDIX A

Three P&ID diagrams are shown representing:

Figure A1 - Single Stage Single Temperature Level
Figure A2 - Single Stage (Economized Screw) Multiple Temperature Level
Figure A3 - Two Stage Multiple Temperature Level

FIGURE A1
COLMAC DX AMMONIA
SINGLE STAGE SINGLE TEMPERATURE LEVEL



NOTES:

1. SERVICE VALVE A IS OPEN AND SERVICE VALVE B IS CLOSED DURING STARTUP AND COMMISSIONING TO ALLOW WATER LADEN DEFROST CONDENSATE TO PASS TO THE SUCTION ACCUMULATOR. AFTER IT IS SHOWN THAT ALL WATER HAS BEEN REMOVED FROM THE SYSTEM (THE AMMONIA IS "DRY"), VALVE A IS CLOSED AND VALVE B OPENED TO SEND DEFROST CONDENSATE TO THE LIQUID LINE.

SOLENOID VALVE	ELECTRONIC EXPANSION VALVE	PRV W/ ELECTRIC SHUT OFF
DRAIN VALVE	3-WAY VALVE	HAND EXPANSION VALVE
RELIEF VALVE	GLOBE VALVE	ANGLE VALVE
AUTO VENT	CHECK VALVE	STRAINER
PUMP	TANK DISTRIBUTOR	DOUBLE ACTING RELIEF VALVE
PRESSURE GAUGE	SIGHT GLASS	LP LEVEL PROBE
SH SUPERHEAT TRANSDUCER	T TEMPERATURE TRANSDUCER	PRV
OIL LEVEL SENSOR		

FIGURE A2
COLMAC DX AMMONIA
SINGLE STAGE (ECONOMIZED SCREW) MULTIPLE TEMPERATURE LEVEL

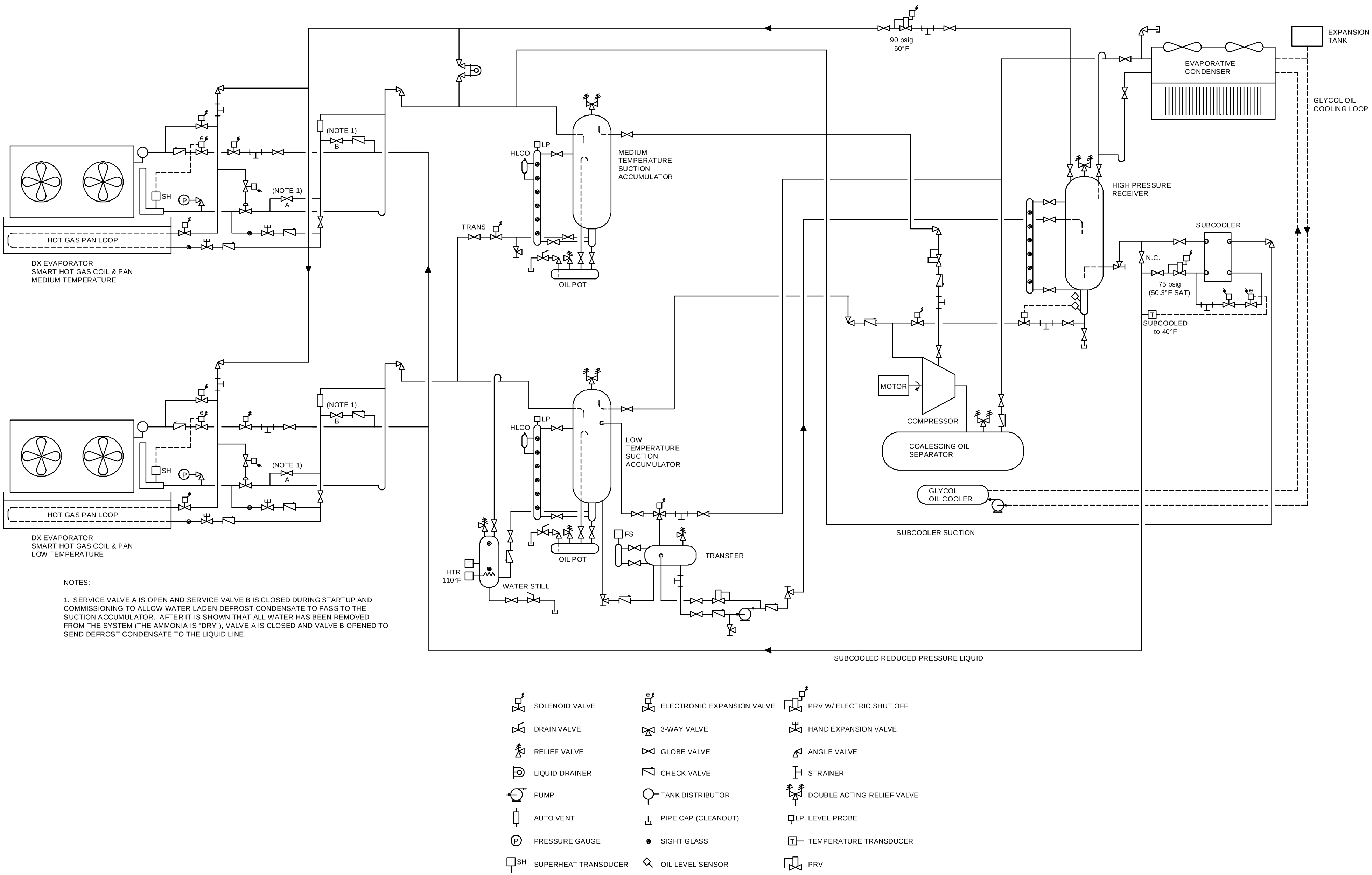


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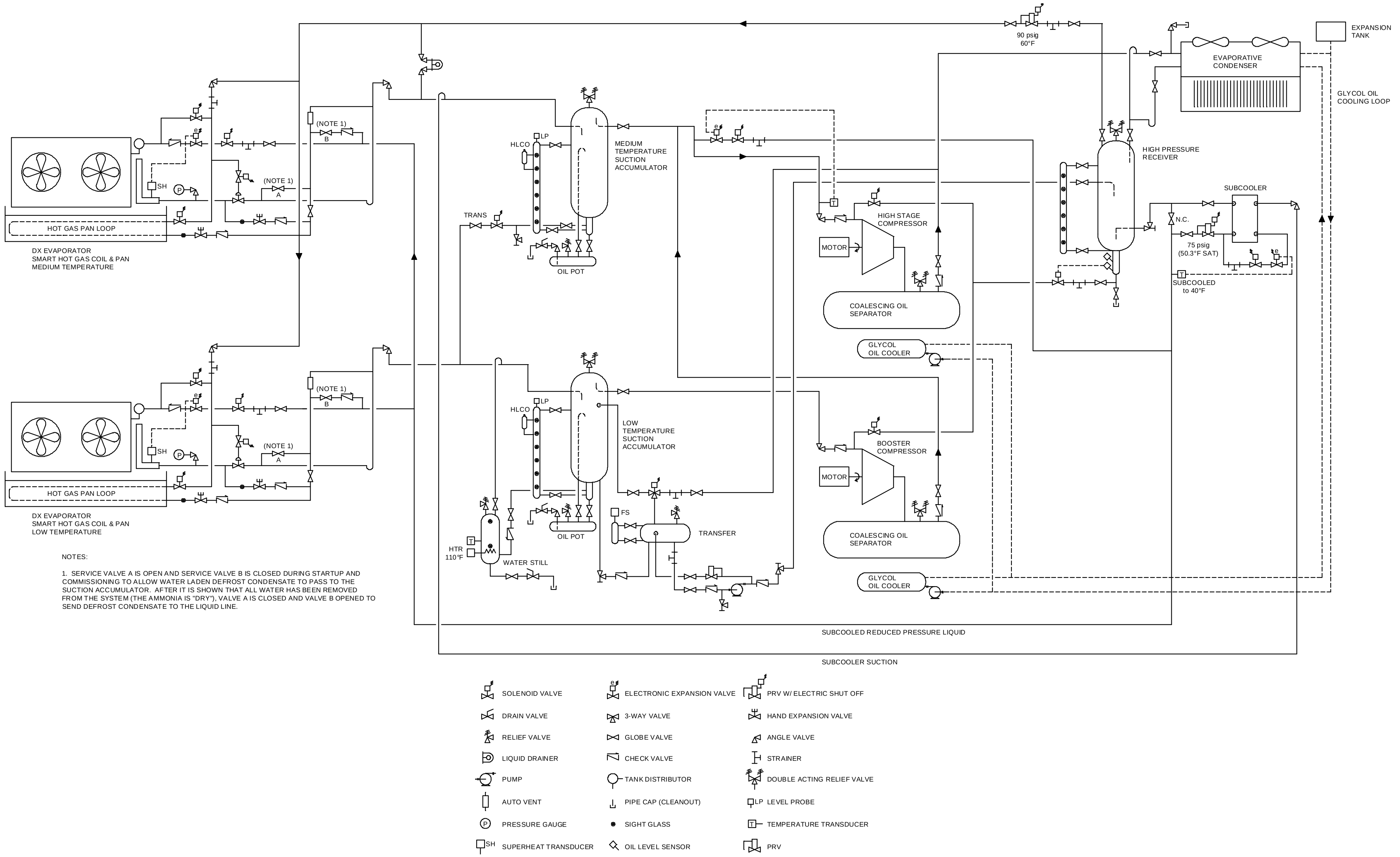
FIGURE A3
COLMAC DX AMMONIA
TWO STAGE MULTIPLE TEMPERATURE LEVEL



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Technical Bulletin

By Bruce I. Nelson, P.E., President, Colmac Coil Manufacturing, Inc.

CO2 Evaporator Design

INTRODUCTION

The process of selecting air cooling evaporators to operate in a CO2 refrigeration system is very similar to selecting evaporators for ammonia. Evaporator manufacturers typically require the same input data for both refrigerants and likewise display performance and selection data in the same way.

Typically, the following inputs are required for properly selecting either CO2 or ammonia evaporators:

a. Elevation
b. Return air (‘Air on’) temperature
c. Return air relative humidity
d. Evaporating temperature
e. Type of feed
f. Overfeed rate (if pumped feed)
g. Liquid pressure and temperature at the expansion valve (if DX)
h. Required cooling duty
i. Type of defrost
j. Supply voltage
k. Materials of construction
l. Required MAWP (Maximum Allowable Working Pressure)

Other inputs may include:

m. Maximum allowable air velocity
n. Minimum air flow rate
o. Maximum allowable fan speed
p. Maximum allowable sound pressure (usually in dB(A))
q. Minimum air throw distance
r. Minimum number of fans
s. Dimensional constraints (maximum height or length limitations)

Output data typically includes:

t. Actual cooling duty
u. Air flow rate and air velocity
v. Leaving air temperature
w. Leaving air relative humidity
x. Sound pressure level
y. Air throw distance
z. Dimensional characteristics
    i. Cabinet H x W x L
    ii. Weights
    iii. Internal volume
aa. Electrical characteristics
    i. Number of fans/motors
    ii. Fan speed
    iii. Fan motor brake power
    iv. Full load amperage and/or power consumption

To the uninitiated, the above may imply that CO_2 evaporators and ammonia evaporators are interchangeable and essentially the same animal. While they are similar in that both have tubes, fins, and fans, CO_2 evaporators are very different in a number of respects which are important for refrigeration designers and operating engineers to understand. Highlighting and quantifying these differences is the subject of this handbook chapter.

GENERAL

Most commonly used feed methods for CO_2 are:

- Pumped liquid
- Direct expansion

While gravity flooded feed is very effective with ammonia, it is not commonly used with CO_2 due to:

1. The higher density of CO_2 liquid compared to ammonia. This higher density results in elevated evaporating temperatures in the evaporator due to liquid head in the surge drum and drop leg.
2. The higher pressure rating required for the surge drum.
3. Poor performance due to necessarily low pressure drop (equal to the available head of liquid in the surge drum drop leg). This reduces allowable mass flux and results in low boiling heat transfer coefficients.

Most ammonia evaporators are defrosted by air, water, or hot gas. Electric defrost is not commonly used due to the flammability characteristics of ammonia. This because electric defrost elements typically have high surface temperatures and are necessarily placed in close proximity to coil tubes.

CO_2, on the other hand, is commonly defrosted by air, water, and electric resistance heating. However, hot gas defrosting is uncommon because of the high gas pressures required. Electric defrost is very effective and is widely used with CO_2 due to its simplicity and low first cost.

As explained above there are many similarities in evaporator rating methods and construction, however, the very different thermodynamic and chemical characteristics of CO_2 compared to ammonia require special attention with regard to:

- Material Compatibility. Unlike ammonia, CO_2 can be used safely with copper and copper-bearing alloys. Actually, dry CO_2 is quite inert and can be used with all commonly used base metals; copper, carbon steel, stainless steel, and aluminum. Care must be taken to select materials with sufficient strength to withstand the higher MAWP required for CO_2. This normally rules out the use of aluminum with CO_2.
- Pressure. CO_2 pressures are much higher than ammonia.
- Heat Transfer. Thermodynamic and transport properties are very different for CO_2 compared to ammonia and result in very different evaporator circuiting arrangements to achieve equivalent cooling capacity.

MATERIAL COMPATIBILITY

For many years, ammonia evaporators were made of carbon steel tubes and fins hot dip galvanized after fabrication. While this type of construction is corrosion resistant and has sufficient strength to perform well in most ammonia refrigeration systems, carbon steel is not an ideal material to use with carbon dioxide for two reasons:

1. Tubeside Corrosion. If there is any residual water present in the piping or vessels of a carbon dioxide system on startup, it can combine with the carbon dioxide to form carbonic acid. Carbon steel is susceptible to corrosion when exposed to even mildly acidic solutions.
2. Embrittlement at Low Temperatures. Carbon steel is known to become brittle at temperatures below about -20 deg F. Even though the strength of the metal increases as the temperature is reduced, even low carbon steel will become embrittled and prone to fracture when subjected to impact loading. One of the advantages of CO_2 is the improved cycle efficiency (reduced power consumption) at very low (blast freezing) temperatures. Low temperature operation with carbon steel evaporators is problematic for this reason and not recommended.

Aluminum is an excellent metal to use in evaporators for several reasons (Nelson 2012) and so is in wide use in industrial ammonia refrigeration systems. While the yield and tensile strength of this metal are sufficient to easily handle ammonia pressures, they are generally not high enough to achieve the higher design pressures needed for carbon dioxide. Aluminum is therefore not recommended for use with carbon dioxide.

Copper, unlike carbon steel, does not suffer embrittlement at low temperatures. It resists corrosion when exposed to mild acids and so can stand exposure to low concentrations of carbonic acid. Because of the possibility of exposure of the brazed joints to carbonic acid, it is highly recommended that copper tube evaporators be brazed using a non-phosphorous bearing alloy filler metal. The yield and tensile strengths of copper are high enough to reach required design pressures for freezer temperatures, but in rooms above about 0 deg F the required design pressures become higher than can be practically achieved with copper tubes. Therefore, copper tube construction is considered appropriate for carbon dioxide evaporators installed in rooms 0 deg F and colder.

Stainless steel is an ideal tube material for use in carbon dioxide evaporators because of its high yield and tensile strength and corrosion resistance. Also, like aluminum and copper, stainless steel is not susceptible to embrittlement even at extremely low (cryogenic) temperatures.

Conclusions: Material Compatibility

- Both copper and stainless steel tubing and pipe are recommended for use in CO2 evaporators provided the diameters and wall thicknesses meet the required design pressures.
- When using copper, a non-phosphorous bearing brazing alloy is recommended. This is needed to limit the risk of leaks caused by acidic conditions resulting from the presence of carbonic acid.
- Carbon steel is not recommended for use in CO2 evaporators due to a) susceptibility to corrosion in the presence of carbonic acid, and b) embrittlement at low temperatures (lower than -20 deg F).
- Aluminum is not recommended for use in CO2 evaporators due to its lower yield and tensile strength characteristics.

PRESSURE

Table 1 below compares the saturation pressures for CO2 and ammonia and illustrates the significantly higher pressures (and consequently higher strength requirements) for CO2.

TABLE 1					
Saturation Pressure vs Temperature					
CO2 vs Ammonia					
		Ammonia		CO2	
Temperature		Pressure		Pressure	
deg F	deg C	psia	bar	psia	bar
-60	-51.1	6	0.4	95	6.5
-40	-40.0	10	0.7	146	10.0
-20	-28.9	18	1.3	215	14.8
0	-17.8	30	2.1	306	21.1
20	-6.7	48	3.3	422	29.1
40	4.4	73	5.1	568	39.1
60	15.6	108	7.4	748	51.6
80	26.7	153	10.6	970	66.8

ASHRAE Standard 15 “Safety Standard for Refrigeration Systems”, sets the minimum design pressure for evaporators in Section 9.2.1. This section of the standard also refers to the ASME Boiler and Pressure Vessel Code, Section VIII, as the appropriate method of determining the design (or ‘working’) pressure given evaporator dimensions and materials of construction.

Section 9.2.1 sets up design pressure criteria for various types of refrigeration systems and states that "…Design pressure for mechanical refrigeration systems shall not be less than 15 psig and, except as noted in Sections… 9.2.6, shall not be less than the saturation pressure corresponding to the following temperatures: a.) Lowsides of all systems: 80 deg F (26.7 deg C)." From Table 1, for CO2 the design pressure corresponding to 80 deg F is 969.6 psia (66.8 bar), or 955 psig.

Section 9.2.2 states "The design pressure for either the highside or lowside need not exceed the critical pressure of the refrigerant unless such pressure are anticipated during operating, standby, or shipping conditions." Critical pressure for CO2 is 1070 psia (73.8 bar), or 1055 psig.

Section 9.2.6 (9.2.1 above) describes specific exceptions when carbon dioxide is the refrigerant, as follows: "When a refrigerating system utilizes carbon dioxide (R744) as a heat transfer fluid, the minimum design pressure for system components shall comply with the following.

> 9.2.6.1 In a circuit without a compressor, the design pressure shall be at least 20% higher than the saturation pressure corresponding to the warmest location in the circuit.
>
> 9.2.6.2 In a cascade refrigerating system, the highside design pressure shall be at least 20% higher than the maximum pressure developed by a pressure-imposing element, and the lowside pressure shall be at least 20% higher than the saturation pressure corresponding to the warmest location in the circuit."

The intent (as understood by the author) of the phrase "warmest location in the circuit" is to mean the room temperature in which the evaporator(s) will operate. For example, a CO2 evaporator in a cascade refrigerating system is being designed to operate in a 0 deg F room. From Table 1 the saturation pressure corresponding to 0 deg F is 305.7 psia. Minimum required design pressure according to Section 9.2.6.2 would then be 305.7 x 1.2 = 366.8 psia = 352 psig.

Table 2 below shows the calculated minimum required design pressure for CO2 evaporators according to Section 9.2.6.

TABLE 2

Minimum Design Pressure vs Temperature

CO2 Evaporators

Temperature		Minimum Design Pressure		
deg F	deg C	psia	psig	bar
-60	-51.1	113	99	7.8
-40	-40.0	175	160	12.1
-20	-28.9	258	243	17.8
0	-17.8	367	352	25.3
20	-6.7	506	492	34.9
40	4.4	681	666	47.0
60	15.6	897	883	61.9
80	26.7	1070*	1055*	73.8*

* Exceeds the critical pressure of CO2 so design pressure is set equal to the critical pressure.

Knowing the required minimum design pressure from the above now allows us to determine tubing diameter and wall thickness according to the calculation method shown in the ASME Boiler and Pressure Vessel Code, Section VIII. Material properties used in the calculations are taken from ASME Section II.

Since copper and stainless steel are recommended for use in carbon dioxide evaporators (see above), Figures 1 and 2 below have been constructed to show the calculated Maximum Allowable Working Pressure (MAWP) for commonly used tube diameters over a range of wall thicknesses.

Using data from Table 2 with Figures 1 and 2 allows the required tubing wall thickness to be calculated for different tubing diameters and materials given the room temperature.

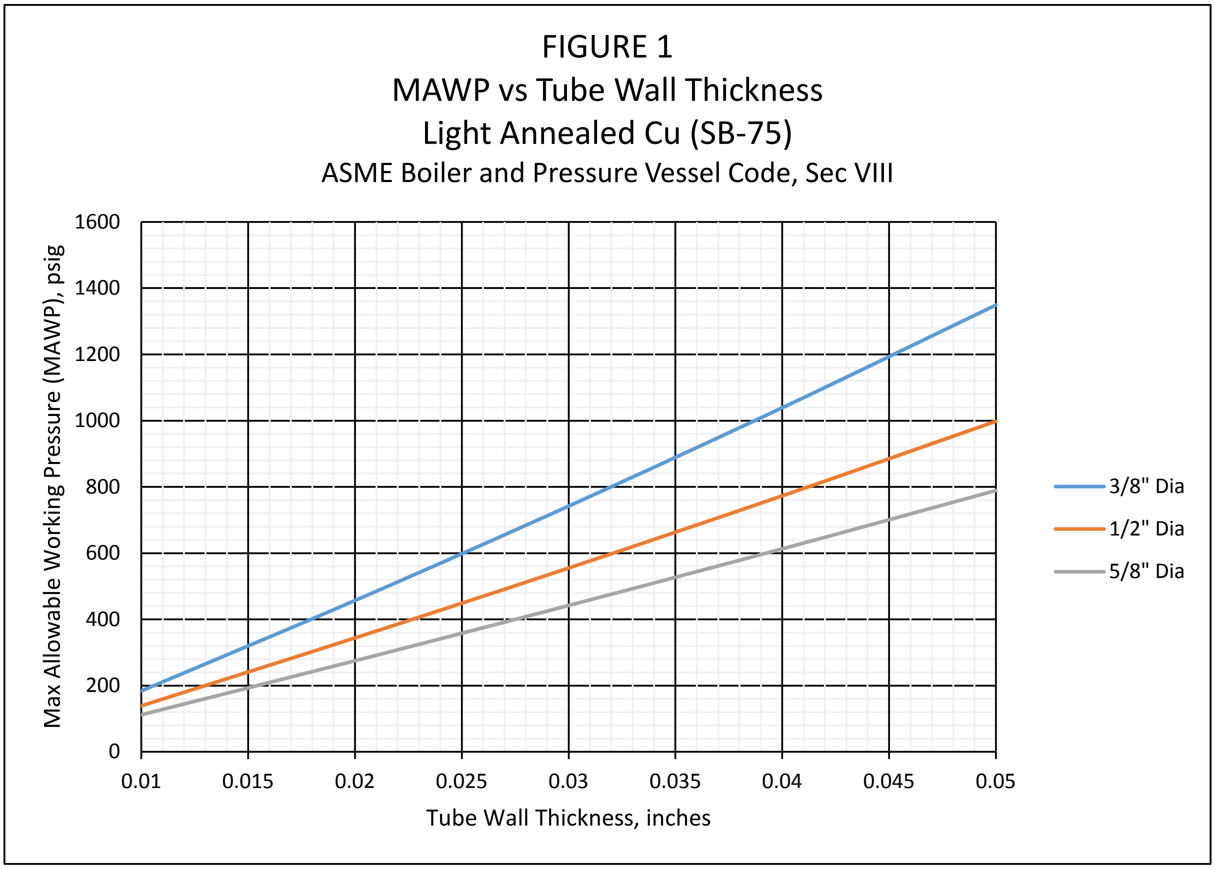


FIGURE 2
MAWP vs Tube Wall Thickness
304 SS (SA-249)
ASME Boiler and Pressure Vessel Code, Sec VIII

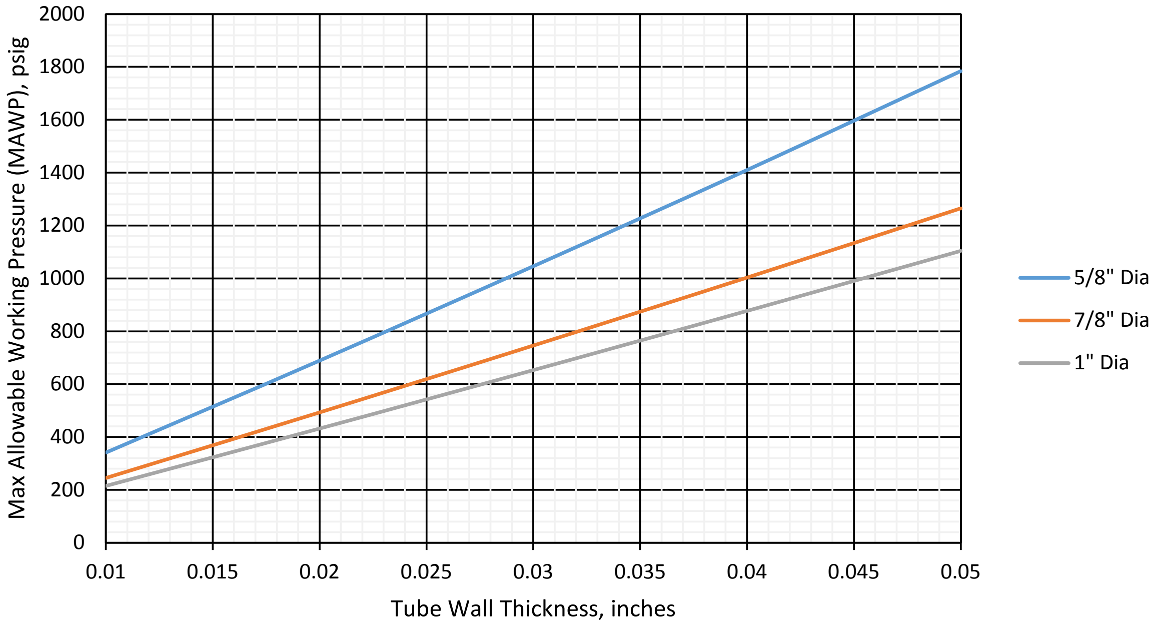


Table 3 below shows the tube wall thickness needed to meet the requirements of ASHRAE Standard 15 in a CO2 evaporator operating at various room temperatures.

TABLE 3							
Minimum Tube Wall Thickness vs Room Temperature (ASHRAE Std 15)							
CO2 Evaporators							
		Minimum Tube Wall Thickness, in					
Room Temperature		SB-75 Cu Tube Diameter			SA-249 304 SS Tube Diameter		
deg F	deg C	3/8"	1/2"	5/8"	5/8"	7/8"	1"
-60	-51.1	0.010	0.010	0.010	0.010	0.010	0.010
-40	-40.0	0.010	0.011	0.013	0.010	0.010	0.010
-20	-28.9	0.012	0.015	0.018	0.010	0.010	0.012
0	-17.8	0.016	0.020	0.025	0.011	0.015	0.017
20	-6.7	0.022	0.028	0.034	0.015	0.021	0.024
40	4.4	0.027	0.035	0.043	0.020	0.027	0.032
60	15.6	0.036	0.046	NR	0.026	0.036	0.041
80	26.7	NR	NR	NR	0.031*	0.042*	0.048*
* Critical pressure used to determine MAWP.							

Note that the minimum tube wall thicknesses shown in Table 3 are theoretical calculated values. In normal manufacturing practice, copper tubing with wall thickness less than about 0.016” is difficult to produce and to handle. With stainless steel tubing the practical minimum wall thickness is around 0.020”.

Bear in mind that Table 3 applies only to evaporator tubes, not to headers or piping connections. The evaporator manufacturer must also properly design coil headers and piping connections according to ASME Section VIII to have MAWP equal to or greater than the tubing MAWP.

While lower temperatures may allow the use of light wall tubing and relatively low design pressures during normal operation, the system designer must remember that the design pressure must be selected to accommodate all potential temperature/pressure conditions including (but not limited to):

a. Startup conditions
b. Peak load operation
c. Abnormal loads (process temperature excursions)
d. Standby conditions that occur frequently
    i. Power outages limited in time duration but which may happen with some frequency
    ii. Shutdown during cleanup

Conclusions: Pressure

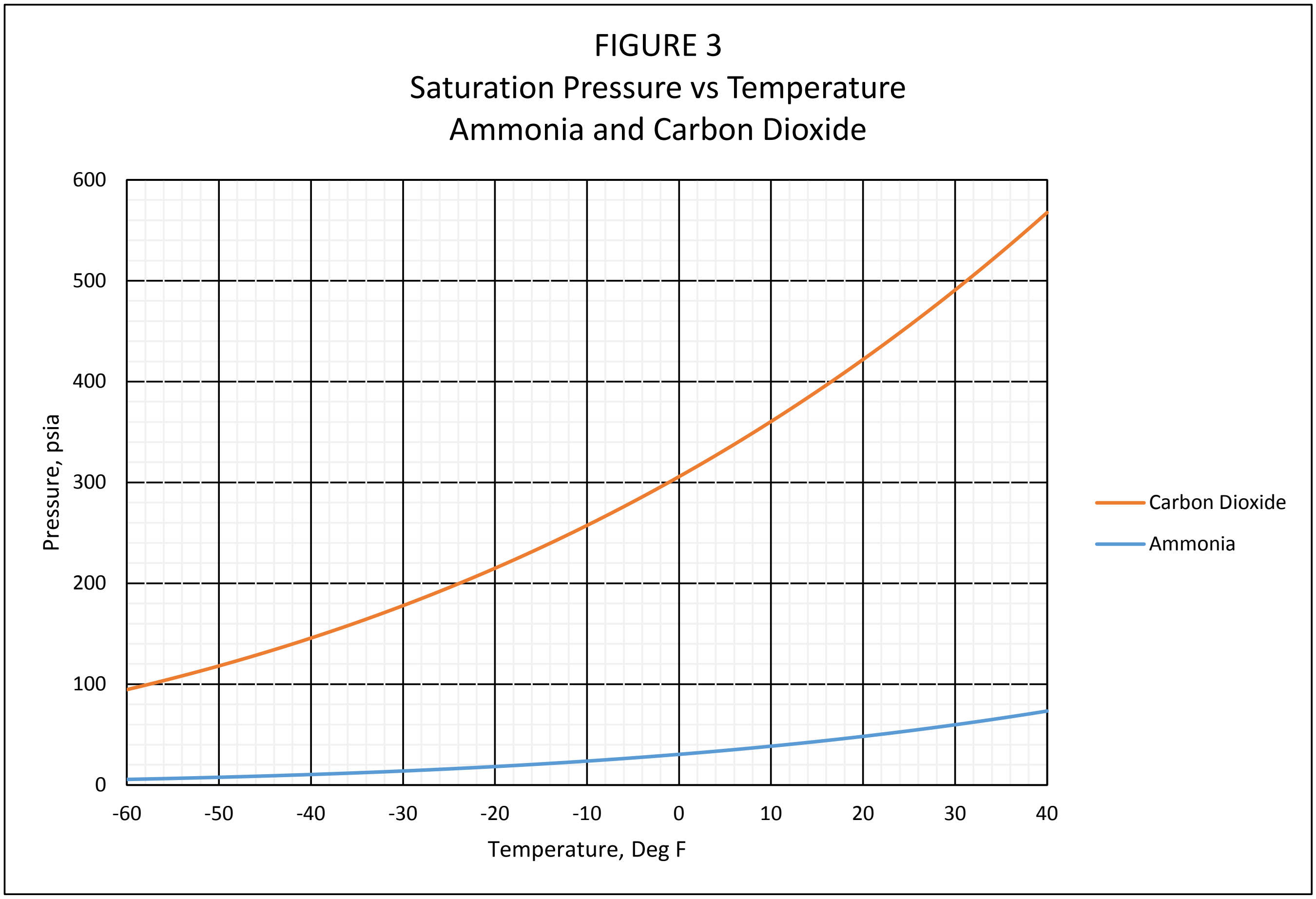
- CO_2 evaporators will operate at significantly higher pressures than ammonia for a given temperature.
- In the United States, ASHRAE Standard 15 establishes design pressure requirements for CO_2 systems.
- ASHRAE Standard 15 requires the design pressure for CO_2 evaporators to be "…at least 20% higher than the saturation pressure corresponding to the warmest location in the circuit." The "warmest location in the circuit" is interpreted as the warmest anticipated room temperature in which the evaporator(s) will operate.
- Minimum recommended tube wall thicknesses are shown in Table 3, however, the evaporator manufacturer must insure that all pressure bearing components in the coil, including headers and pipe connections, are designed correctly.
- The temperature used to establish design pressure must be carefully selected to account for conditions which include (but are not necessarily limited to) those shown below:
    a. Startup conditions
    b. Peak load operation
    c. Abnormal loads (process temperature excursions)
    d. Standby conditions that occur frequently
        i. Power outages limited in time duration but which may happen with some frequency
        ii. Shutdown during cleanup

HEAT TRANSFER

The driving potential for heat transfer in an air cooling evaporator is the mean temperature difference between the air and the boiling refrigerant. Frictional pressure drop on the tubeside of the evaporator reduces the mean temperature difference and therefore the cooling capacity of the evaporator. This coupling of fluid flow (frictional pressure drop) and heat transfer is unique to evaporators. As refrigerant mass flux increases; a) the heat transfer coefficient increases which increases cooling capacity, but b) pressure drop also increases which reduces cooling capacity. Evaporator manufacturers optimize this balance of heat transfer with pressure drop by adjusting the number of feeds and passes for a given coil geometry and operating conditions.

Boiling heat transfer in tubes has been studied for several decades with continual improvement to correlations and accuracy of the predictions. The convective boiling heat transfer coefficient is a strong function of refrigerant mass flux (also called mass velocity), viscosity, and the ratio of liquid to vapor densities. It is a weaker function of thermal conductivity and specific heat. The combination of these properties actually favor ammonia, which produces significantly higher (200% to 300%) boiling heat transfer coefficients when compared to CO_2 at the same mass flux.

The good news with CO_2 is the much steeper slope of the vapor pressure curve compared to ammonia, shown in Figure 3 below. This relatively steep slope (dP/dT) means that CO_2 evaporator circuiting can be designed for higher mass flux without the pressure drop penalty seen with ammonia. The higher design mass flux with CO_2 offsets the lower boiling heat transfer coefficient compared to ammonia and results in evaporator performance which is very nearly equivalent.



The slope of the vapor pressure curve in Figure 3 has been tabulated in Table 4 and illustrates the difference between pressure drops seen in ammonia versus CO2 evaporators. Typically evaporator manufacturers will design evaporator circuiting to limit tubeside pressure drop to a value corresponding to approximately 1.8 deg F (1.0 deg K) change in evaporating temperature. Using the slope of the vapor pressure curve (dP/dT) shown in Table 4, at -20 deg F saturated suction temperature, a 1.8 deg F change in evaporating temperature corresponds to a pressure drop of 1.8 x 0.489 = 0.88 psi for ammonia, and 1.8 x 3.973 = 7.15 psi for CO2. As explained earlier, this higher allowable pressure drop with CO2 means that evaporator circuiting can be arranged for fewer feeds and more passes (longer circuit length) compared to ammonia. Again, when designed properly by the manufacturer, similar sized evaporators will produce cooling capacity with CO2 which is equivalent to ammonia.

TABLE 4

dP/dT vs Saturation Temperature

		Ammonia		CO2	
Temperature		dP/dT		dP/dT	
deg F	deg C	psi/deg F	kPa/deg C	psi/deg F	kPa/deg C
-60	-51.1	0.184	2.3	2.157	26.8
-40	-40.0	0.309	3.8	2.980	37.0
-20	-28.9	0.489	6.1	3.973	49.3
0	-17.8	0.735	9.1	5.143	63.8
20	-6.7	1.059	13.1	6.510	80.8
40	4.4	1.470	18.2	8.100	100.5

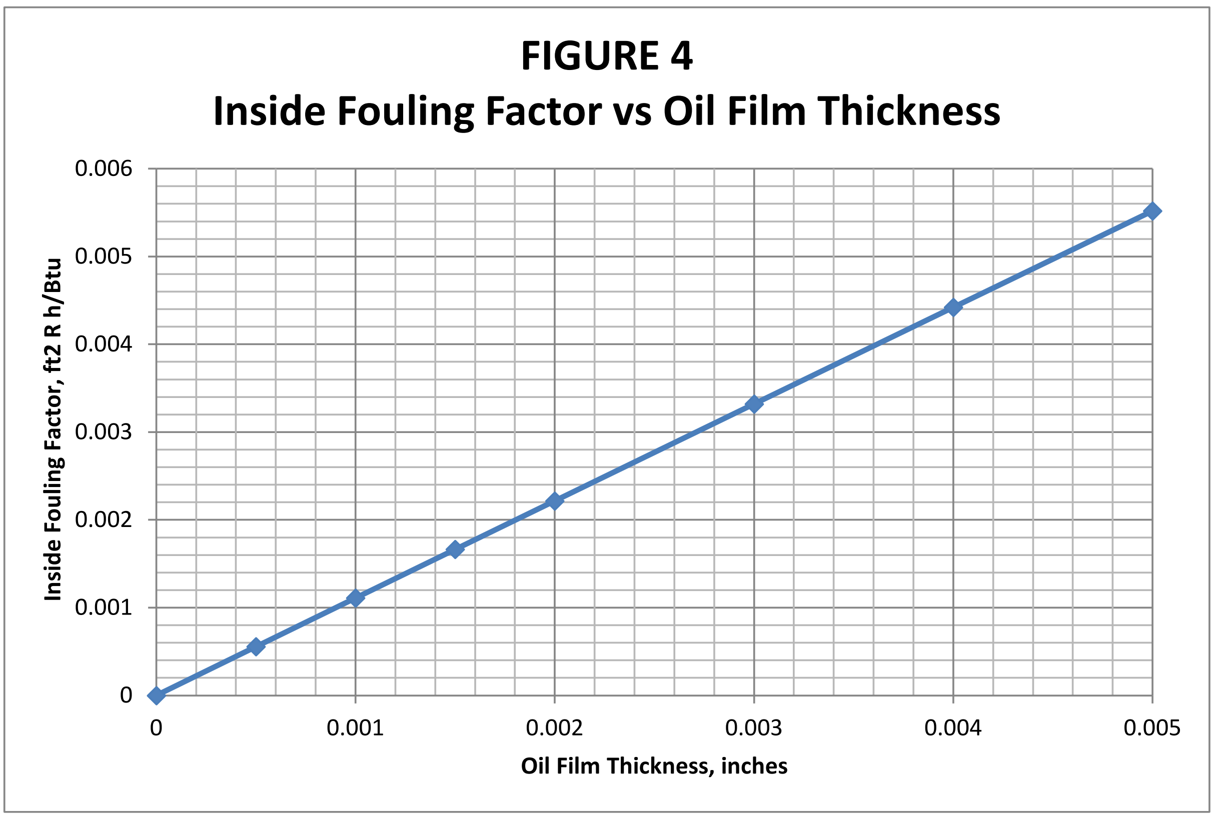
Conclusions: Heat Transfer

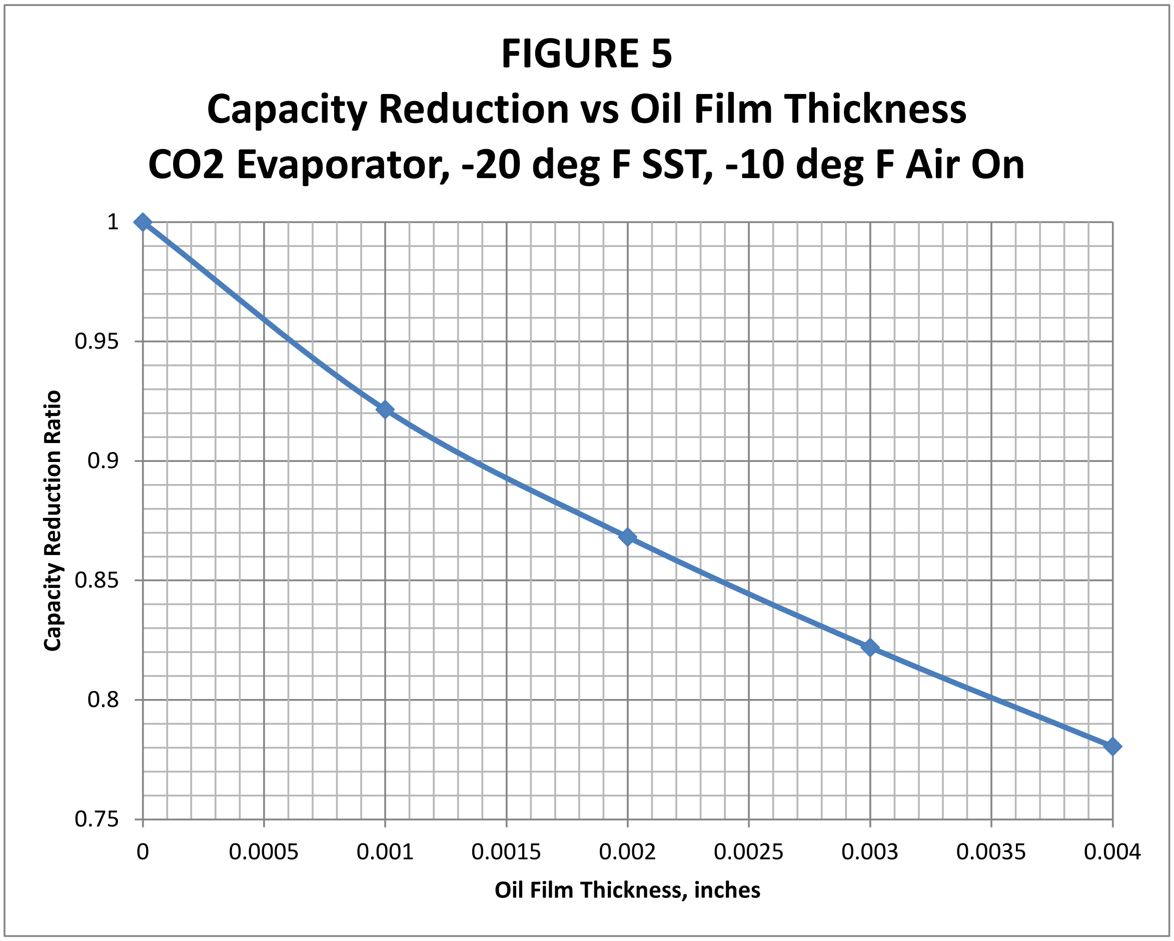
- CO_2 evaporators should be designed for higher mass flux and pressure drops than ammonia evaporators due to the much larger dP/dT characteristic of CO_2. This appears as longer circuit lengths for CO_2 compared to ammonia.
- If circuited properly, an evaporator operated with CO_2 will have equivalent cooling capacity to an evaporator of the same dimensions operated with ammonia. i.e. CO_2 does not penalize performance in evaporators compared to ammonia.

EFFECTS OF OIL IN EVAPORATORS

Industrial CO_2 refrigeration systems typically use immiscible oil for compressor lubrication. Unless effectively removed from the CO_2 discharge gas in the oil separator, some amount of oil is likely to reach evaporators and coat internal tube surfaces. The effect of this oil coating can be quantified in the form of a fouling factor, which is added to the overall resistance to heat transfer of the evaporator surface. Figure 4 below shows the calculated fouling factor for increasing oil film thickness in evaporator tubes.

Figure 5 translates this fouling factor into an expected reduction in cooling capacity for a CO_2 evaporator operated with increasing oil film thickness.





For example, a CO_2 evaporator design to operate oil-free will have its cooling capacity reduced by a factor of 0.87 (a 13% reduction) when the internal tube surfaces are coated with an oil film 0.002" thick.

Conclusions: Effect of Oil on Heat Transfer

- If immiscible compressor oil is allowed to coat internal tube surfaces in CO_2 evaporators, cooling capacity will be reduced.
- Installation of a high efficiency oil separator to minimize the amount of oil reaching evaporators is recommended.

OPTIMUM OVERFEED RATE FOR PUMPED CO2

Reducing the overfeed rate in pumped refrigerant systems is desirable because pumping power will be reduced by the cube of the ratio of the reduction in flowrate. As the liquid overfeed rate is reduced, however, the risk of operating evaporators with the refrigerant in separated flow patterns (stratified/wavy) increases. Cooling capacity of the evaporator falls off dramatically when this occurs. With CO_2 in an evaporator having 5/8" tubes, a minimum mass flux of 200 kg/m2-s is required to avoid stratified/wavy flow.

The thermodynamic properties of CO_2 differ significantly from ammonia:

- Latent heat of vaporization is much lower resulting in higher mass flow rates for a given cooling capacity.
- The ratio of liquid to vapor density is much lower which results in lower void fractions (less tube volume occupied by vapor).
- Higher mass flux for reasons explained above (see Heat Transfer section).

These characteristics allow pumped CO_2 evaporators to be designed for lower overfeed rates compared to ammonia. Recommended overfeed rates for pumped CO_2 evaporators are 1.5:1 for coolers and 2:1 for freezers.

In comparison, to avoid separated flow in pumped ammonia evaporators, recommended overfeed rates are 3:1 for coolers and 4:1 for freezers.

Conclusions: Optimum Overfeed Rate

- Pumped CO_2 systems can be successfully operated with lower overfeed rates compared to ammonia.
- Recommended overfeed rates for pumped CO_2 evaporators are 1.5:1 for coolers and 2:1 for freezers.

DIRECT EXPANSION WITH CO2

CO_2 evaporators can be operated with direct expansion feed. Care must be taken by the evaporator manufacturer to circuit the coil in such a way that the refrigerant mass flux is kept above 200 kg/m2-s in order to avoid stratified/wavy flow. This becomes challenging with larger diameter tubes (greater than 5/8"). At very low temperatures, enhanced tubes (microfin copper) are recommended as a way to mitigate separated flow patterns and improve performance.

DEFROST

CO_2 evaporators are commonly defrosted using the following methods:

- Air
- Water
- Electric Resistance

Control valve groups for these methods of defrost are very simple and low cost.

Hot gas defrost with CO_2 evaporators is not commonly used. In a cascade system, the intermediate CO_2 temperature/pressure is normally too low to allow the CO_2 from that circuit to be used for defrost. This then requires a separate high pressure (capable of 50 bar) compressor with sufficient capacity to be installed expressly for purposes of providing hot gas for defrost. Other means of generating hot CO_2 gas for defrost include use of a heat-driven boiler vessel, typically heated by discharge gas from the high side of the cascade system. The complexity and added expense of hot gas defrost with CO_2 has limited its application.

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For more information contact Colmac Coil Manufacturing, Inc.
mail@colmaccoil.com | P: 800.845.6778 or 509.684.2595
P.O. Box 571 | Colville WA 99114-0571 | www.colmaccoil.com

COLMAC COIL Manufacturing Inc.

Technical Bulletin

By Bruce I. Nelson, P.E., President, Colmac Coil Manufacturing, Inc.

SELF-POSITIONING SYSTEM FOR ELECTRIC RESISTANCE DEFROST HEATING ELEMENTS (US PATENT NO. 7,712,327)

BACKGROUND

Air-cooling heat exchangers operating at temperatures below the freezing point of water (32F) will accumulate frost on fin and tube surfaces which must be removed periodically in order to maintain system cooling capacity. One method of removing frost involves tubular electric resistance heating elements inserted in vacant tube spaces within the heat exchanger fin bundle. These heating elements are energized periodically to warm the frosted fin and tube surfaces sufficiently to melt the frost which is then captured as liquid water and removed from the space being refrigerated. After all of the frost has been melted and removed from the heat exchanger, the heating elements are de-energized and the heat exchanger is cooled back down to refrigerating temperature. This periodic removal of frost is termed a “defrost cycle”.

As the heating elements warm up during a defrost cycle, melted frost in the form of liquid water can make its way into the space(s) occupied by the heating element(s). This liquid water re-freezes at the end of the defrost cycle, attaching itself to the heating element and to the sides of the space occupied by the heating element. As the heating element cools back down to refrigerating temperature its length is reduced by an amount equal to the coefficient of linear expansion of the metal in the heating element sheath times the length of the element times the temperature difference between the freezing point of water (32F) and refrigerating temperature. In the case of long heating elements typically found in commercial and industrial heat exchangers, the amount of expansion and contraction during the defrost cycle can be relatively large (greater than ½” for a 240” long heating element operating in a –30F refrigerated environment).

If the heating element is unrestrained, this repeated heating and cooling with its associated re-freezing of melted frost and contraction of the heating element results in the heating element “creeping” or “walking” out of the heat exchanger. The re-freezing of liquid water onto the surface of the contracting heating element generates extremely powerful forces acting to slowly move the heating element along the length of the vacant space in the heat exchanger. If the heating elements are allowed to creep or walk out of the heat exchanger, damage to electrical wiring and to the element itself will result. Simply restraining the heating element with a rigid clamping system is insufficient to keep the heating element from creeping or walking – a simple clamp cannot be designed that is strong enough to resist these forces!

COLMAC BREAKTHROUGH TECHNOLOGY

Colmac is proud to introduce a new technology designed and proven to solve this problem. The Colmac Self-Positioning Defrost Element System provides a means of restraining electric resistance heating elements used for defrosting air-cooling heat exchangers in a way which allows limited movement of the heating element during heating and cooling but acts to return the element to its original proper position in the heat exchanger at the beginning of the next defrost cycle.

The newly patented system effectively eliminates the possibility of heating elements creeping or walking out of the heat exchanger thus preventing damage to the element or to electrical wiring attached to the element. The new system has been shown in many field installations to insure proper operation of these heating elements over their normal working life.

The Colmac system also simplifies installation of heating elements compared to current designs by minimizing the number of parts required to securely mount heating elements in the heat exchanger. In addition, the need for a separate ground strap to electrically ground the heating element sheath is eliminated.

HOW IT WORKS

The Colmac Self-Positioning Defrost Element System is simple!

It works by means of a spring which is attached securely to both the heating element sheath and to the coil tubesheet. The spring allows movement of the heating element in either direction parallel to the axis of the heating element. Movement of the heating element is caused when melted frost in the form of liquid water re-freezes and bonds the heating element sheath to an adjacent heat exchanger surface at a point along the length of the heating element while the element continues to shrink as it cools to refrigerating temperature. During the next defrost cycle the defrost element heats up, ice is melted, and the spring brings the element back to its original position in the coil.

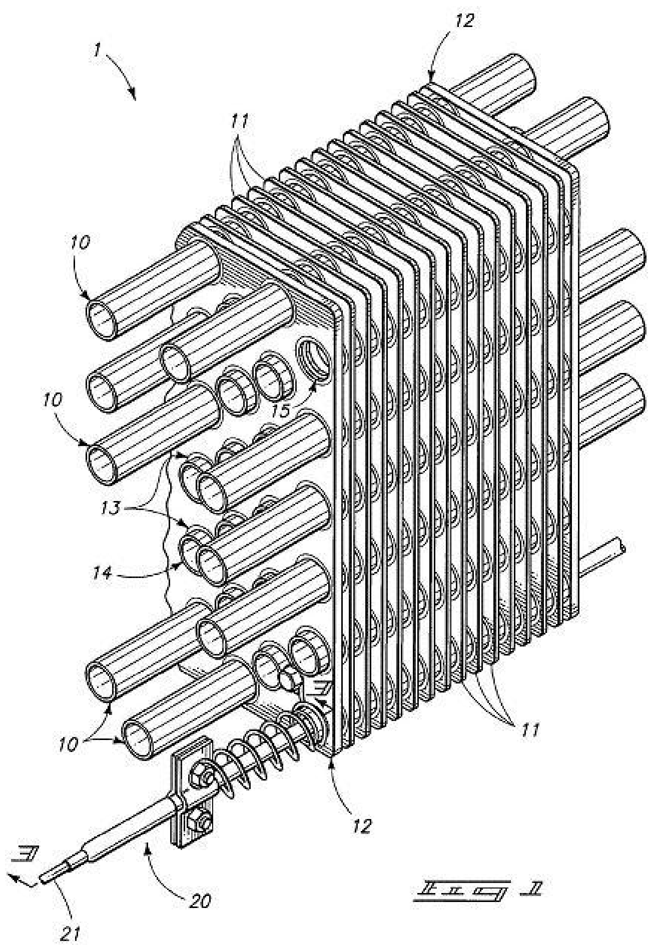
BENEFITS

The Colmac Self-Positioning Defrost Element system improves the reliability of electric defrost (extends the life of heating elements), and reduces first costs (wiring and installation) by:

- Eliminating damage to the defrost elements and electrical wiring caused by heating elements “creeping” out of the coil,
- Simplifying electrical wiring by eliminating the need for separate grounding of the defrost element

This new design from Colmac is offered as a standard feature on all Colmac electric defrost evaporators, and can even be supplied as a retrofit to existing evaporators. Finally, trouble-free electric defrost is possible! Demand Colmac Self-Positioning Electric Defrost on your next electric defrost evaporator order!

Figure 1 below shows the Colmac Self-Positioning Defrost Element System (item 20) installed in a finned-tube coil (item 12).



For more information contact Colmac Coil Manufacturing, Inc.
mail@colmaccoil.com | P: 800.845.6778 or 509.684.2595
PO Box 571 | Colville, WA. 99114-0571 | www.colmaccoil.com

COLMAC COIL Manufacturing Inc.

Technical Bulletin

By Bruce I. Nelson, P.E., President, Colmac Coil Manufacturing, Inc.

"Optimizing Hot Gas Defrost"

Introduction

Several methods are commonly used to remove accumulated frost from air cooling evaporators which operate below freezing. They include; water, electric, and hot gas defrost. If designed and operated properly, hot gas defrost offers the refrigeration system operator a method which is:

- Effective
- Automatic
- Reliable, and
- Safe

Why is using hot gas an effective method of defrosting evaporators?

1. The evaporator becomes a condenser. During the hot gas defrost process, high pressure hot gas from the discharge side of the compressor is introduced into the evaporator in a controlled fashion where it condenses back to its liquid state.
2. The latent heat of the refrigerant is used. The process of condensing releases a large amount of energy, equal to the mass flow rate of the hot gas entering the evaporator times the latent heat of vaporization of the refrigerant. The heat released during condensing is called "latent" heat since there is no change in temperature during the condensing process (the term latent means "hidden"). If the condensing pressure is held constant, the condensing process will take place at a constant temperature. The amount of heat released during the condensing process is much greater than the amount of heat released when superheated gas is cooled without condensing (called "sensible" cooling).
3. The condensed liquid is "recycled" and sent directly back to other evaporators. The condensed liquid from the defrosting evaporator is expanded into the wet suction line and returned to the Low Pressure Receiver (LPR) or Intermediate Pressure Receiver (MPR) where it is "recycled" and pumped directly back out to evaporators.
4. Hot gas defrost acts like a heat pump to "move" heat. A heat pump moves heat "uphill" by gathering energy at a low temperature level in the evaporator, compressing the evaporated refrigerant to a higher pressure, then releasing the energy at a higher temperature level during the condensing process. This process is 7 to 8 times more energy efficient than burning fossil fuel or electricity directly to produce the same heating effect. In the same way the heat used for hot gas defrosting has actually been gathered from the refrigerated space by the operating evaporators, then "moved" to the defrosting evaporators by the compression process at a refrigerant pressure and temperature high enough to melt the frost. Hot gas defrosting is very energy efficient!

Defining Defrost Efficiency

A generally accepted definition of defrost efficiency is shown below:

$$\eta_D = \frac{Q_f}{Q_{total}}$$

$$where:$$

$$\eta_D = \quad \textit{Defrost Efficiency}$$

$$Q_f = \quad \textit{Heat to warm and melt frost}$$

$$Q_{total} = \quad \textit{Total energy input for defrost}$$

The absolute minimum amount of heat required for an ideal defrost (100% efficient) would equal just enough to warm and melt the frost itself. Any additional heat applied to the evaporator reduces the defrost efficiency to less than 100%. Unfortunately, heat must be applied at the start of the defrost cycle to heat the metal of the evaporator from the evaporating temperature up to 32F (0C). This heat must then again be removed at the end of defrost when the refrigeration system is restarted. Heat must also be added to the drainpan to keep the melted frost liquid long enough to escape the refrigerated space through the drain. This heating (and cooling) of the coil and drainpan metal is unavoidable and results in a reduction in the ideal maximum defrost efficiency.

Defrost efficiency is also reduced when some of the defrost heat is lost to the room as heated air (convection) and radiation. Finally, hot gas bypassing the defrost regulator at the end of the defrost cycle represents another loss by imposing a false load on the compressor, and further reduces defrost efficiency. Improving defrost efficiency by reducing these last two types of defrost heat losses is the subject of the following discussion.

How efficient is a typical freezer defrost?

Cole (1989) observed that most freezer evaporators operate with *defrost efficiency of only 15% to 20%*. Of the total defrost energy input he determined that:

- 15 to 20% was utilized to melt the frost,
- 60% was lost to the room via convection and radiation,
- 20% was required to heat and cool the metal in the evaporator, and
- about 5% was lost due to hot gas bypassing the defrost regulator at the end of defrost.

Cole further suggested that the maximum theoretical defrost efficiency was probably in the range of 60% to 70%.

Defrost efficiency will be reduced as energy lost to the room during defrost increases. The amount of heat lost to the room is directly affected by room temperature (a colder room will have larger convective losses), the duration of the defrost (a longer defrost will result in more convective heat loss), and the temperature of the hot gas (higher temperature hot gas will result in more convective losses).

The frequency of defrosts and amount of accumulated frost will also affect defrost efficiency, that is, more accumulated frost will directly increase defrost efficiency by the equation shown above.

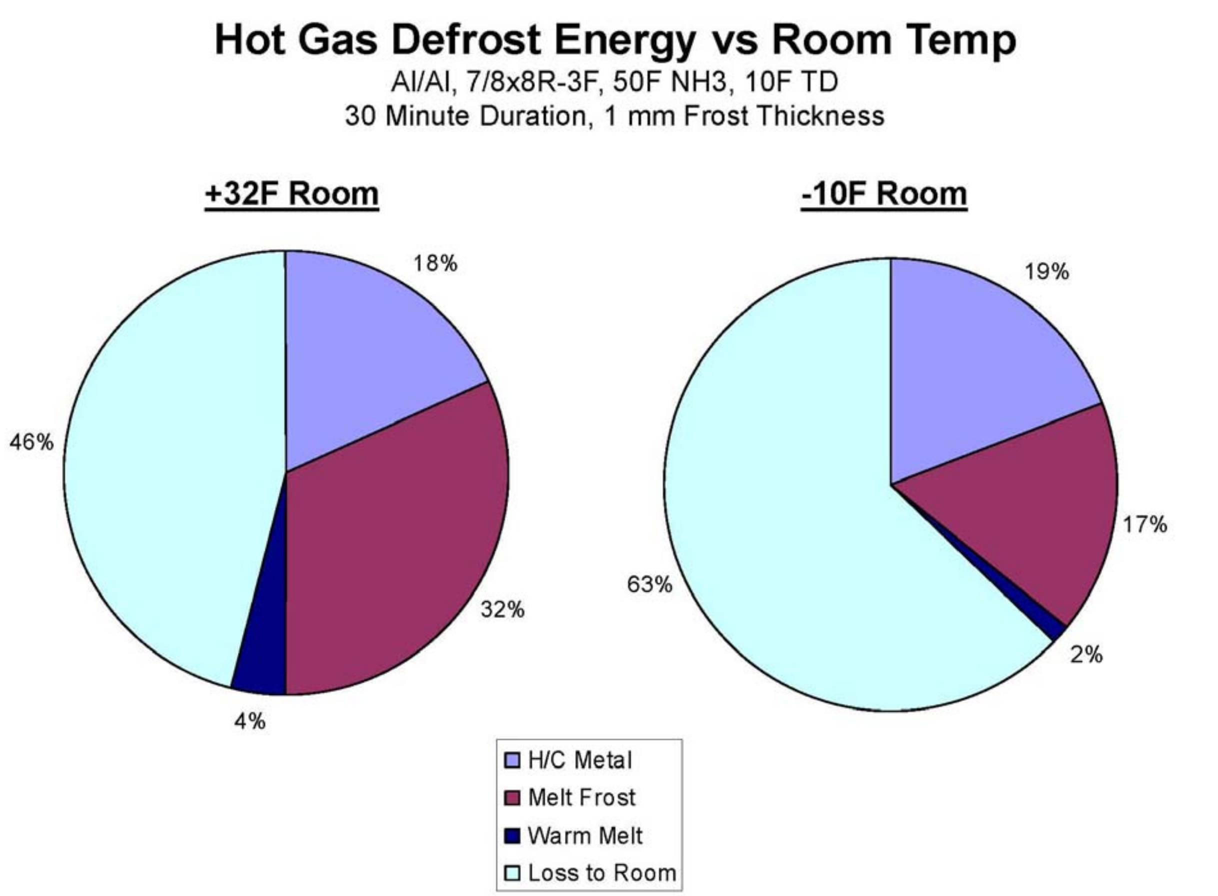
A heat transfer model was written for a typical industrial evaporator to examine how defrost efficiency is affected by:

- Room temperature,
- Hot gas temperature,
- Duration of defrost,
- Frost thickness, and
- Materials of construction

Room Temperature

As room temperature is reduced, the defrost heat lost to the room due to convective heating of air unavoidably becomes greater. This means that defrost efficiency in a freezer room will always be less than defrost efficiency in a medium temperature room. Figure 1 below illustrates the greater convective heat loss in the freezer (63%) compared to the medium temperature room (46%), and the resulting lower defrost efficiency in the freezer (17%) versus the medium temp room (32%). Note that the defrost efficiency is equal to the “Melt Frost” percentages shown in the charts. This highlights the relatively large amount of heat that is lost to the room during defrost due to convective air heating regardless of the room temperature. Reducing this convective heat loss by changing the design of the evaporator cabinet therefore represents an opportunity to significantly improve defrost efficiency and will be discussed later.

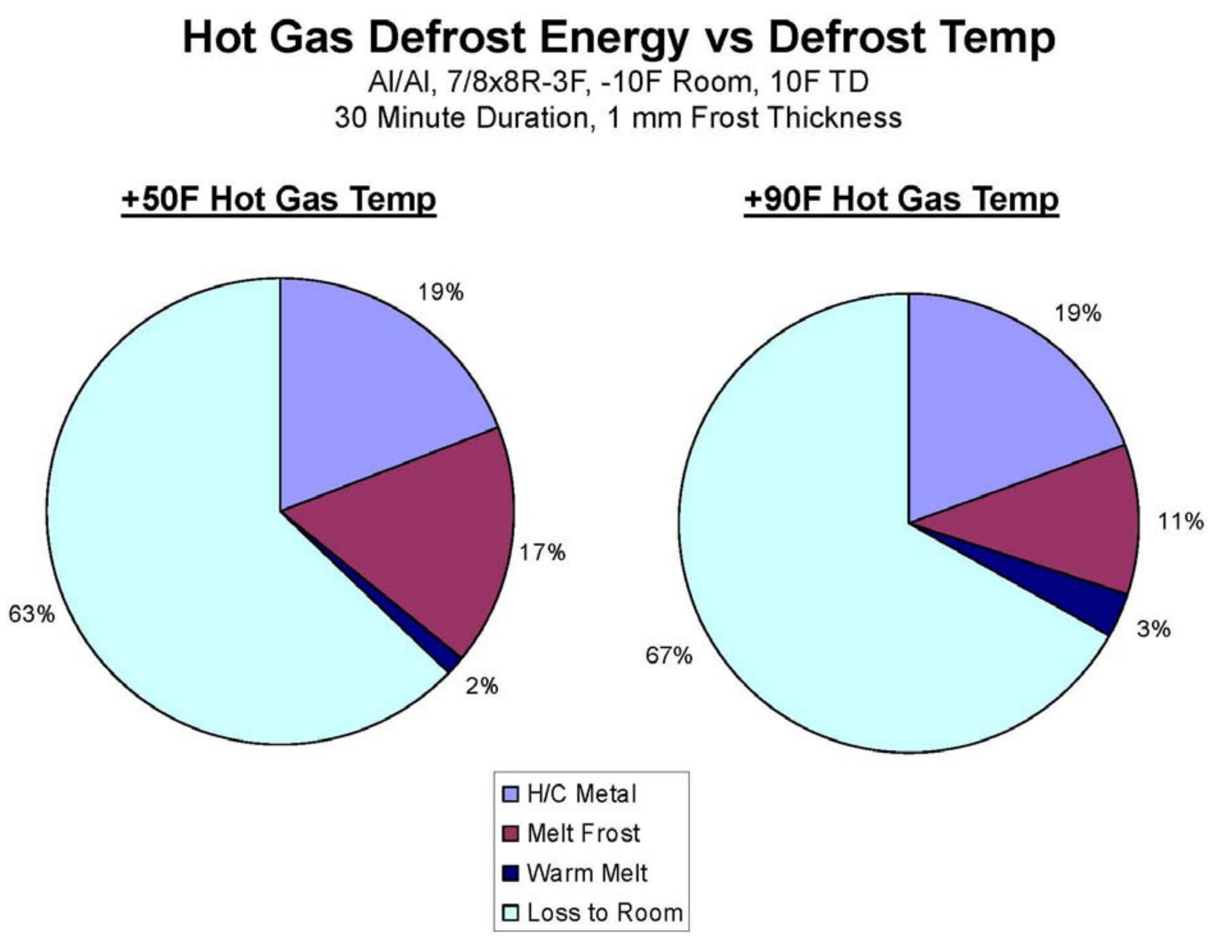
FIGURE 1



Hot Gas Temperature

Since the amount of convective heat loss to the room is directly affected by the temperature difference between hot gas temperature and room temperature, any increase in hot gas temperature above the absolute minimum required to melt the frost results in a proportional increase in the convective loss. It is generally accepted that the practical minimum hot gas temperature for effective defrosting is around 50F (a defrost regulator setting of 75 psig). Figure 2 illustrates how an increase in the hot gas temperature results in an increase in convective heat loss and reduction in defrost efficiency. It is the author's observation that in many facilities, the hot gas temperature is raised above the minimum required 50F in an attempt to clear the coil of ice due to some design related issue(s) such as ice buildup in drainpans, or improper defrost piping.

FIGURE 2



In a conventional hot gas control valve arrangement, hot gas pressure (and therefore defrost temperature) is determined by the defrost regulator setting. It is important to recognize that some minimum pressure difference between hot gas supply pressure and the defrost regulator setting must be maintained in order to provide enough "push" to keep clearing the condensed refrigerant out of the coil. A pressure differential of 15 to 20 psig should be sufficient to keep the coil clear of condensed refrigerant. If this pressure difference becomes too small (either hot gas supply pressure falls too low or the defrost regulator setting is too high) then condensed liquid refrigerant can accumulate in the coil tubes and become subcooled, typically in the bottom rows. Once the refrigerant liquid becomes subcooled it loses its ability to melt the frost and ice will accumulate.

Also, coil manufacturers must properly design evaporators to continuously drain and clear condensed refrigerant from the:

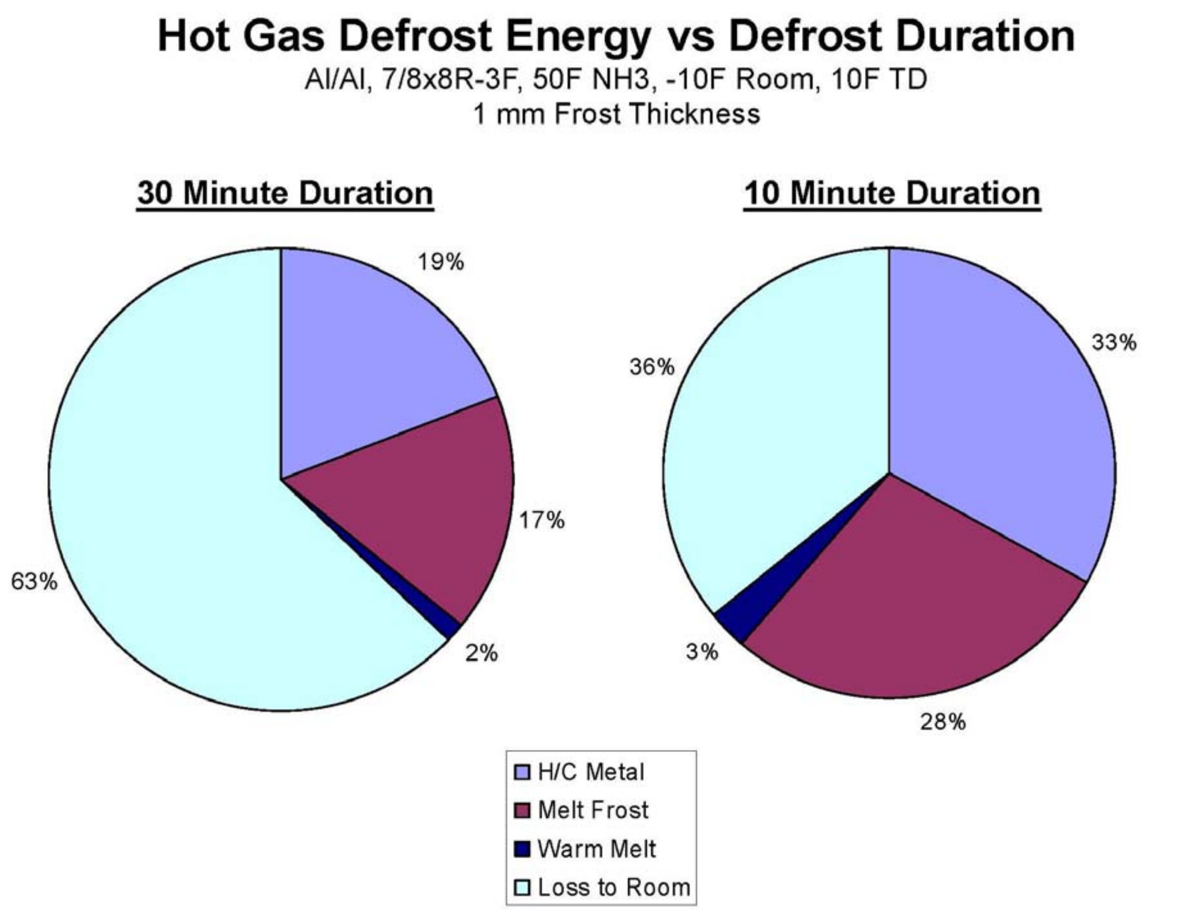
- Hot gas pan loop,
- Coil circuits, and
- Liquid header and connection

Designing the liquid header to effectively trap condensed refrigerant and form a liquid seal below the lowest tube in the coil is particularly important to avoid the problem of accumulating subcooled liquid in the bottom coil tubes mentioned above.

Duration of Defrost

Cole (1989) confirmed by his own measurements, and by the observation of others, that the minimum time required to melt the frost on evaporator tubes and fins is only between 8 and 10 minutes. However, it is the observation of the author that most evaporators in industrial refrigeration facilities have hot gas defrost duration settings in excess of 30 minutes, that is, the period of time the hot gas solenoid is open. Figure 3 shows the significant reduction in convective heat loss, and the increase in defrost efficiency, resulting from shortening the duration of defrost from 30 minutes to 10 minutes.

FIGURE 3

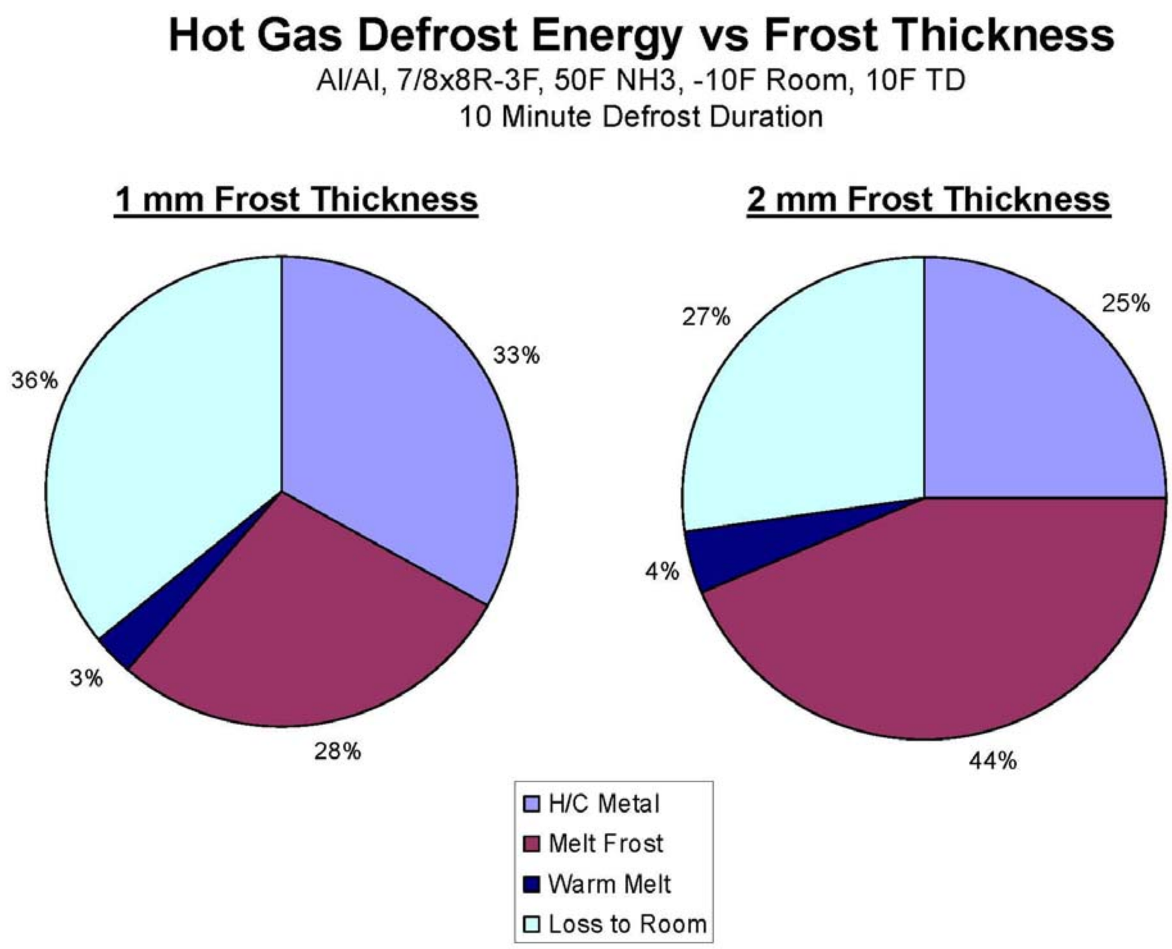


Defrost duration of longer than the minimum 10 minutes should not be needed, however, it is quite common to see defrost durations of 30 minutes or longer. This being a result of deficiencies in either the design of the evaporator (ice in drainpans or improperly trapped coil outlet connection), or in the defrost piping and/or controls.

Frost Thickness

The definition of defrost efficiency implies that increasing the amount of frost melted during defrost will directly increase the efficiency. Reducing the number of defrosts per day will increase frost thickness and increase efficiency of defrosting. Figure 4 shows the effect of increasing frost thickness from 1 mm to 2 mm, and confirms a significant increase in efficiency.

FIGURE 4



Reducing the number of defrosts per day may or may not be possible with existing installations, depending on the evaporator design. In order for evaporators to carry more frost on fin surfaces between defrosts, two design characteristics are needed:

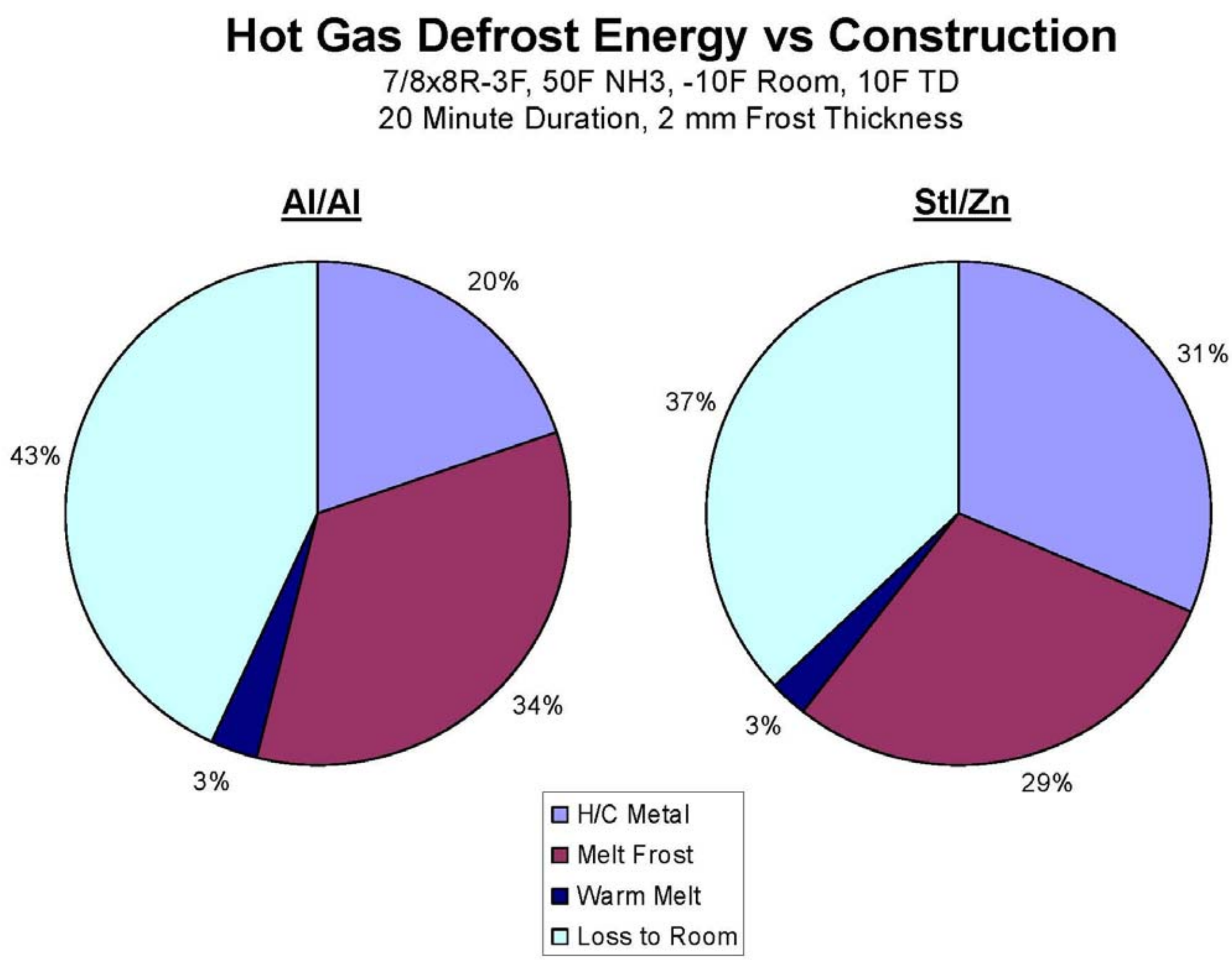
1. Wide fin spacing. A fin spacing of 3 fpi (8.5 mm/fin) will allow more accumulated frost between defrosts compared to 4 fpi (6.4 mm/fin) with less restriction of airflow and less reduction in evaporator performance.

2. A large ratio of secondary (fin) to primary (tube) surface. Evaporators having very close tube spacing will have reduced total surface area for a given cooling duty and reduced frost carrying capability. Evaporators having tubes spaced farther apart will have greater total surface area and greater frost carrying capability. For example, an evaporator with 50mm tube spacing and 3 fpi will allow longer run time between defrosts than an evaporator with 38mm tube spacing and 4 fpi. More total surface area for a given cooling duty allows fewer defrosts per day.

Materials of Construction

Nelson (2003) showed that more energy is required to heat and cool the metal in a galvanized steel evaporator compared to an aluminum tube/aluminum fin evaporator during a defrost cycle. This is due primarily to the greater mass of metal in the galvanized steel construction. Figure 5 shows the reduction in defrost efficiency for a galvanized evaporator (Stl/Zn) compared to an all aluminum (Al/Al) one.

FIGURE 5



Summary: Defrost Efficiency

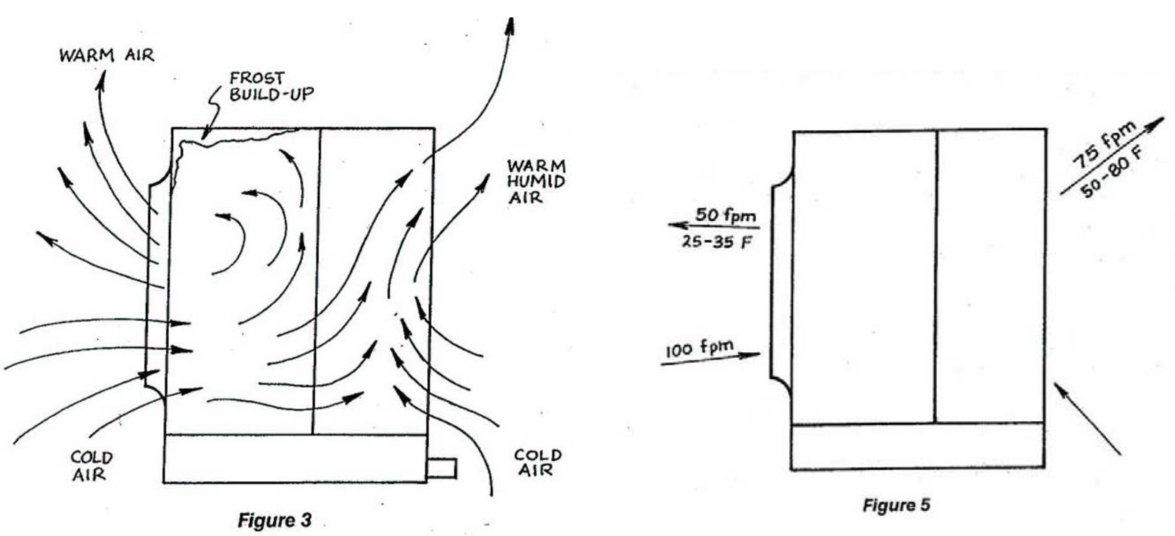
From the preceding discussion we can summarize:

1. Colder room temperatures will unavoidably have lower defrost efficiencies.
2. Defrost efficiency improves as:
    a) Hot gas temp is <u>*lowered*</u>, and/or
    b) Defrost duration is <u>*shortened*</u>, and/or
    c) Time between defrosts (frost thickness) is <u>*increased*</u>.
3. Convective heat loss is a significant penalty in all cases.
4. Reducing *duration* and increasing *frost thickness* <u>improved</u> defrost efficiency from 17% to 44% in the freezer.
5. All aluminum (Al/Al) construction improved defrost efficiency from 29% to 34% in the freezer compared to galvanized steel (Stl/Zn). Note that all aluminum construction will also defrost faster than galvanized steel due to the much higher thermal conductivity of aluminum.

Reducing Convective Heat Loss

As shown above, reducing convective heat losses during defrost represents a significant opportunity to improve the energy efficiency of hot gas defrosts. Figure 6 below from Cole (1989) shows field measured air movement patterns and velocities taken during defrost.

FIGURE 6
CONVECTIVE AIR MOVEMENT DURING DEFROST

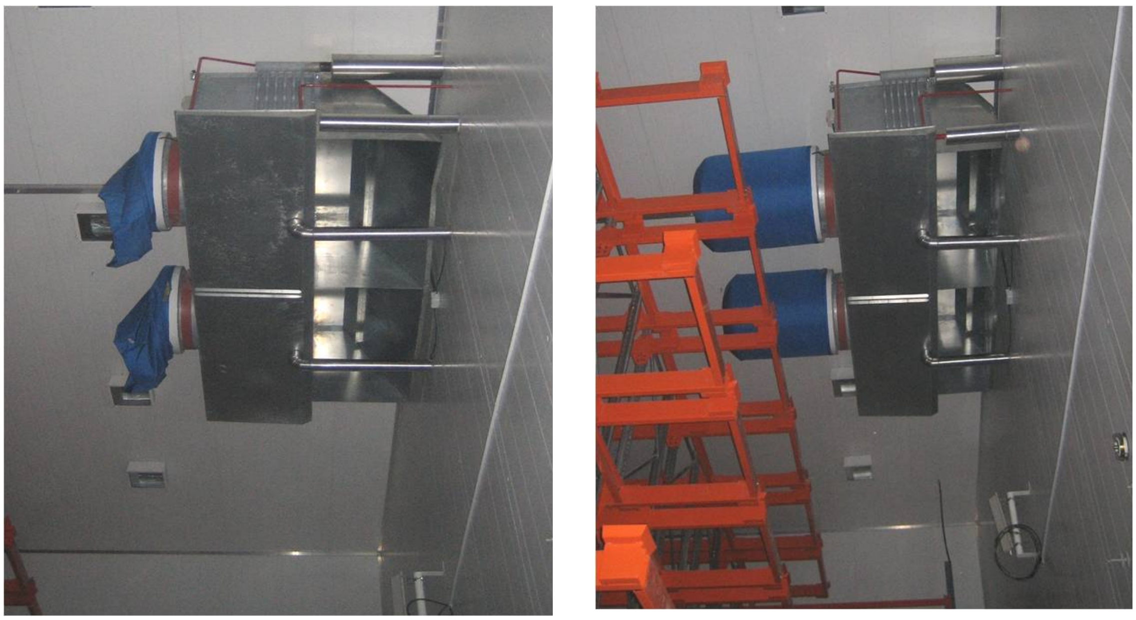


Taken from: Cole, R.A. 1989. “Refrigeration Loads in a Freezer Due to Hot Gas Defrost and Their Associated Costs.” *ASHRAE Transactions*, V.95, Pt.2.

The use of return air hoods, and fan discharge socks is a recent development now available as an option from several evaporator manufacturers. Return air hoods in combination with fan discharge socks effectively eliminate convective air movement and heat loss during defrost. Figure 7 shows typical return air hoods and fan discharge socks installed on an evaporator.

FIGURE 7

EVAPORATOR WITH RETURN AIR HOOD AND DISCHARGE SOCK INSTALLED



Return air hoods such as those shown are very effective. However, if care is not taken to (a) insulate the hood, and (b) actively heat the inside surfaces of the hood during defrost, then hoar frost and ice can build up on the inside surfaces of the hood and either block airflow or fall to the floor below. Also, fan discharge socks may require periodic removal for cleaning and de-icing.

Optimizing Hot Gas Defrost: Conclusions

From the above discussion, it can be seen that hot gas defrosting of evaporators can be made significantly more efficient by doing the following:

1. Minimize convective heat loss.
    - Use lowest practical defrost regulator setting. 75 to 90 psig (50 to 60F) should be adequate. Note: If higher pressures are needed, look for problems elsewhere.
    - Capture defrost heat (i.e. install Return Air Hoods).
2. Shorten defrost duration.
    - Use top feed or DX (direct expansion) evaporator feed to reduce time required for pump out.
    - Open the hot gas solenoid only long enough to clear coil (8-10 minutes).
    - Install a separate hot gas solenoid and defrost regulator for pre and post-heating of the pan loop. Alternately, install electric resistance drainpan heating.
3. Reduce the number of defrosts per day.
    - Reduce the number of defrosts per day to match the frost load.
    - Choose evaporators with wide fin spacing (3 fpi instead of 4 fpi) and large secondary (fin) surface area to maximize frost carrying capacity.

Calculating the Cost of Defrost

It has been shown that defrost efficiency can be significantly improved by reducing the amount of energy lost to the room by convection during defrost. The next logical question becomes: “How much money can I really save by optimizing hot gas defrost?”

To answer this question, the defrost model described in the preceding sections was used to calculate the cost savings resulting from:

1. Reducing defrost duration from 30 minutes to 10 minutes, and
2. Increasing frost thickness from 1mm to 2mm (reducing the number of defrosts per day by half).

The calculations assume:

- Evaporator capacity: 100 TR
- Compressor runtime: 16 h/day
- Cost of Electricity: $0.10/kWh

Table 1 shows calculated cost savings for four different room temperatures.

As room temperature is lowered, less moisture is held in the air (the humidity ratio is reduced). i.e. Cold air is “drier” than warm air. Hence, at freezer temperatures the latent component of the total refrigerating load is lower (less frost accumulates for each ton of refrigeration) compared to higher room temperatures. This is reflected in the Sensible Heat Ratio (SHR) shown in the table.

To make the cost savings calculation, system Coefficient of Performance (COP) also needs to be assumed. The COP values in the table assume single stage compression for the 0C (+32F) and -18C (0F) room temperatures, and two-stage compression for the -23C (-10F) and -34C (-30F) room temperatures.

TABLE 1

CALCULATED COST SAVINGS ($/y/100 TR) FOR OPTIMIZED VS CONVENTIONAL DEFROST

	Room Temp, C (F)			
	0 (+32)	**-18 (0)**	**-23 (-10)**	**-34 (-30)**
SHR	0.66	0.89	0.93	0.97
System COP:	3.2	2.5	2.2	2
Frost Removed, kg/day:	2,778	899	572	245
Frost Removed, kg/y:	1,014,096	328,090	208,784	89,479
I. Baseline (30 min, 1 mm)				
Defrost Efficiency, %	32%	18%	17%	14%
Defrost Convective Losses, %:	46%	61%	63%	65%
Defrost Convective Losses, kWh/y:	1,012,438	753,334	545,922	283,071
Baseline Cost of Defrost (Convective), $/y:	**$31,639**	**$30,133**	**$24,815**	**$14,154**
II. Optimized (10 min, 2 mm)				
Defrost Efficiency, %	61%	46%	43%	40%
Defrost Convective Losses, %:	15%	26%	27%	30%
Defrost Convective Losses, kWh/y:	168,740	125,556	90,987	47,178
Optimized Cost of Defrost (Convective), $/y:	**$5,273**	**$5,022**	**$4,136**	**$2,359**
Savings Optimized vs Baseline, $/y:	**$26,366**	**$25,111**	**$20,679**	**$11,795**

Smart Hot Gas Defrost Piping

Conventional ammonia evaporators are typically arranged for bottom feed with the hot gas pan loop piped in series with the coil. As mentioned above, a “smart” hot gas piping arrangement resulting in higher defrost efficiency and reduced operating costs utilizes top feed (or DX) with the hot gas pan loop piped separately from the coil.

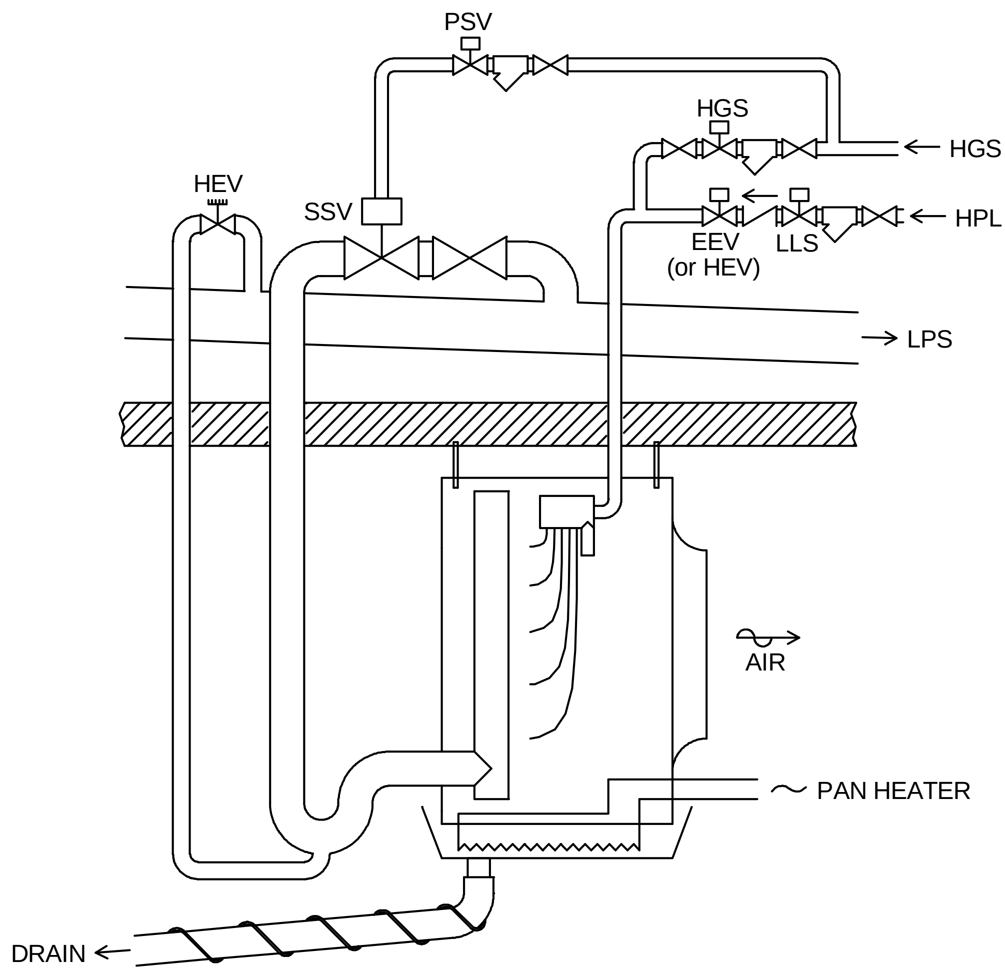
This “Smart Hot Gas Defrost” piping arrangement is shown in Figures 8 and 9.

With conventional bottom feed and hot gas defrost piping arrangement, during defrost, hot gas is first sent through the drainpan loop and then in series through the coil block. This commonly used arrangement is effective and simple, however, it requires that the hot gas solenoid remains open to keep the drainpan heated long enough for all water to completely drain and exit through the drain piping. Convective heat loss to the room continues after the coil is clear of frost while the pan is draining. A more efficient (and cost effective) arrangement is to control hot gas to the coil block and to the drainpan loop separately through two separately timed hot gas solenoid valves. This separate control of pan heating can also be accomplished by electrically heating the drainpan. This arrangement shortens the amount of time hot gas is flowing through the coil block, minimizing the convective heat loss and maximizing defrost efficiency.

It is interesting to note that the control valves for the Smart Hot Gas Defrost piping arrangement shown in Figures 8 and 9 are less expensive than a conventional bottom feed hot gas defrost piping arrangement with defrost regulator.

FIGURE 8

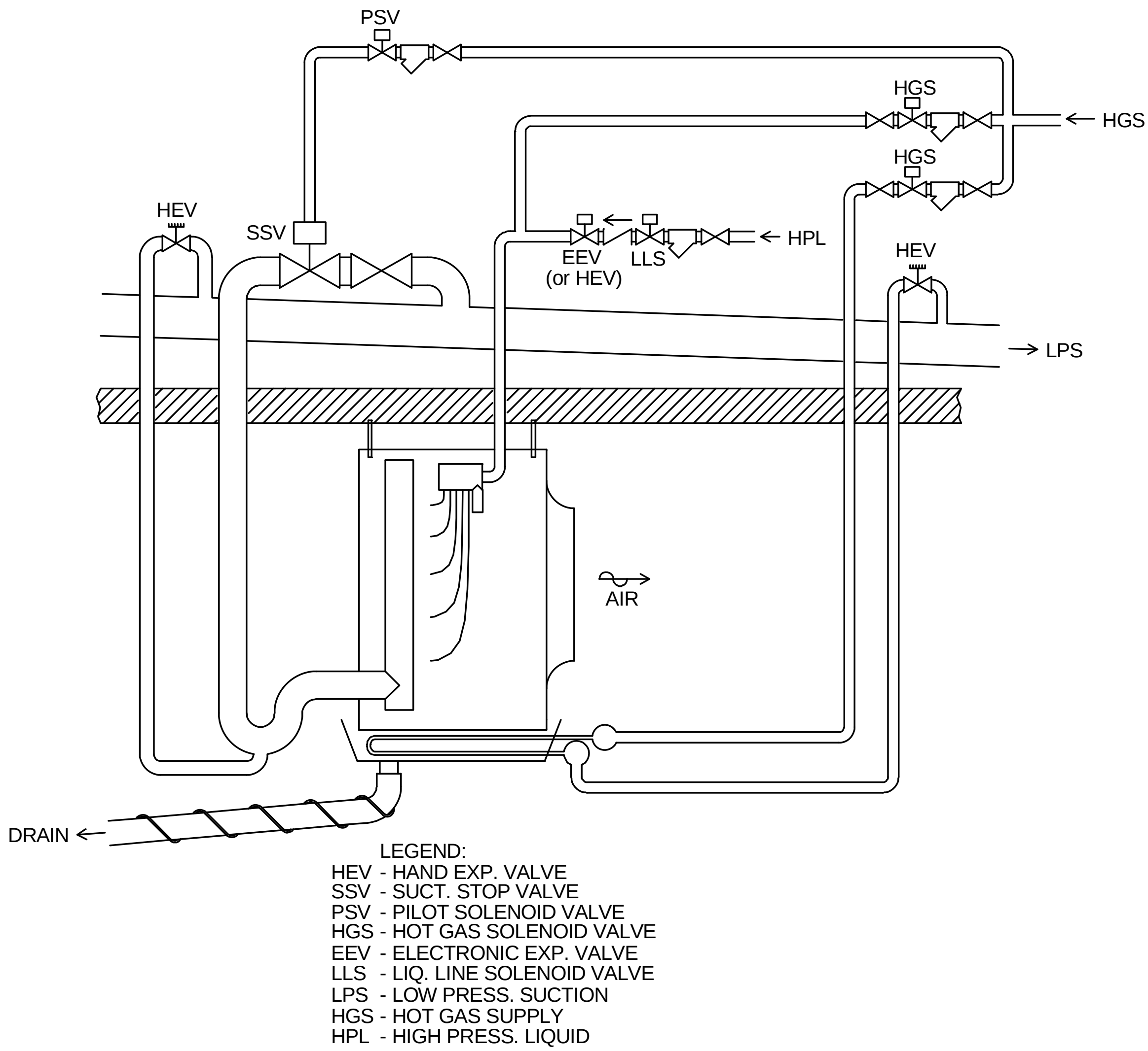
SMART HOT GAS DEFROST PIPING DIAGRAM (ELECTRICALLY HEATED PAN)



LEGEND:
HEV - HAND EXP. VALVE
SSV - SUCT. STOP VALVE
PSV - PILOT SOLENOID VALVE
HGS - HOT GAS SOLENOID VALVE
EEV - ELECTRONIC EXP. VALVE
LLS - LIQ. LINE SOLENOID VALVE
LPS - LOW PRESS. SUCTION
HGS - HOT GAS SUPPLY
HPL - HIGH PRESS. LIQUID

FIGURE 9

SMART HOT GAS DEFROST PIPING DIAGRAM (WITH PAN LOOP)



Typical Smart Hot Gas Defrost Sequence of Operation

1. Defrost is initiated. Defrost initiation can be timed or on demand by an air pressure differential sensor (indicates frosted condition)
2. Liquid Line Solenoid (LLS) closes
3. Timed pump out for 5-10 minutes
4. Fan(s) stop
5. Pan heaters (or pan loop solenoid) energized for timed pan preheat (2-3 minutes)
6. Coil hot gas solenoid and pilot solenoid (closes suction stop valve) open
7. Timed defrost (8-10 minutes)
8. Coil hot gas solenoid closes
9. After coil pressure is equalized to suction pressure (3-5 minutes), Suction Stop Valve opens

10. Open LLS
11. Pan heater (or pan loop solenoid) de-energized
12. After 5 minute cool down delay fans restart

Design for Reliability

Reliable operation of the hot gas defrost system depends on an adequate supply of hot gas throughout the defrost cycle. Remember to:

1. Correctly size and insulate hot gas lines according to IIAR guidelines (IIAR 2004).
2. Make sure 2 coils are running for every coil that is defrosting. This is because the evaporator has approximately twice the condensing capacity as evaporating capacity during defrost.

Reliable hot gas defrost operation also depends on correct selection and sizing of control valves. Control valve manufacturers' literature and guidelines should be consulted.

Design for Safety

Safety must always be a primary consideration when designing and operating an ammonia hot gas defrost system. Remember, as a minimum, to do the following:

1. Use good piping practice per the IIAR Piping Handbook (2004).
2. Keep hot gas lines clear of liquid by pitching down toward liquid drainers.
3. Use a two-position Suction Stop Valve to allow the coil to allow the coil to gradually come back down to suction pressure at the end of defrost.
4. Develop and maintain a complete PSM-RMP (Process Safety Management – Risk Management Program) for your ammonia refrigeration system.
5. Develop and maintain a culture of safety training and preparedness throughout all levels of your organization.

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For more information, please contact Colmac Coil Manufacturing, Inc.
Phone: 800.845.6778 or 509.684.2595
P.O. Box 571, Colville, WA. 99114-0571; www.colmaccoil.com

Technical Bulletin

By Bruce I. Nelson, P.E., President, Colmac Coil Manufacturing, Inc.

WATER DEFROSTING AT FREEZER TEMPERATURES

Introduction

The following guidelines should be used when designing water defrost systems for low temperature freezer applications.

1. Water defrost is fast and effective at medium *and* low temperatures.

2. Coil steaming can be minimized by keeping water temperatures below about 60F. Typically, frost accumulation problems in cold stores are the result of excessive infiltration of humid outside air. Water defrost generally produces less steam over the defrost period compared to hot gas and electric defrost, due to its shorter duration and lower temperatures.

3. Water temperature must be kept above 40F to avoid refreezing problems.

4. Use of cooling tower, or evaporative condenser sump water is not recommended because of entrained sediments that will be present. If sump water is used it must be filtered. Also, water temperatures must be controlled to avoid excessive steaming. Normally, tap water can effectively be used for water defrosting if kept within the temperature range mentioned above.

5. In low temperature applications, it is critical that water be allowed to completely drain from water supply lines and control valves when defrost is terminated to avoid freezing. See Installation, Operation & Maintenance manual for instructions.

6. One potential nightmare in low temperature cold stores is a water supply valve that sticks and allows water to continue to flow to the air cooler after defrost has terminated. Water must be filtered, and piping designed to eliminate this possibility.

7. In blast freezer applications, water defrost is desirable for cleanup reasons. A "hot gas assist" system is very effective where the coil is warmed with hot gas to loosen ice and frost, then washed off with water.

8. To avoid water hammer in defrost lines, use motorized water supply valves instead of fast-acting solenoid valves.

9. Pitch drain lines exposed to freezing temperatures approx. 1-1/2” per foot. Heat tracing of drain lines is not necessary if they are properly pitched, even in low temperature rooms.

For more information, please contact Colmac Coil Manufacturing, Inc.
Email mail@colmaccoil.com; Phone (800) 845-6778 or (509) 684-2595
P.O. Box 571, Colville, WA. 99114-0571; Website www.colmaccoil.com

Technical Bulletin

By Bruce I. Nelson, P.E., President, Colmac Coil Manufacturing, Inc.

Comparing Air Cooler Ratings – Part 1: Not All Rating Methods are Created Equal

SUMMARY

Refrigeration air coolers (evaporators) are widely used to cool and circulate air in cold storage warehouses and food processing facilities. Manufacturers of air coolers publish cooling capacities based on differing assumptions and rating methods. It is important for refrigeration design professionals to understand these different rating methods and to apply them appropriately. In extreme cases, air coolers can be grossly undersized even though nominal catalog ratings appear to satisfy the calculated refrigeration load. The article illustrates the differences in these rating methods and highlights the importance of selecting air coolers using ratings suited to the operating conditions.

BACKGROUND

Refrigeration air coolers (evaporators) are widely used to cool and circulate air in cold storage warehouses and food processing facilities. Manufacturers of air coolers publish cooling capacities based on differing assumptions and rating methods (Nelson 2010). In Europe, a number of manufacturers of commercial air coolers (i.e. coolers designed for use with R404a/R507) subscribe to the Eurovent certification program based on the European test standard EN 328 (EN 2002), however, no manufacturer is currently certified for industrial air coolers (i.e. coolers designed for use with ammonia refrigerant). In the U.S. the performance standard AHRI-420 exists (AHRI 2008), but no manufacturers participate in a certification program based on this standard. It is, therefore, important for refrigeration design professionals to understand the different rating methods being used and to apply them appropriately. In extreme cases, air coolers can be grossly undersized even though nominal catalog ratings appear to satisfy the calculated refrigeration load. The smaller size and lower first cost of air coolers which are inadvertently undersized due to misunderstood or misapplied ratings are seductively attractive to contractors and end users, however, the price difference will ultimately be more than paid for by the unsuspecting end user whose undersized air coolers cause lower-than-expected operating suction temperatures with associated increased energy consumption and loss of refrigerating capacity.

AIR TEMPERATURE CHANGE

As air passes across the fins of an evaporator coil, the temperature is reduced according to the following relationship (ASHRAE 2009):

$$\dot{q} = \dot{m} \cdot C_p \cdot (T_{ent} - T_{lvg}) \quad (1)$$

where

$\dot{q}$ = cooling capacity (sensible only), Btu/h (kW)
$\dot{m}$ = mass flow rate of air, lbm/h (kg/s)
C_p = specific heat capacity of moist air, Btu/lbm F (kJ/kg C)
T_{ent} = dry bulb air temperature entering the coil (“air on” temperature), F (C)
T_{lvg} = dry bulb air temperature leaving the coil, F (C)

In a room being refrigerated by air cooling evaporators, the change in the temperature of the air (reduction) as it passes through the evaporator coils will equal the change in the temperature of the air (increase) as it circulates throughout the room. This means that in a well-designed cold room, the air temperature gradient found in the room will be roughly equal to, and will be determined in large part by the air temperature change in the evaporator coils. By Equation (1) the magnitude of the air temperature change (gradient) in the room will be determined by the air mass flow rate through the evaporators. For example, if a relatively small air temperature gradient is desirable in a refrigerated room, then air coolers with relatively high air flow rate (i.e. high CFM/TR) for a given capacity must be selected.

HEAT EXCHANGER EFFECTIVENESS

One well known method used to calculate the sensible cooling capacity of evaporators is the effectiveness method (Kays and London 1964). Heat exchanger effectiveness is defined as the ratio of the actual amount of heat transferred to the maximum possible amount of heat that could be transferred with an infinite area. This method is extremely useful because cooling capacity can be calculated directly knowing only the dimensional characteristics of the coil and the initial temperature difference (entering air temperature minus the evaporating temperature). This initial temperature difference is referred to as "DT1" (or "TD") in the refrigeration industry. Sensible cooling capacity is calculated as follows:

$$\dot{q} = \dot{m} \cdot C_p \cdot \epsilon \cdot (T_{ent} - T_{evap}) = \dot{m} \cdot C_p \cdot \epsilon \cdot DT1 \quad (2)$$

where

$\dot{q}$ = cooling capacity (sensible only), Btu/h (kW)
$\dot{m}$ = mass flow rate of air, lbm/h (kg/s)
C_p = specific heat capacity of moist air, Btu/lbm F (kJ/kg C)
ϵ = effectiveness = $(T_{ent} - T_{lvg})/(T_{ent} - T_{evap})$
T_{ent} = dry bulb air temperature entering the coil ("air on" temperature), F (C)
T_{lvg} = dry bulb air temperature leaving the coil, F (C)
T_{evap} = average refrigerant evaporating temperature, F (C)

For a given sized coil operating with constant air flow rate, the effectiveness can be considered constant over the small operating temperature ranges typical of refrigeration applications, and therefore, capacity can be considered to be proportional to the ratio of DT1. Hence, if evaporator coil sensible capacity is known for a given DT1, then capacity at a new initial temperature difference, DT1', can be found simply by multiplying the original capacity by the ratio DT1'/DT1. For example, a refrigeration air cooler has a rating of 10 TR at a DT1 of 10F. The capacity of the same cooler operating with a new DT1 of 12F will be very close to 10 x 12/10 = 10 x 1.2 = 12 TR.

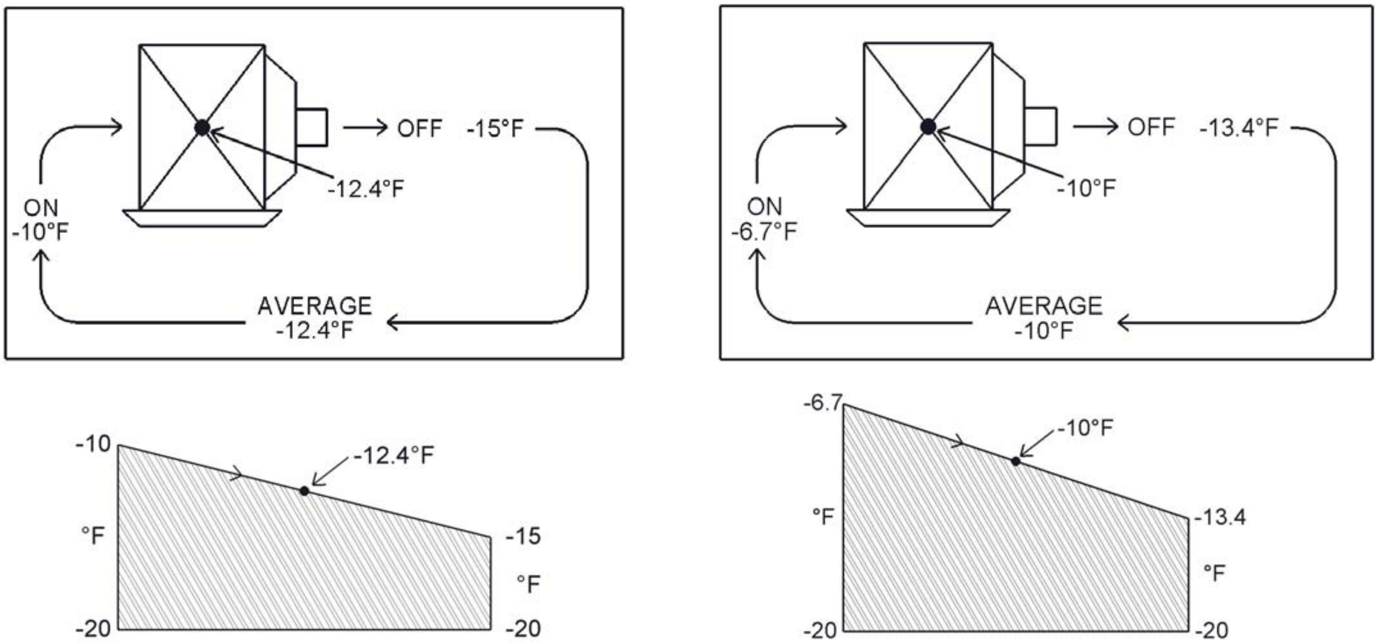
AVERAGE ROOM TEMPERATURE AND DTM RATINGS

Control of the refrigeration system is normally accomplished by maintaining room air temperature, that is, compressors and coolers are cycled on or off depending on whether room temperature is rising or falling. Location of the air temperature sensing device relative to the location of evaporators will affect evaporator performance since a temperature gradient always exists in the room and, as seen above, evaporator performance is determined by the air on temperature (i.e. by DT1). Evaporators located high in the room (mounted on the ceiling, for example), will be exposed to the highest air temperature in the room and operate with the largest DT1. Conversely, floor mounted evaporators will be exposed to the coldest air in the room and operate with the smallest DT1.

For the specific case where; 1) air coolers are ceiling mounted (i.e. operate at the warmest location in the room), and 2) the system control temperature sensor is mounted at a location where it will sense the *average* room temperature (i.e. at the midpoint elevation in the room), manufacturers of air coolers publish ratings based on *mean* (average room) temperature difference. This average temperature difference is termed "DTM". DTM ratings for the same air cooler will always be higher than DT1 ratings since the effective initial temperature difference seen by the evaporator coil is higher by approximately ½ of the air temperature change. Figure 1 below illustrates how air temperature changes as it passes through an evaporator at two different operating conditions. Note that airflow is held constant for both operating conditions. The first condition with DT1 = 10F is shown as Figure 1(a). The second condition with DTM = 10F is shown as Figure 1(b). Because the DTM = 10F condition has the larger *initial* temperature difference of -6.7 – (-20) = 13.3F, the cooling capacity and air temperature change are significantly larger than for the DT1 = 10F condition. It is interesting how the same evaporator can produce more cooling capacity simply by redefining "temperature difference"!

FIGURE 1
Temperature Profiles for DT1 vs DTM

(a) DT1 = 10F (Air On) Temp Difference **(b) DTM = 10F (Average) Temp Difference**



DT1 LMTD = 7.2 F DTM LMTD = 9.6 F

Although DTM ratings may useful in the specific case of ceiling mounted air coolers (equipment size and first cost can be reduced), refrigeration system designers must be careful to recognize the limitations of this rating system and avoid the mistake of misapplying DTM ratings. Whenever air coolers are installed at a location in the room where the air on temperature to the coil is less than the highest temperature in the room, DTM ratings should not be used. This would be the case with cooler inlet air ducted from some lower temperature point in the room, or with floor mounted coolers.

DT1 ratings used with actual anticipated air on temperature will always result in accurate ratings and correct air cooler selections. This method for air cooler selection is conservative and recommended whenever air on temperature to the coil is less than the maximum found in the room or process.

CONVERTING DT1 TO DTM AIR COOLER RATINGS

Equations (1) and (2) above were used to derive the relationships shown in Equations (3) and (4) below which can be used to convert from known a DT1 air cooler rating to a new DTM rating for the same cooler.

$$\dot{q}_{DTM} = \frac{\dot{q}_{DT1} \cdot \frac{DTM}{DT1}}{\left(1 - \frac{\dot{q}_{DT1}}{2 \cdot 60 \cdot C_p \cdot \rho \cdot \dot{V} \cdot DT1}\right)} \quad \text{(IP)} \qquad (3)$$

$$\dot{q}_{DTM} = \frac{\dot{q}_{DT1} \cdot \frac{DTM}{DT1}}{\left(1 - \frac{\dot{q}_{DT1} \cdot 3600}{2 \cdot C_p \cdot \rho \cdot \dot{V} \cdot DT1}\right)} \quad \text{(SI)} \qquad (4)$$

where

$\dot{q}_{DTM}$ = capacity at mean (room) temperature difference, Btu/h (kW)
$\dot{q}_{DT1}$ = capacity at initial (air on) temperature difference, Btu/h (kW)
DT1 = initial temperature difference = Air On Temp - Evap Temp, F (C)
DTM = mean (room) temperature difference = Ave Room Temp – Evap Temp, F (C)
C_p = air specific heat, Btu/lbm F (kJ/kg C)
ρ = air density, lbm/ft3 (kg/m3)
$\dot{V}$ = actual volumetric air flow rate, ft3/min (m3/h)

Example:

An air cooler has a DT1 rating of 120,000 Btu/h at DT1 = 10F and -10F air on temperature. The cooler has a published airflow rating of 18,850 CFM. Assume the coil is operating with average air density = 0.0883 lbm/ft3, and average air specific heat = 0.24 Btu/lbm F. Note this is the same cooler shown in Figure 1 above.

Find the DTM rating for the same cooler with DTM = 10F.

From Equation (3):

$$\dot{q}_{DTM} = \frac{120{,}000 \cdot \frac{10}{10}}{\left(1 - \frac{120{,}000}{2 \cdot 60 \cdot 0.24 \cdot 0.0883 \cdot 18{,}850 \cdot 10}\right)} = 160{,}050\ Btu/h$$

As is seen from the example, DTM ratings are typically significantly higher than DT1 ratings for the same air cooler operating under the same conditions. In the case of the example, the DTM rating is +33% greater than the DT1 rating!

Note that the above equations apply only to sensible capacity calculations and ratings and do not account of the effects of latent cooling on coil performance and temperature change. The effects of latent load on coil performance and ratings are covered in the following sections.

LATENT LOAD AND SENSIBLE HEAT RATIO (SHR)

Whenever cooling coil surfaces operate at temperatures below the dew point of the air being cooled, water vapor in the airstream is condensed to liquid (at temperatures above 32F (0C)) or deposited to form frost (below 32F (0C)). The cooling effect associated with this dehumidification of the airstream is termed “latent” cooling. The sum of the sensible cooling load and latent cooling load is termed the “total” load. The ratio of the sensible cooling load divided by the total cooling load is called the Sensible Heat Ratio (SHR) and defines the slope of the air process line on a psychrometric chart.

$$SHR = \frac{Sensible\ Cooling\ Load}{Sensible\ Cooling\ Load + Latent\ Cooling\ Load} \qquad (5)$$

Accurate prediction of the refrigeration load, both sensible and latent components, is critical to proper refrigeration system equipment selection and successful operation. Various types of sensible cooling loads must be anticipated and included in the calculation, such as: lighting, electric motors, forklifts, product cooling/freezing, transmission of heat through walls, ceilings, and floors, and cooling of infiltration air. Latent cooling loads are present whenever moisture is added to the air in the refrigerated space. Sources of introduced moisture typically include: infiltration air, respiring food products, surface moisture on products, packaging, and other objects entering the space, human respiration, and humidification equipment (above freezing).

The SHR determined from the load calculation will come to equilibrium with the SHR of the air passing through the air cooler evaporator coil. In general, as air temperature decreases the amount of water vapor held in air decreases by the law of partial pressures, and the minimum possible SHR increases.

Relative humidity of the refrigerated space can be predicted by plotting the air process line on a psychrometric chart with the end point plotted on the saturation curve at the predicted coil surface temperature, and the air process line extending from left to right at a slope equal to the SHR. The intersection of this line with a vertical line drawn through the entering air dry bulb temperature indicates the relative humidity of the air entering the coil. Table 1 below shows typical Sensible Heat Ratios for various air temperatures at 95% air on relative humidity.

TABLE 1
SHR FOR 95% RH AIR ON AND DT1 = 10F AT VARIOUS TEMPERATURES

Room Temperature, F (C)	**SHR**
45 (7.2)	0.55
32 (0)	0.66
10 (-12.2)	0.83
0 (-17.8)	0.89
-10 (-23.3)	0.93
-30 (-34.4)	0.97

IMPACT OF LATENT LOAD (SHR) ON AIR COOLER RATINGS

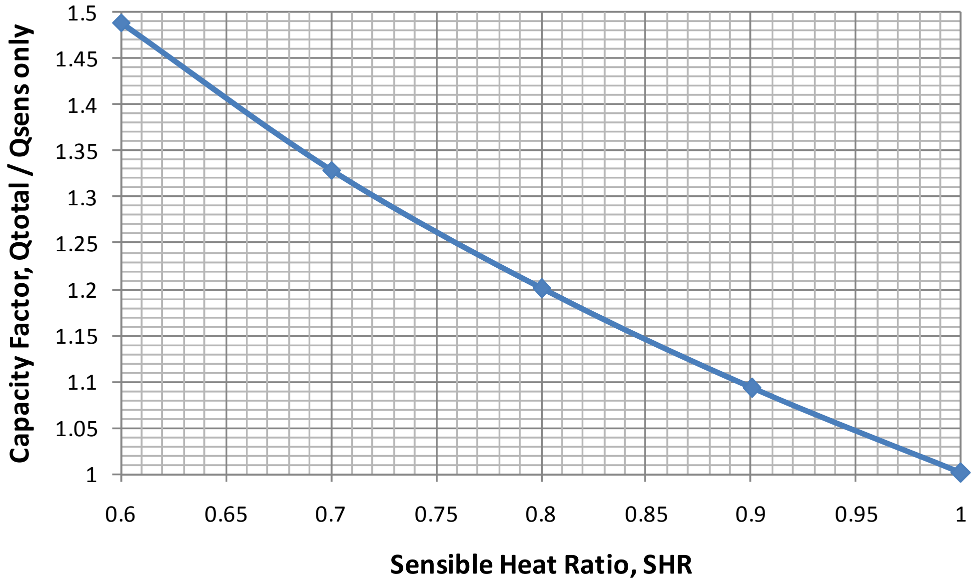
Evaporator coils are typically constructed of plate fins bonded to tubes. Fins are referred to as “secondary” surface while tubes are referred to as “primary” surface. For purposes of calculating evaporator performance, primary surface is considered to be 100% effective in its contribution to the total heat transfer surface area while secondary surface has a surface effectiveness less than 100% due to the change in surface temperature from the root to the tip of the fin.

The capacity of the evaporator surfaces to transfer mass (condense water, or deposit frost, from the airstream) is a function of the difference in water vapor pressure between the coil surface and air stream and the surface mass transfer coefficient. The mass transfer process is much more “thermally effective” than the sensible heat transfer process, that is, the heat flux through the evaporator surfaces during the mass transfer process is extremely high (AHRI 2001). Consequently, if the surface effectiveness of the coil were to remain constant, the increase in the evaporator cooling capacity during combined sensible and latent cooling would be equal to the sensible cooling capacity divided by the SHR, as follows:

$$Total\ Cooling\ Capacity_{Ideal} = \frac{Sensible\ Cooling\ Capacity}{SHR} \qquad (6)$$

However, the increase in heat flux through the fin surfaces has the effect of decreasing fin efficiency and overall surface effectiveness due to an increase in the fin surface temperature gradient (Xia & Jacobi 2005). The result is a slightly lower total cooling capacity than that predicted by Equation (6). Using a computer model developed to accurately calculate fin efficiency and surface effectiveness for both sensible and combined sensible and latent heat transfer, a prediction of the increase in evaporator coil performance as a function of SHR was made. Results of the predicted capacity increase as a function of SHR for an ammonia refrigeration evaporator coil operating over a wide range of room temperatures (+35F to -30F) and having typical fin spacings and geometry with DT1 = 10F are shown in Figure 2 below.

FIGURE 2
Total Cooling Capacity Factor vs SHR



Air cooler ratings which include latent cooling will appear higher (in some cases significantly higher) than all sensible ratings. Care must be taken, therefore, to correctly predict the cooling load SHR and the resulting relative humidity in the refrigerated space. From the above it should be apparent that selecting an air cooler with a rating based on a relatively high room relative humidity (SHR less than 1.0) for a room with an actual SHR equal to or close to 1.0 will result in undersized air coolers.

For example, a long term cold storage warehouse is designed for +0F (-17.8C) room temperature with a calculated SHR nearly equal to 1.0 (i.e. packaged products and minimal infiltration). From Table 1, the SHR for +0F air temperature and 95% relative humidity would be 0.89. From Figure 2, an air cooler rated on a total cooling basis at +0F and 95% air on relative humidity would show a nominal capacity +11% greater (capacity factor = 1.11) than a sensible only rating. In this case, therefore, air coolers selected using ratings based 95%rh air on would be significantly undersized.

CONCLUSIONS

U.S. air cooler manufacturers have traditionally published capacity ratings based on SHR = 1.0 (all sensible) and DT1. European manufacturers typically include latent cooling in their air cooler ratings, indicated by an air on relative humidity typically between 85% and 95%. European manufacturers also publish ratings based on either DT1 or DTM, or both. The discussion above illustrates the differences in these rating methods and highlights the importance of selecting air coolers using ratings suited to the operating conditions. Misapplication of DTM and/or total cooling ratings can result in severely undersized air coolers and the consequent failure of the refrigeration system to perform to energy efficiency and cooling capacity expectations.

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For more information contact Colmac Coil Manufacturing, Inc.
mail@colmaccoil.com; P: 800.845.6778 or 509.684.2595
P.O. Box 571, Colville, WA. 99114-0571; www.colmaccoil.com

COLMAC COIL Manufacturing Inc.

Technical Bulletin

By Bruce I. Nelson, P.E., President, Colmac Coil Manufacturing, Inc.

Comparing Air Cooler Ratings – Part 2: Why DTM Ratings Cost You Money

SUMMARY

As explained in a previous article, manufacturers of refrigeration evaporators publish ratings based on either average "room" temperature difference (DTM), or air on temperature difference (DT1). Compared to DT1 ratings, the DTM rating method results in evaporator selections which are undersized for the cooling load and will cause the system to operate with lower than expected suction temperatures. This article calculates the energy efficiency penalty resulting from selecting evaporators using DTM ratings, and puts the benefit of reduced power consumption when using DT1 ratings in terms of incremental return on investment (IROI). Depending on the room temperature and type of compression system (single or 2-stage) the IROI when using DT1 ratings can be as high as 156%, a simple payback of as short as 8 months!

BACKGROUND

In a previous article (Nelson 2010), two commonly used methods for rating refrigeration air coolers (evaporators), DT1 and DTM, were defined and quantified. DT1 and DTM refer to two different definitions of the difference between air temperature and evaporating temperature used to select an evaporator for a given cooling load.

DT1 = Air On Temperature – Evaporating Temperature
DTM = Average ("Room") Air Temperature – Evaporating Temperature

The effect of including latent cooling on ratings and evaporator selection was also discussed and explained.

It was shown that using DTM ratings allows the selection of air coolers which have less surface area compared to air coolers selected using DT1 ratings for the same cooling load and temperature difference. As with many things in life, "If something sounds too good to be true, it is too good to be true!". If coolers selected using DTM ratings have less surface area than DT1 coolers, then it follows that DTM rated coolers will operate with a lower suction temperature than DT1 rated coolers for the same cooling load.

This article, as a continuation of the previous discussion, quantifies exactly how much lower the operating suction temperature will be with DTM coolers and how much the system operating costs will increase as a result.

ROOM AIR TEMPERATURE GRADIENT AND DTM

DTM evaporator ratings assume a room air temperature gradient which is equal to the air temp change through the evaporator coil. Put another way, DTM assumes there is no (zero) mixing of the air leaving the evaporators with the room air. This is a false assumption which never occurs with ceiling hung air coolers discharging air from fans into the refrigerated space.
The cooled air leaving an evaporator is termed a non-isothermal jet of air. Air distribution in rooms created by jets of various configurations and aspects has been studied for some time (ASHRAE 2009, Li et al 1993). While air change effectiveness is very difficult to predict precisely, the air throw, spread, fall, and entrainment ratio of free air jets can be estimated using various formulas.

The final air temperature gradient in a refrigerated room will ultimately be determined by the effective mixing of the cooled air leaving the evaporators with the room air. Over the length of a free air jet, the amount of mixing that takes place can be quantified by calculating the entrainment ratio.

At a distance of 25 to 100 fan diameters from the point of discharge, the entrainment ratio for a horizontal free air jet can be determined using the following formula:

$$\frac{Q_x}{Q_0} = \frac{2X}{K_c\sqrt{A_0}} \tag{1}$$

Where

$Q_x = Total\ airflow\ rate\ at\ distance\ X\ from\ face\ of\ the\ outlet$
$Q_0 = Airflow\ rate\ measured\ at\ the\ outlet$
$X = Distance\ from\ face\ of\ the\ outlet$
$K_c = Centerline\ velocity\ constant\ determined\ by\ testing$
$A_0 = Jet\ discharge\ area$

Using equation (1) we can estimate the temperature gradient in a refrigerated space knowing only the air temperature change through the evaporator(s), the length of the room, and the number and diameter of the evaporator fans.

Example:

Two evaporators are ceiling hung in a cold storage room which is 36 m long. Each evaporator has 3 x 762 mm diameter fans.

Given:
Air temperature change through the evaporator(s): 3 deg C
Assume a centerline velocity constant of 4.5, which is typical for fans with wire fan guards

Calculated:
Total fan discharge area per evaporator: 3 x 0.46 sq m per fan = 1.37 sq m

Assuming the average entrainment ratio for the room will be found at half the distance to the back wall, a distance of 36 / 2 = 18 m will be used.

$$Average\ Entrainment\ Ratio = \frac{2\ x\ 18}{4.5\ x\ \sqrt{1.37}} = 6.8$$

Since the entrainment ratio indicates the amount of air mixing that will take place in the room, the average room temperature gradient will be approximately equal to the air temperature change through the evaporator divided by the average entrainment ratio.

$$Average\ Room\ Temp\ Gradient = \frac{Temp\ Change\ Through\ Evaporator}{Average\ Entrainment\ Ratio} = \frac{3}{6.8} = 0.4\,\mathrm{deg}\,C$$

The above analysis clearly shows that the DTM assumption that room temperature gradient is equal to the air temperature change through the evaporator, is NOT valid.

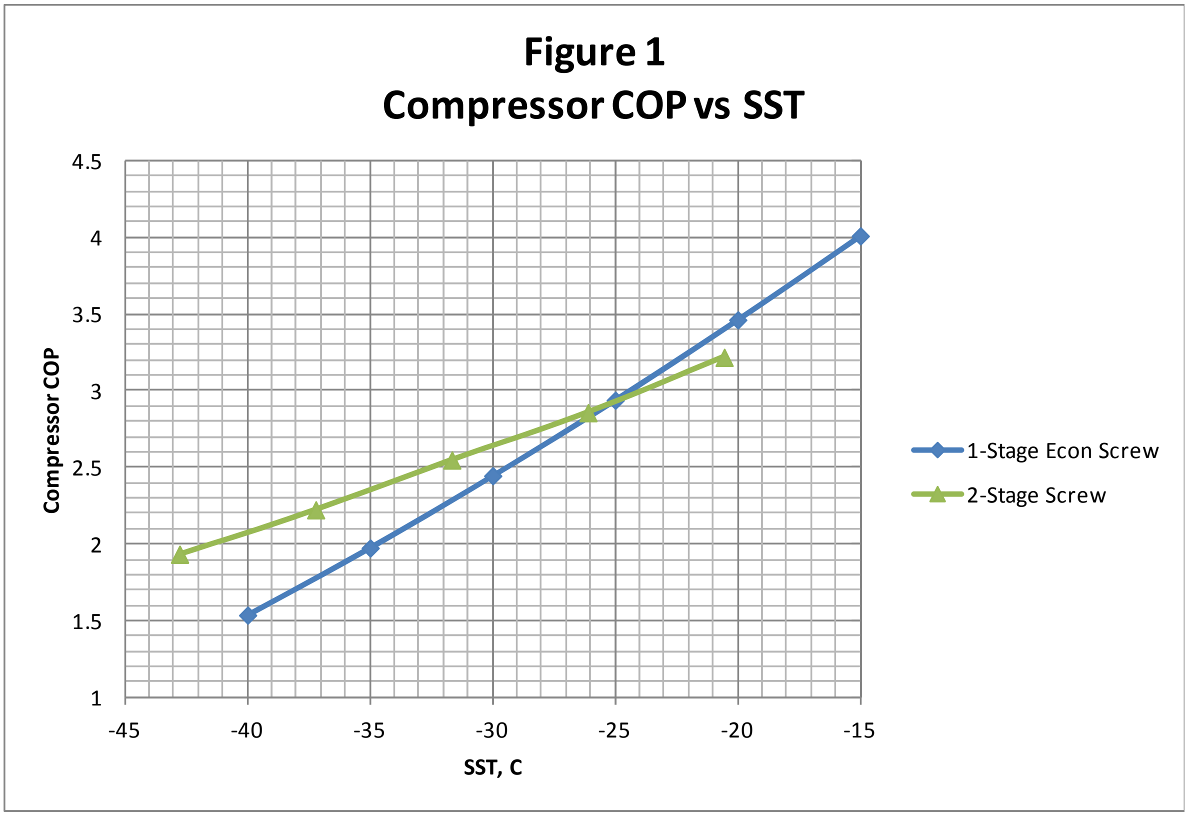
Because of the mixing effect of the entrainment ratio, evaporators selected using DTM ratings will be undersized for the load and will operate with a suction temperature that is lower than expected in order to achieve the design cooling capacity.

Using the DT1 rating method, on the other hand, assumes there is complete mixing of the air in the refrigerated space. Put another way, DT1 conservatively assumes an infinite entrainment ratio and therefore no room air temperature gradient. While this is not absolutely true, it is much closer to reality and results in operating suction temperatures much closer to design compared to evaporators selected using DTM ratings.

The next sections examine the increase in operating costs resulting from the lower operating suction temperatures required by DTM rated evaporators compared to DT1 rated evaporators.

EFFECT OF SUCTION TEMPERATURE ON ENERGY CONSUMPTION

For a given fixed condensing temperature, all compressors lose efficiency as suction pressure falls. With



ammonia, the Coefficient of Performance (COP) falls approximately 2.0 to 3.6% for every 1 deg C reduction in suction temperature (Stoecker 1998). Figure 1 shows compressor COP vs suction temperature for typical single stage and 2-stage screw compressor systems at a condensing temperature of 29.4 deg C (85 deg F). Below about -25 deg C (-13 deg F) suction temperature, 2-stage compression systems operate with higher COP compared to single stage compression with economizing (Jekel 2008).

As explained in the previous section, evaporators selected using DTM ratings will cause the system to operate at a lower than expected suction temperature compared to evaporators selected using DT1 ratings. Using the relationships shown in Figure 1 along with fundamental evaporator capacity relationships we can determine how much additional power will be consumed by system compressors when evaporators are selected based on DTM ratings.

POWER CONSUMPTION COMPARISON DTM VS DT1

Two sets of evaporators having the same total airflow rate will be selected for the same cooling load and temperature difference, one on the basis of DTM and the other on the basis of DT1, to answer the questions:

1. What will the difference in actual operating suction temperatures be between DTM and DT1 evaporators?
2. What will be the resulting difference in compressor power consumption?
3. What incremental return on investment benefit will result from selecting evaporators using DT1 ratings instead of DTM ratings?

Assumptions:

- Total Cooling Load: 352 kW (100 TR)
- Temperature Difference, TD: 6.67 deg C (12 deg F)

- Sensible Heat Ratio: 1.0 (all sensible cooling)
- Saturated Condensing Temperature: 29.4 deg C (85 deg F)
- Airflow Rate: 302,308 m3/h (177,930 cfm)
- Specific Heat of Air: 1.005 kJ/kg K (0.24 Btu/lbm F)
- Cost of Electricity: $0.15/kWh
- Price of DT1 Rated Evaporators: $1,600/kW C
- Air in the room is fully mixed. i.e. Zero or very little room temperature gradient

Based on the above, the following calculations were made for a range of air temperatures and shown in Tables 1 and 2 below:

Air Density: $$\rho_a = 1.225\ x\ \frac{(273.15 + 15)}{(273.15 +\ T_0)} \qquad (2)$$

Rated DTM Air On Temp: $$T_{on\ DTM} =\ T_0 + \frac{\dot{q}}{2\ x\ \frac{Q}{3600}\ x\ \rho_a\ x\ C_p} \qquad (3)$$

Rated DTM Air Off Temp: $$T_{off\ DTM} =\ T_{on\ DTM} - \frac{\dot{q}}{\frac{Q}{3600}\ x\ \rho_a\ x\ C_p} \qquad (4)$$

Rated DTM Suction Temp: $$T_{evap\ DTM} =\ T_0 -\ TD \qquad (5)$$

DTM Effectiveness: $$\varepsilon = \frac{T_{on\ DTM} - T_{off\ DTM}}{T_{on\ DTM} - T_{evap\ DTM}} \qquad (6)$$

Actual DTM Air On Temp: $$T'_{on\ DTM} =\ T_0 \qquad (7)$$

Actual DTM Air Off Temp: $$T'_{off\ DTM} =\ T'_{on\ DTM} - \frac{\dot{q}}{\frac{Q}{3600}\ x\ \rho_a\ x\ C_p} \qquad (8)$$

Actual DTM Suction Temp: $$T'_{evap\ DTM} =\ T'_{on\ DTM} - \frac{T'_{on\ DTM} - T'_{off\ DTM}}{\varepsilon} \qquad (9)$$

Actual DT1 Air On Temp: $$T_{on\ DT1} =\ T_0 \qquad (10)$$

Actual DT1 Air Off Temp: $$T_{off\ DT1} =\ T_{on\ DT1} - \frac{\dot{q}}{\frac{Q}{3600}\ x\ \rho_a\ x\ C_p} \qquad (11)$$

Actual DT1 Suction Temp: $$T_{evap\ DT1} =\ T_{on\ DT1} -\ TD \qquad (12)$$

DTM Power Used: $$PU_{DTM} = 365\frac{days}{y} x\ 24\frac{h}{day}\ x\ \frac{\dot{q}}{COP_{DTM}} \qquad (13)$$

DT1 Power Used: $$PU_{DT1} = 365\frac{days}{y} x\ 24\frac{h}{day}\ x\ \frac{\dot{q}}{COP_{DT1}} \qquad (14)$$

DT1/DTM Price Ratio: $$PR = \frac{T_{on\ DTM} - T_{evap\ DTM}}{TD} \qquad (15)$$

DT1 Price Premium: $$PP = (PR - 1)\ x\ \frac{\$1600/(kW/C)\ x\ \dot{q}}{TD} \qquad (16)$$

DT1 v DTM Simple Payback: $$SPB = \frac{PP}{(PU_{DTM} - PU_{DT1})\ x\ \$0.15/kWh} \quad (17)$$

Incremental Return on Investment: $$IROI = \frac{1}{SPB}\ x\ 100 \quad (18)$$

TABLE 1					
SINGLE STAGE (ECONOMIZED) POWER CONSUMPTION COMPARISON					
Room Temp, C	-12.2	-17.8	-23.3	-28.9	-34.4
Room Temp, F	10	0	-10	-20	-30
Air Density, kg/m3:	1.35	1.38	1.41	1.45	1.48
Rated DTM Air On, C:	-10.7	-16.3	-21.9	-27.4	-33.0
Rated DTM Air Off, C:	-13.8	-19.3	-24.8	-30.3	-35.9
Rated DTM SST, C:	-18.9	-24.4	-30.0	-35.6	-41.1
Rated DTM SST, F:	-2.0	-12.0	-22.0	-32.0	-42.0
DTM Effectiveness:	0.38	0.37	0.36	0.36	0.35
Actual DTM Air On, C:	-12.2	-17.8	-23.3	-28.9	-34.4
Actual DTM Air Off, C:	-15.3	-20.8	-26.3	-31.8	-37.3
Actual DTM SST, C:	-20.4	-26.0	-31.5	-37.0	-42.5
Actual DTM SST, F:	-4.8	-14.7	-24.7	-34.6	-44.5
DTM COP (29.44C SCT):	3.42	2.84	2.30	1.80	1.33
Actual DT1 Air On, C:	-12.2	-17.8	-23.3	-28.9	-34.4
Actual DT1 Air Off, C:	-15.3	-20.8	-26.3	-31.8	-37.3
Actual DT1 SST, C:	-18.9	-24.4	-30.0	-35.6	-41.1
Actual DT1 SST, F:	-2.0	-12.0	-22.0	-32.0	-42.0
DT1 COP (29.44C SCT):	3.58	3.00	2.44	1.93	1.44
DTM Power Used, kWh/y:	901,854	1,083,296	1,337,619	1,714,718	2,319,003
DT1 Power Used, kWh/y:	860,264	1,027,953	1,260,360	1,600,079	2,133,436
Savings/y, $:	$6,239	$8,302	$11,589	$17,196	$27,835
DT1/DTM Price Ratio:	1.23	1.23	1.22	1.22	1.21
DT1 Cooler Cost, $ / (kW/C):	$1,600	$1,600	$1,600	$1,600	$1,600
DT1 Price Premium, $:	$19,482	$19,067	$18,652	$18,238	$17,823
DT1 Simple Payback, y:	3.12	2.30	1.61	1.06	0.64
DT1 Incremental ROI, %/y:	32.0%	43.5%	62.1%	94.3%	156.2%

TABLE 2					
2-STAGE POWER CONSUMPTION COMPARISON					
Room Temp, C	-12.2	-17.8	-23.3	-28.9	-40.0
Room Temp, F	10	0	-10	-20	-40
Air Density, kg/m3:	1.35	1.38	1.41	1.45	1.51
Rated DTM Air On, C:	-10.7	-16.3	-21.9	-27.4	-38.6
Rated DTM Air Off, C:	-13.8	-19.3	-24.8	-30.3	-41.4
Rated DTM SST, C:	-18.9	-24.4	-30.0	-35.6	-46.7
Rated DTM SST, F:	-2.0	-12.0	-22.0	-32.0	-52.0
DTM Effectiveness:	0.38	0.37	0.36	0.36	0.34
Actual DTM Air On, C:	-12.2	-17.8	-23.3	-28.9	-40.0
Actual DTM Air Off, C:	-15.3	-20.8	-26.3	-31.8	-42.8
Actual DTM SST, C:	-20.4	-26.0	-31.5	-37.0	-48.0
Actual DTM SST, F:	-4.8	-14.7	-24.7	-34.6	-54.5
DTM COP (29.44C SCT):	3.42	2.89	2.56	2.24	1.70
Actual DT1 Air On, C:	-12.2	-17.8	-23.3	-28.9	-40.0
Actual DT1 Air Off, C:	-15.3	-20.8	-26.3	-31.8	-42.8
Actual DT1 SST, C:	-18.9	-24.4	-30.0	-35.6	-46.7
Actual DT1 SST, F:	-2.0	-12.0	-22.0	-32.0	-52.0
DT1 COP (29.44C SCT):	3.58	3.00	2.65	2.32	1.75
DTM Power Used, kWh/y:	901,854	1,065,634	1,204,661	1,376,579	1,816,120
DT1 Power Used, kWh/y:	860,264	1,027,953	1,164,475	1,328,353	1,756,369
Savings/y, $:	$6,239	$5,652	$6,028	$7,234	$8,963
DT1/DTM Price Ratio:	1.23	1.23	1.22	1.22	1.21
DT1 Cooler Cost, $ / (kW/C):	$1,600	$1,600	$1,600	$1,600	$1,600
DT1 Price Premium, $:	$19,482	$19,067	$18,652	$18,238	$17,408
DT1 Simple Payback, y:	3.12	3.37	3.09	2.52	1.94
DT1 Incremental ROI, %/y:	32.0%	29.6%	32.3%	39.7%	51.5%

CONCLUSIONS

The author has examined two commonly used rating methods for refrigeration evaporators, DTM and DT1. The following conclusions are based on the results of the discussion:

1. The DTM rating method assumes an air entrainment ratio of 1, that is to say, the room air temperature gradient equals the air temperature change through the evaporator coil. This is a fundamentally flawed assumption and results in an artificially high assumed temperature difference between air on temperature and evaporating temperature.
2. Because of the artificially high assumed temperature difference, evaporators selected using DTM ratings will have less surface area and will cost less than evaporators selected using DT1 ratings.
3. Because DTM ratings result in undersized evaporator selections, the operating system suction temperature will be lower than expected. This results in greater compressor power consumption compared to evaporators selected using DT1 ratings.

4. Selecting evaporators based on DT1 ratings avoids the DTM power consumption penalty and results in significant energy savings due to higher operating suction temperatures. In the examples given, the beneficial DT1 Incremental Return on Investment (IROI) for the single stage compression case ranged from 32% to 156% per year. For the 2-stage compression case, the DT1 IROI ranged from 32% to 52% per year.

NOMENCLATURE

$A_0 = Jet\ discharge\ area, m^2$
$IROI = Incremental\ return\ on\ investment, \%/y$
$K_c = Centerline\ velocity\ constant\ determined\ by\ testing, dimensionless$
$PP = DT1\ price\ premium, \$$
$PR = \frac{DT1'}{DT1}\ price\ ratio, dimensionless$
$PU_{DT1} = DT1\ power\ consumption, {kWh}/{y}$
$PU_{DTM} = DTM\ power\ consumption, {kWh}/{y}$
$\dot{q} = Cooling\ load, kW$
$Q = Evaporator\ airflow\ rate, {m^3}/{h}$
$Q_0 = Airflow\ rate\ measured\ at\ the\ outlet, {m^3}/{h}$
$Q_x = Total\ airflow\ rate\ at\ distance\ X\ from\ face\ of\ the\ outlet, {m^3}/{h}$
$\frac{Q_x}{Q_0} = Entrainment\ ratio$
$SPB = DT1\ vs\ DTM\ simple\ payback, y$
$T_0 = Room\ air\ temperature, C$
$TD = Air\ minus\ evaporating\ temperature\ difference, C$
$T_{on\ DT1} = Actual\ DT1\ air\ temperature\ entering\ the\ evaporator, C$
$T_{off\ DT1} = Actual\ DT1\ air\ temperature\ leaving\ the\ evaporator, C$
$T_{evap\ DT1} = Actual\ DT1\ evaporating\ (suction) temperature, C$
$T_{on\ DTM} = Rated\ DTM\ air\ temperature\ entering\ the\ evaporator, C$
$T_{off\ DTM} = Rated\ DTM\ air\ temperature\ leaving\ the\ evaporator, C$
$T_{evap\ DTM} = Rated\ DTM\ evaporating\ (suction) temperature, C$
$T'_{on\ DTM} = Actual\ DTM\ air\ temperature\ entering\ the\ evaporator, C$
$T'_{off\ DTM} = Actual\ DTM\ air\ temperature\ leaving\ the\ evaporator, C$
$T'_{evap\ DTM} = Actual\ DTM\ evaporating\ (suction) temperature, C$
$X = Distance\ from\ face\ of\ the\ outlet, m$
$C_p = Air\ specific\ heat\ capacity, {kJ}/{kg\ K}$
$\varepsilon = Evaporator\ effectiveness, dimensionless$
$\rho_a = Air\ density, {kg}/{m^3}$

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For more information contact Colmac Coil Manufacturing, Inc.
mail@colmaccoil.com; P: 800.845.6778 or 509.684.2595
P.O. Box 571, Colville, WA. 99114-0571; www.colmaccoil.com

Technical Bulletin

By Bruce I. Nelson, P.E., President, Colmac Coil Manufacturing, Inc.

Comparing Ammonia Evaporator Construction: *"Which one is best?"*

Abstract

Industrial ammonia evaporator manufacturers offer several types of construction including: galvanized steel, stainless steel tubes with aluminum fins, stainless steel tubes with stainless steel fins, and aluminum tubes with aluminum fins, as well as a number of corrosion resistant coatings. Trying to decide on the right one for a given facility and/or process can be confusing and leads to the question: "Which one is best for my application?" The metals used in each type of construction mentioned above have unique properties which affect the evaporator in terms of thermal performance, weight, defrost energy, corrosion resistance, and cost. Good performance and energy efficiency have a direct positive effect on return on investment for the facility. The weight of the evaporators may affect the roof structure of the building in the case of ceiling or roof mounted units, especially in high seismic zones. In food processing plants where harsh cleaning chemicals are increasingly used on evaporators, appropriate corrosion resistance behavior is critical. The article examines the different types of construction and their characteristics and makes recommendations regarding which type of construction best suits specific applications and operating environments.

Background

Air-cooling evaporators ("air coolers") used in ammonia systems have traditionally been made using galvanized (zinc coated) carbon steel. There are other metals which exhibit excellent compatibility with ammonia, including stainless steel and aluminum.

Designers and installers of industrial ammonia evaporators must be concerned with the cost, weight, performance, and reliability of the equipment being specified. Additionally, there may be requirements for corrosion resistance, cleanability, and defrosting characteristics, which need to be considered.

Aluminum is a good choice for both tubes and fins. The surface of the metal is naturally passivated (the protective oxide layer is stabilized) when directly exposed to ammonia, leading to its widespread use for ammonia-containing vessels, pipe, and tubing. The properties of aluminum also make it an ideal metal to use as fin material. Aluminum is low cost, lightweight, highly conductive, and corrosion resistant.

Some of the properties of stainless steel make it an excellent choice for tubing in ammonia heat exchangers. It has very high tensile strength, which results in high working pressures. Stainless steel is highly corrosion resistant which minimizes the potential for ammonia leaks in hostile environments. It is readily available commercially and is widely used in the food processing industries for piping, vessels, and equipment. It is also easily repaired in the field by welding.

Negative aspects of using stainless steel in heat exchangers are its high relative cost and very low thermal conductivity. These negative characteristics can be mitigated by: a) specifying the wall thickness of the tubing to match the required working pressure of the system, and b) using another more conductive metal, such as aluminum, as the fin material.

Three types of evaporator construction using these metals are in common use and are widely available from a number of manufacturers:

1. Hot Dip Galvanized Steel (Stl/Zn)
2. Stainless Steel Tubes with Aluminum Fins (SST/Al)
3. Aluminum Tubes with Aluminum Fins (Al/Al)

Trying to decide which of these metals and types of construction are the best choice for a given application and duty can be confusing. In order to answer the question "Which one is best?", this article will make a comparison of the following characteristics of each type of construction:

- Strength
- Cost/Price
- Weight
- Performance
- Defrosting
- Corrosion Resistance
- Reliability

Comparison of Properties:

Table 1 below compares several properties of stainless steel and aluminum to those of carbon steel and zinc. Galvanized steel is obtained by dipping carbon steel in a bath of molten zinc, hence these two base metals are shown in the table.

TABLE 1
Properties of Various Metals

Metal	Density, lbm/cu ft	Thermal Conductivity, Btu/sq ft h F ft	Specific Heat Capacity, Btu/lbm F	Tensile Strength, ksi
Carbon Steel	490	26	0.107	47
Zinc	445	65	0.094	21
304L Stainless Steel	501	9.4	0.120	70
3003 Aluminum	165	117	0.215	14

The density of the metal directly affects the weight of the heat exchanger, and when multiplied by the specific heat capacity the product indicates the amount of energy required to heat up and cool down the heat exchanger during a defrost cycle.

The thermal conductivity of the metal affects the thermal performance of the heat exchanger, as well as the speed and effectiveness of defrost.

The tensile strength of the metal will determine the burst pressures of the heat exchanger tubes and headers for a given wall thickness. It is interesting to note that various metals behave differently at low temperatures. Carbon steel becomes brittle at temperatures below –20F. Special allowances must be made when designing with carbon steel below –20F such as using special impact tested material, increasing the wall thickness of the pipe, and post-weld heat treating to avoid failures caused by embrittlement of the metal. Table 2 below shows the normal allowable working temperature range for various metals.

TABLE 2
Normal Allowable Working Temperature Range for Various Metals*

Metal	Allowable Working Temperature Range, F
Carbon Steel (SA-179)	-20 to +500
304L Stainless Steel (SA-249)	-320 to +300
3003 Aluminum (SA-210)	-452 to +400

* Taken from ASME Pressure Vessel Code, Section II, Part D.

It is apparent from Table 2 that stainless steel and aluminum offer excellent performance in low temperature freezer applications compared to galvanized steel.

Comparison: Working Pressure

Maximum Allowable Working Pressure (MAWP) is an important design parameter which must be calculated by the designer (or manufacturer) to insure the pressure bearing parts of the refrigeration system will not fail when exposed to the maximum anticipated operating pressures. Standard ANSI/IIAR 2-2008 (IIAR 2008) states that, for forced air evaporator coils: "Minimum design pressure shall be 150 psig [1030 kPa gage] or in the case where hot gas defrost is utilized, minimum design pressure shall be 250 psig [1720 kPa gage] or the design pressure of the high side source of hot gas, whichever is greater" (Section 8.1.1.1). The standard also states that, for air-cooled ammonia condensers: "Minimum design pressure shall be 300 psig [2070 kPa gage]" (Section 7.1.1.1).

The MAWP for a pressure vessel (i.e. evaporator pipe or tube) can be easily calculated from the ASME Pressure Vessel Code Section VIII when the following parameters are known: diameter, wall thickness, corrosion allowance, maximum allowable stress, and joint efficiency. Table 3 below shows calculated MAWP for 7/8" (22 mm) diameter tubes of various metals and commonly used wall thicknesses.

TABLE 3

MAX. ALLOWABLE WORKING PRESSURE FOR SHELLS UNDER INTERNAL PRESSURE

(CALCULATIONS BASED ON ASME SECTION VIII, 2002 ADDENDA, UG-27)

Pipe/Tube Dia., (in)	Pipe/Tube Wall, (in)	Pipe/Tube Matl	Corrosion Allowance, (in)	Max. allowable Working Press, bar (P)	Max. allowable Working Press, psig (P)	Max. allowable Stress Value (PSI) (S)
7/8	0.028	304L SST	0.002	51	738.2	14200
7/8	0.049	SA-179 CS	0.002	88	1284.7	13400
7/8	0.065	3003 Alum	0.002	31	443.7	3400

As shown in the table, the calculated MAWP for all of the metals being compared easily exceed the 300 psig mentioned above from ANSI/IIAR-2.

Comparison: Cost and Weight

The relative cost (and resulting price) and weight of an evaporator are obviously important considerations when selecting the appropriate type of evaporator construction for a given project. On a per pound basis, carbon steel is lower in cost than both stainless steel and aluminum. This cost differential is offset for aluminum, however, by the metal's low density. Since stainless steel has such a high tensile strength (see Table 1), the wall thickness of the stainless steel tubing can be safely reduced, which reduces the tubing cost per foot accordingly. The expensive process of hot dip galvanizing is not required for stainless tube/aluminum fin construction, which further offsets the higher cost per pound of these metals compared to carbon steel.

In order to make an accurate comparison of the three types of construction (Stl/Zn, SST/Al, and Al/Al) a calculation of relative weight and cost (using current material costs) was made for a typical ammonia evaporator coil block having the following characteristics:

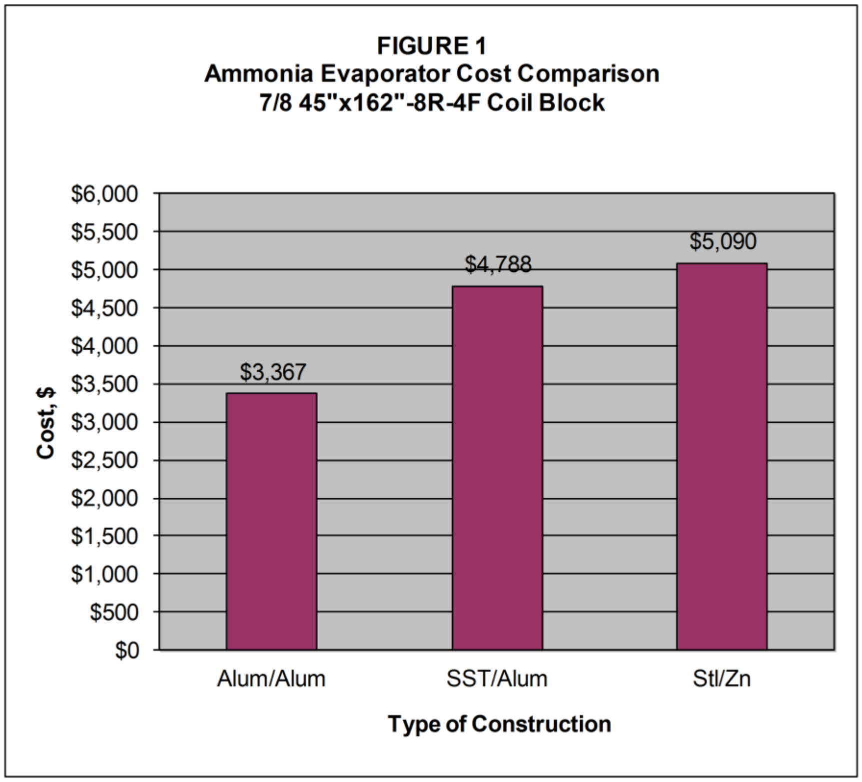
- 7/8" (22 mm) diameter tubes
- 45" FH x 162"FL (1143mm FH x 4115mm FL) – 8 Rows – 4 FPI
- Approximate cooling capacity = 15 TR (53 kW)

Cost:

Figure 1 shows the cost comparison for the three types of construction. As mentioned above, the low density of aluminum combined with its relatively low cost per pound makes Al/Al construction the lowest cost type of construction.

Generally speaking the following conclusions can be made:

1. Stl/Zn construction is most expensive,
2. SST/Al construction costs slightly less than Stl/Zn,
3. Al/Al construction offers lowest cost
   - 25 to 30% lower cost coil block compared to Stl/Zn,
   - 12 to 15% lower cost air cooler compared to Stl/Zn.

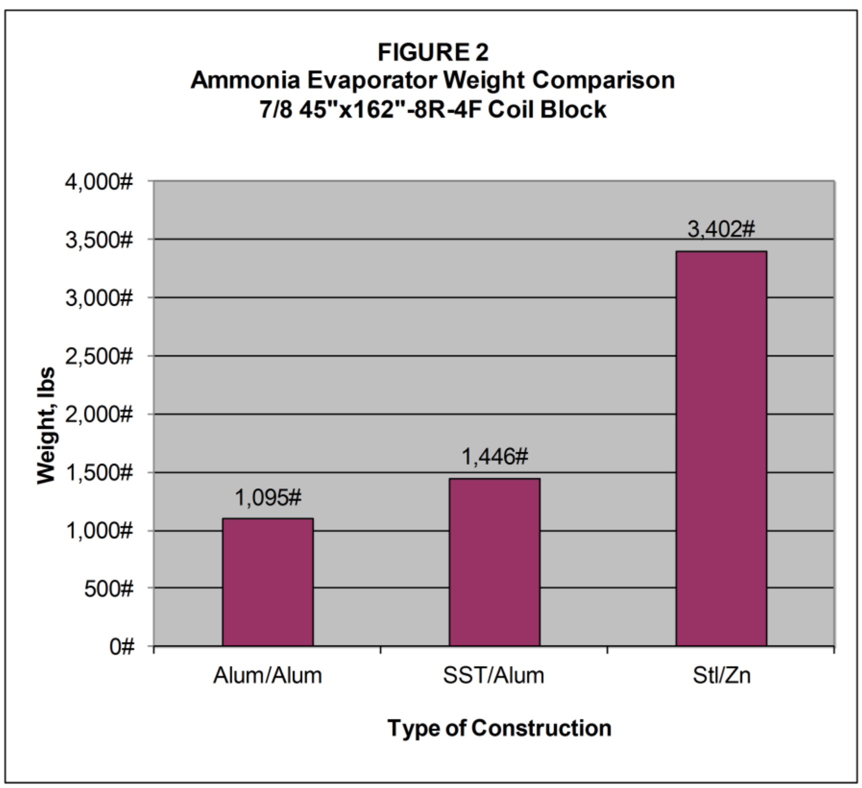


Weight:

The very low density of aluminum makes it an ideal metal to use for heat exchanger fins when weight is a concern. Table 1 shows densities for carbon steel, zinc, and aluminum. The densities of steel and zinc (galvanized steel) are approximately 3 times greater than aluminum. In a refrigeration evaporator, the fins represent approximately ½ the total weight of the coil block. Most of the remaining weight of the coil block is contributed by the tubes and headers.

Tensile and yield strength of the tubing and header metal will affect the wall thickness required for a given working pressure. The higher the tensile strength, the thinner the allowable wall thickness and the lighter the weight of the tubing. From Table 1 it is apparent that tubing made of stainless steel will have a thinner wall thickness and lighter weight when compared to carbon steel tubing for a given calculated working pressure and burst pressure.

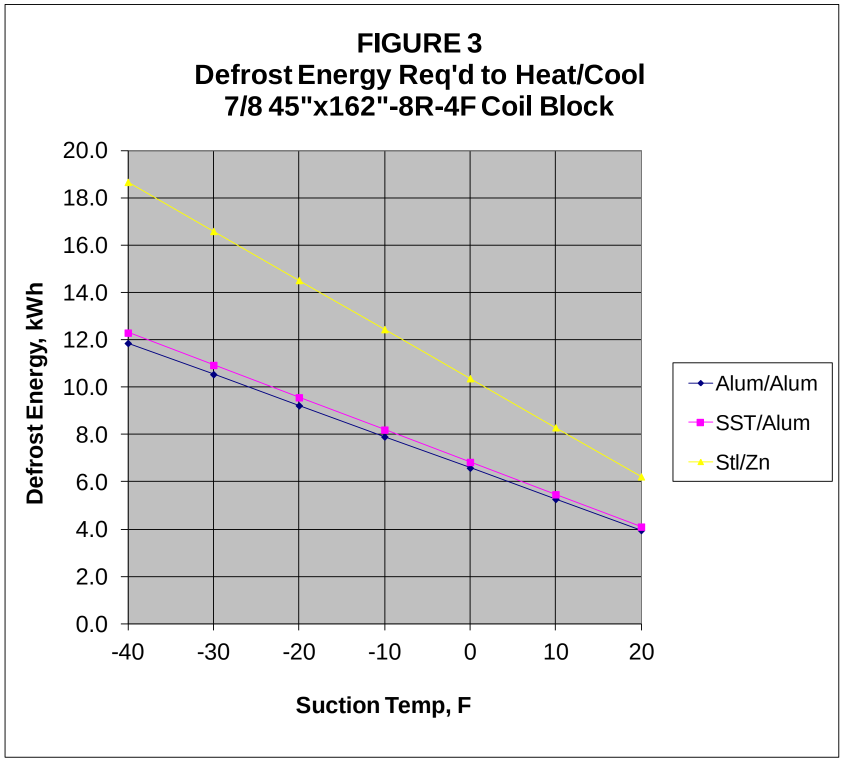
Using appropriately selected stainless steel tubing with aluminum fins produces a coil block that is significantly lighter in weight than the same size galvanized steel coil block. A coil block made with both aluminum tubes and fins is even lighter in weight. Figure 2 shows the calculated weights for the three types of construction.



As can be seen in Figure 2, the calculated weight of the galvanized steel (Stl/Zn) coil block (3,402 lbs) is 2.4 times greater than a stainless tube/aluminum fin (SST/Alum) coil block (1,446 lbs), and 3.1 times greater than an aluminum tube and fin (Al/Al) coil block of the same size.

Air coolers are often mounted on the ceiling or roof of the refrigerated building. The weight of the air coolers has a significant impact on the structural design of the building and is of particular importance in high seismic areas. SST/Al and particularly Al/Al air coolers from Colmac offer architects and engineers a new replacement technology to traditional heavy galvanized air coolers. This weight advantage can be used to significantly reduce the cost of building structural members.

The lighter weight of SST/Al and Al/Al air coolers from Colmac also offer installers improved safety for workers when rigging and handling. It is easy to visualize the safety advantages of mounting a cooler weighing only 2,000 lbs in a building with a 25 foot ceiling compared with a heavy galvanized steel cooler of the same capacity weighing 5,000 lbs or more!



Comparison: Performance

The thermal conductivity of aluminum is 4 ½ times higher than steel, and 2 times higher than zinc. Thermal conductivity of the fin material has a direct effect on heat transfer efficiency, the higher the better. Aluminum is superior to galvanized steel for efficient heat transfer. The measured performance of an Al/Al ammonia evaporator will be approximately 12 to 14% higher than a Stl/Zn evaporator having the same dimensions (Stencel 1992). A SST/Al ammonia evaporator will have slightly lower performance than the Al/Al due to the poor conductivity of the stainless steel tubing, but will still outperform a Stl/Zn evaporator of the same dimensions by 10 to 12%.

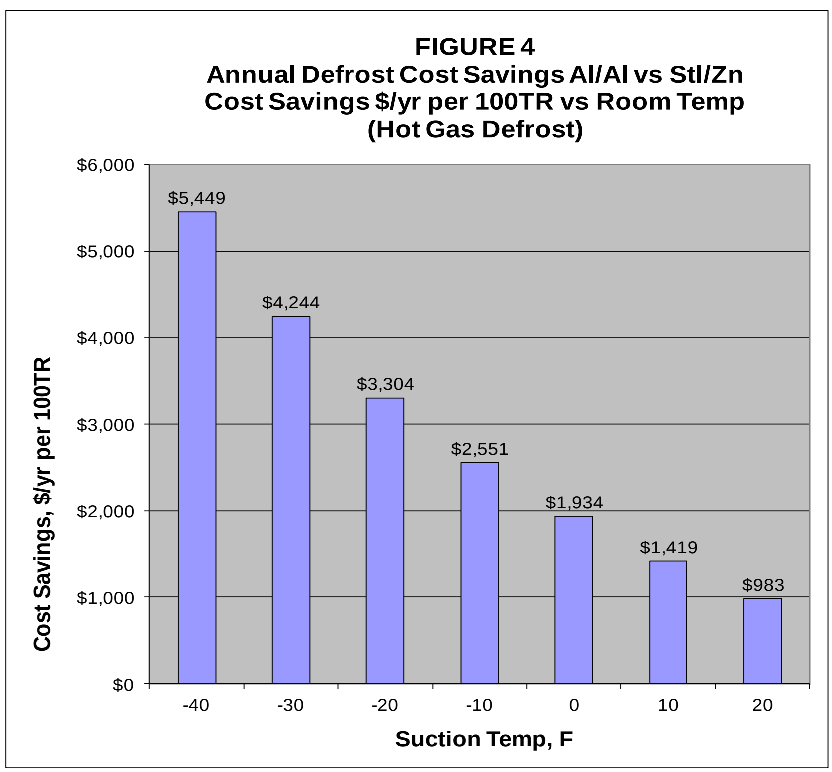
The superior cooling capacity of Al/Al and SST/Al construction compared to Stl/Zn allows the designer the choice between (a) selecting an evaporator having fewer rows and/or wider fin spacing for lower first cost, or (b) using the same size unit (same rows and fin spacing) and operating at higher suction pressures with resulting reduced operating costs.

Comparison: Defrost Energy

The high thermal conductivity of aluminum fins also produces faster, more effective defrosts compared to galvanized steel. SST/Al and Al/Al evaporators simply defrost faster and better than Stl/Zn steel coils.

SST/Al and Al/Al evaporators also perform better than Stl/Zn during defrost on an energy basis. A substantial amount of energy is expended during defrost to heat the mass of metal in a refrigeration evaporator up to the defrost temperature, then to cool the metal back down to operating temperature after defrost. When the density of the metal is multiplied by the thermal conductivity the product indicates the amount of energy required to heat (or cool) a heat exchanger of a given volume by one degree.

Based on this analysis, a comparison was made for our example evaporators. Figure 3 shows the total amount of energy required to heat the coil block from suction temperature to 50F and then cool it back to down again. This energy is expended every defrost cycle.



As shown in Figure 3, the Al/Al and SST/Al coil blocks consume significantly less energy to heat up and cool down during defrost (30 to 35% less) than the Stl/Zn coil block. This reduced amount of energy required for heating and cooling metal results in significant ongoing savings in operating costs compared with traditional energy consuming Stl/Zn evaporators.

Defrost Energy Savings

This difference in energy consumption can be converted to cost savings by making assumptions for number of defrosts per day, days of operation per year, and the electric utility rate. A cost calculation was made for 100TR (350 kW) of evaporator capacity, assuming 6 defrosts per day for 365 days/year, a utility rate of $0.10/kWh, typical screw compressor system COPs (assumed defrost is with hot gas), and a hot defrost pressure regulator setting of 74.3 psig (50F). Calculated cost savings for hot gas defrost are shown in Figure 4.

Comparison: Corrosion Resistance

Corrosion of heat exchangers by contact with, or proximity to foodstuffs is a concern in food processing facilities (Nelson 2007). All foodstuffs are mildly acidic. Aluminum and stainless steel are both more corrosion resistant than galvanized steel when exposed to:

- Acetic and citric acids (dairy products, citrus products)
- Fatty acids (anti-caking agents, lubricants)
- Lactic acids (bread, confections, beverages, fermentation, blood)

Aluminum is also more corrosion resistant than galvanized steel in the presence of:

- Sodium chloride (preservation of meats and vegetables)
- Sulfur dioxide (grape storage)

Neither galvanized steel nor aluminum is recommended for exposure to nitrites (cured and smoked meats). Stainless steel is the suggested material to use in the presence of nitrites.

Generally speaking, aluminum and stainless steel are better metals to use than galvanized steel where there is concern about corrosion due to contact with most foodstuffs.

Cleaning Chemicals

In order to control contamination of food in processing facilities, various chemical compounds are used for cleaning and sanitizing. Cleaning is defined as the removal of organic soils (fats and oils) and/or inorganic soil (mineral scale or stains). Sanitizing is defined as the process of treating cleaned surfaces to effectively kill or remove pathogens.

The USDA requires that these two processes, cleaning and sanitizing, be done separately. Cleaning and sanitizing chemicals used in the food processing industry fall into four catagories:

1. Acidic
2. Strongly Alkaline
3. Mildly Alkaline
4. Chlorine Based

Zinc, Aluminum, and Stainless Steel (304L, 316L) react differently to these cleaning chemicals (NACE 1985). In some cases severe corrosion and metal loss can occur. Generally speaking, corrosion and rate of metal loss increases with:

- Increasing temperature
- Increasing concentration
- Longer duration of exposure
- Increased aeration of the solution

Following is a summary of how each of these metals reacts to various environments and recommendations regarding cleaning and sanitizing chemicals appropriate for each.

Aluminum

General

- The protective oxide layer forms very quickly when the metal is exposed to air and is very stable in the pH range of 4 to 9 (Davis 1999).
- Aluminum corrodes very quickly when exposed to strong alkaline cleaners such as caustic soda (sodium hydroxide) (Alum Assoc 1994) .
- Aluminum is also attacked by strong acids as well as chlorine based cleaners (concentrated sodium hypochlorite).

Cleaning

- Foaming mildly alkaline cleaners are recommended for the removal of animal fats (organic soil). Example: ZEP FS Strike Three, ZEP FS Foamate

- Foaming mildly acidic cleaners (phosphoric acid based with pH >4) are recommended for removal of stains and scale (inorganic soil). Example: ZEP Formula 7961

Sanitizing

- Spray-on quaternary ammonium type sanitizers are recommended. Example: ZEP FS Amine Z, ZEP Amine A
- The use of sodium hypochlorite in high concentrations can cause pitting of aluminum and is NOT recommended for sanitizing.

Stainless Steel (304L, 316L)

General

- The chromium in stainless steel forms a very dense passive film layer which is generally very stable over a wide pH range (Carpenter 1987).
- These alloys are resistant to strong alkaline cleaners such as caustic soda (sodium hydroxide).
- Halogen salts (primarily chlorides) penetrate the passive layer and can result in pitting and/or stress corrosion cracking.
- Exposure to sodium hypochlorite, or hydrochloric acid solutions, in high concentrations will result in pitting and/or stress corrosion cracking.

Cleaning

- Foaming mildly alkaline cleaners are recommended for the removal of animal fats (organic soil). Example: ZEP FS Strike Three, ZEP FS Foamate
- Foaming mildly acidic cleaners (phosphoric acid based with pH >4) are recommended for removal of stains and scale (inorganic soil). Example: ZEP Formula 7961

Sanitizing

- Spray-on quaternary ammonium type sanitizers are recommended. Example: ZEP FS Amine Z, ZEP Amine A
- The use of sodium hypochlorite in high concentrations will cause pitting and/or stress corrosion cracking and is NOT recommended.

Zinc (galvanized steel)

General

- The oxide layer forms quickly in the presence of air and is stable in the pH range of 7 to 12 (Stencel 1993).
- Zinc corrodes very quickly when exposed to acidic solutions, even mildly acidic.
- The metal is resistant to corrosion by alkaline cleaners such as caustic soda (sodium hydroxide).

Cleaning

- Foaming mildly alkaline cleaners are recommended for the removal of animal fats (organic soil). Example: ZEP FS Strike Three, ZEP FS Foamate
- Acidic cleaners of all types (pH <7) will result in rapid metal loss and are to be avoided. This makes removal of stains and scale (inorganic soil) very difficult and problematic.

Sanitizing

- Spray-on quaternary ammonium type sanitizers are recommended. Example: ZEP FS Amine Z, ZEP Amine A
- The use of sodium hypochlorite is NOT recommended.

Figure 5
Old Flange Union vs New Colmac BiM Technology

Figure 6
Al/Al Evaporator with Colmac BiM Connections

Comparison: Reliability

In a recent survey of ammonia refrigeration end users, it was found that 95% of all incidental ammonia leaks occur at flange union pipe connections, including coil connections. With Stl/Zn and SST/Al construction the coil connections are typically welded and so the potential for ammonia leaks greatly reduced. Al/Al coil connections traditionally used dielectric type flange unions which are prone to leaks over time. A new technology is now available from Colmac which eliminates the need for flange union coil connections on Al/Al construction. Colmac BiM couplers make the transition from the aluminum coil liquid and suction connections to the system steel (or stainless steel) piping via a proprietary metallurgical bonding process, eliminating the need for bolts, gaskets, and flanges. This new technology is shown below in Figures 5 and 6.

Conclusions:

Three types of ammonia evaporator construction (Al/Al, SST/Al, and Stl/Zn) have been analyzed and compared.

1. Al/Al construction was found to have:
    a. Lowest first cost
    b. Lightest weight
    c. Best performance
    d. Lowest operating cost
2. Unlike Stl/Zn which becomes brittle and requires special design considerations, both SST/Al and Al/Al construction retain full strength and do not become brittle, even at very low temperatures.
3. When Al/Al ammonia evaporators are installed in food processing plants and exposed to cleaning and sanitizing chemicals:
    a. Highly alkaline (pH >10) cleaners should be avoided. Foaming mildly alkaline cleaners are recommended.
    b. Sodium hypochlorite based sanitizers should be avoided. Quaternary ammonium sanitizers are recommended.

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For more information contact Colmac Coil Manufacturing, Inc.
mail@colmaccoil.com; P: 800.845.6778 or 509.684.2595
P.O. Box 571, Colville, WA. 99114-0571; www.colmaccoil.com

COLMAC COIL Manufacturing Inc.

Technical Bulletin

By Bruce I. Nelson, P.E., President, Colmac Coil Manufacturing, Inc.

SUCCESSFUL REFRIGERATION DEPENDS ON GOOD AIRFLOW

Introduction

Very often we forget that air is the most commonly used heat transfer fluid in air-conditioning and refrigeration systems. We typically remove heat from a refrigerated space by circulating cooled air throughout the room and across the product being refrigerated. A good airflow pattern is critical to the success of any refrigerated space design. A poor airflow pattern will result in poor air cooler and system performance even though the equipment may be adequately sized for the cooling load.

Most refrigeration air coolers use propeller type fans for moving air across the coil and circulating the cooled air throughout the room. Propeller fans are typically low cost, move adequate quantities of air, and use roughly one half the power of centrifugal fans for a given quantity of air at the static pressures normally seen (less than 1 iwg TSP) in refrigeration applications. Proper selection of air cooler configuration and propeller fan design is the topic of this article.

Colmac offers several air cooler configurations to match different airflow requirements. The LP, HP, ICL, and ICH product lines are ceiling-hung with draw through fan/coil arrangement discharging air horizontally. This type of unit is used in relatively large, open rooms where air throw to an opposite wall is desired. Good airflow in the room will depend on a number of factors:

Placement of Air Coolers

Avoid mounting air coolers directly over door openings. Locating the unit(s) opposite door openings reduces infiltration and the amount of warm, humid air drawn into the air cooler. Also, locate air coolers so that the distance to the opposite wall does not exceed the unit's rated air throw distance.

Condition of Ceiling Surface

Smooth ceiling surfaces are always best. The air leaving an air cooler tends to "stick" to and "roll along" the ceiling. A rough ceiling surface will obviously dissipate the momentum in the airstream and reduce air throw. Obstructions on the ceiling, such as beams, piping, ductwork, etc. will also kill air circulation.

Shape of the Room

A wide room (approx. 3X air cooler width) gives the best air circulation. A narrow (2X or less air cooler width), long room is the worst case for air circulation. Here the use of air straighteners is required to promote good air movement.

Straighteners perform three functions:

a) Increase discharge velocity;
b) Reduce turbulence of the air stream; and
c) Increase the amount of entrained air leaving the unit.

Rooms with low ceilings can also create airflow problems. Here, efforts must be made to keep the discharge air stream moving along the ceiling to the opposite wall, such as use of turning vanes in room corners, along with smooth ceiling conditions. Air straighteners may also be used to direct air upwards to the ceiling if needed.

Colmac also offers air coolers suitable for applications where low velocity air movement is required, such as in rooms where workers are in close proximity, or where products are sensitive to high velocity air streams (i.e. flowers). The GF, LV, and AR product lines are designed to provide maximum cooling capacity with low velocity airflow for these types of applications. Generally, these types of units are ceiling mounted and located throughout the room so air throw distance is not a large concern.

For applications requiring airflow with higher static pressures, such as blast freezing, the Colmac BF line with blow through fan/coil configuration is available. In this case air throw distance is not so critical as: a) even distribution of discharged air, and b) high static pressure capability of the fans.

Depending on fan diameter and speed, the maximum external static pressure that can be generated by a propeller fan typically used on air coolers is approximately 0.25 to 0.50 iwg. Generally speaking, static pressure is generated at the tip of the fan blade. Increasing the tip speed will increase the static pressure for a given blade. Tip speed can be increased by increasing rotational speed and/or increasing fan diameter. Also, as static pressure requirements increase, the clearance between blade tip and venturi becomes more important (the closer the clearance the better the performance). So, if high static pressures are required, the best performance will be gotten from a fan with large diameter and the highest rotational speed practical.

Conclusion

In conclusion, proper air circulation depends on several considerations including: fan design, air cooler configuration, static pressure requirements, as well as shape and size of the room. To design high performance refrigeration systems using Colmac air coolers use the guidelines mentioned above for creating good room airflow patterns.

For more information, please contact Colmac Coil Manufacturing, Inc.
Email mail@colmaccoil.com; Phone (800) 845-6778 or (509) 684-2595
P.O. Box 571, Colville, WA. 99114-0571; Website www.colmaccoil.com

Fin and Tube Specifications

A+ Series™ Air Coolers

COLMAC COIL
Manufacturing Inc.

Introduction

Colmac Coil A+Series™ air coolers are available with multiple fin and tube patterns, allowing them to be easily optimized for any operating conditions. Matching the cooler to the application will ensure the best performance and longest runtimes from your A+ Series™ cooler. This bulletin provides an overview of the available options, their effects on cooler performance, and when to use them.

Tube Diameter

The diameter of the tubes in a cooler has a direct effect on the flow pattern of the refrigerant traveling through them. This flow pattern is a major factor in the heat transfer efficiency and refrigerant pressure drop of the cooler. Matching the tube pattern to the refrigerant flow rate will help achieve the best flow pattern.

Because the refrigeration system type provides a general idea of what the flow rate of the refrigerant will be, it can be used as a guideline to select the tube size. A+ Series™ air coolers are available in two tube diameters: 5/8” and 7/8”.

5/8” Tubes

This size is preferred for systems with lower refrigerant mass flow rates, such as DX and glycol coolers. The smaller tube area does, however, create more refrigerant pressure drop, which limits its use in certain applications. Pump recirculated coolers can use 5/8” tubes, as long as an acceptable refrigerant pressure drop can be reached. Colmac’s A+Pro™ software automatically calculates this and will provide notification if it cannot be achieved. CO_2 systems commonly use 5/8” tubes, due to their higher working pressure.

7/8” Tubes

The increased area of this tube allows it to accommodate more refrigerant flow with lower pressure drops. It is the most common choice for pump recirculated coolers and is required for flooded operation. With a Colmac tube enhancement, it can also be used for glycol/brine or Low Temperature DX ammonia coolers.

TABLE 1

Common Tube Diameters Based on System Type*

Refrigeration System	Tube Diameter
Flooded	7/8” (required)
Pump recirculated	5/8 or 7/8”
Single phase liquids, brines	5/8” or 7/8” enhanced
Standard DX	5/8”
CPR	5/8” or 7/8”
Low Temp DX Ammonia	7/8” enhanced (required)

*Always verify design using Colmac’s A+Pro™ software or by contacting your local Colmac representative.

Fin and Tube Specifications

A+ Series™ Air Coolers

COLMAC COIL
Manufacturing Inc.

Tube Pattern

The arrangment of the tubes in the cooler determines how the air will flow around them. This affects the air side heat transfer of the cooler as well as the air pressure drop. There are two basic styles of tube patterns, staggered and inline. A staggered pattern causes more air turbulence, which increases heat transfer, but also causes a greater air pressure drop. Inline patterns allow the air to pass more easily for a lower air pressure drop, but more evaporator surface is required with this pattern. The A+ Series™ coolers combine these patterns with the tube diameters for three options: 5/8” staggered, 5/8” inline and 7/8” staggered.

5/8” tubes, 1.5” Staggered Pattern (Fig. 1)

This is a compact pattern for high heat transfer efficiency in a small envelope. This results in the cost effective solutions for warm temperature (>32°F) applications that have low refrigerant flow rates. Because of the compact nature of this pattern, it is more quickly blocked by frost buildup and therefore not recommended for room temperatures below 35°F. Common feed methods for this pattern are DX, single phase liquids/brines, CPR, and low overfeed pump recirculated systems.

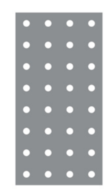
Figure 1

5/8” Tube, 2” (50mm) Inline Pattern (Fig. 2)

This is a wider pattern with the lowest fan power requirement of the three options. With more space between the tubes, it is also well suited for frosted conditions (<32°F) when a 5/8” tube is required. The clear line of sight through the evaporator also increases the cleanability of the inline pattern. The large amount of secondary (fin) surface also helps distribute frost buildup over a large area, allowing for the longest runtime between defrosts of all three patterns.

Electric defrost A+ Series™ coolers are only available in this pattern due to its ability to accommodate heating elements without dropping tubes.

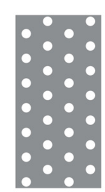
Figure 2



7/8” Tube, 2.25” Staggered (Fig. 3)

This is a widely spaced staggered pattern for high heat transfer efficiency while minimizing the effect on air pressure drop. This pattern has the widest tube spacing and large amounts of secondary surface area for excellent frost carrying capacities and runtimes. The A+ Series™ Engineering Catalog is designed exclusively with this pattern.

Figure 3



Fin Spacing

Fins make up the majority of the heat transfer surface of the cooler and have the greatest effect on its overall heat transfer, air pressure drop and runtime. More closely spaced fins are good for getting the most capacity out of a given envelope, but are more sensitive to blockage by frost and debris. Wider spaced fins provide a lower air pressure drop and more space for frost buildup, but require the cooler to be larger. The most common fin spacing choices are detailed below.

6 FPI (Fins per Inch)

This is the tightest fin spacing available on A+ Series™ coolers. This provides the maximum heat transfer surface area, but can quickly become blocked by debris or frost. It is recommended only for high temp applications (> 35°F) with light condensation and minimal airborne debris. Air velocities must be kept below 600 fpm to prevent water carryover.

4 FPI

By increasing the space between fins, more room is provided for frost to build without blocking the air flow. Because the fins are wider, there are less of them, resulting in slightly less heat transfer surface. This is the standard spacing for medium temperature applications (0°F – 35°F) and is also recommended for high temperature applications (> 35°F) when large amounts of airborne debris are expected. In applications above freezing, air velocities must be kept below 600 fpm to prevent water carryover.

3 FPI

This is the widest standard fin spacing available on A+ Series™ air coolers. It provides extra room for frost buildup, particularly when used with variable fin spacing, as explained below. This spacing is recommended for low temperature applications (< 0°F).

Variable Fin Spacing (Fig. 4)

Variable fin spacing reduces the fin spacing by half on the first two rows of tubes, providing added space for frost buildup where it is needed most. This is recommended in applications with heavy frost accumulation due to airborne ice crystals, such as blast freezers and in cold stores near doorways. Variable fin spacing will provide the longest runtime between defrosts.

Figure 4
Variable Fin Spacing

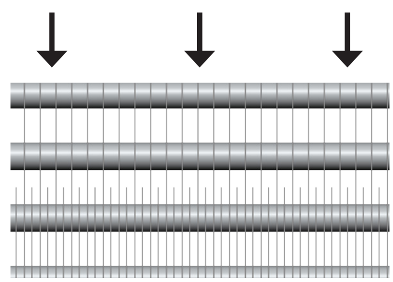


TABLE 2

Recommended Fin Spacing Based on Operating Condition

Room Temp	Conditions	Fin Spacing
> 35°F	Standard	6 FPI
	Fouling/Debris	4 FPI
0°F – 35°F	Standard	4 FPI
	Heavy Frost	Variable: 2/4 FPI or 1.5/3 FPI
< 0°F	Standard	3 FPI
	Heavy Frost	Variable: 1.5/3 FPI

For more information, please contact Colmac Coil Manufacturing, Inc.
mail@colmaccoil.com | +1.800.845.6778 | +1.509.684.2595
PO Box 571 | Colville WA 99114-0571 | www.colmaccoil.com

US006843509B2

(12) United States Patent

Nelson

(10) Patent No.: US 6,843,509 B2
(45) Date of Patent: Jan. 18, 2005

(54) **COUPLER FOR USE WITH METAL CONDUITS**

(75) Inventor: **Bruce I. Nelson**, Colville, WA (US)

(73) Assignee: **Colmac Coil Manufacturing, Inc.**, Colville, WA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 61 days.

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(52) **U.S. Cl.** **285/288.11**; 285/148.12; 285/329; 228/107; 428/651

(58) **Field of Search** 285/148.11, 148.12, 285/288.1, 288.11, 329; 228/107, 108, 109; 428/651

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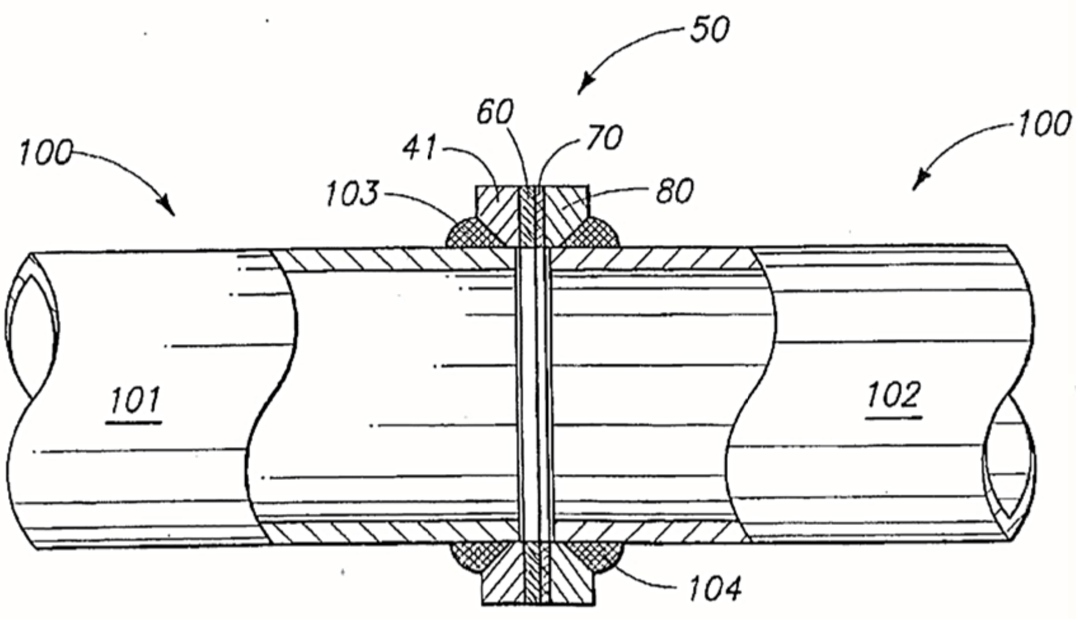
Primary Examiner—James M. Hewitt
(74) *Attorney, Agent, or Firm*—Wells St. John P.S.

(57) **ABSTRACT**

A coupler for joining an aluminum conduit to a steel or stainless steel conduit and which includes a main body which is formed from a first layer of aluminum and a layer of steel or an iron-chromium alloy which are explosively welded together, and wherein the main body has a first aluminum surface, and an opposite, second steel or iron-chromium alloy surface, and wherein the aluminum conduit is welded to the first aluminum surface, and the steel or stainless steel conduit is welded to the second steel or iron-chromium surface.

4 Claims, 3 Drawing Sheets



US007597137B2

(12) **United States Patent**
Nelson et al.

(10) **Patent No.: US 7,597,137 B2**
(45) **Date of Patent: Oct. 6, 2009**

(54) **HEAT EXCHANGER SYSTEM**

(75) Inventors: **Bruce I. Nelson**, Colville, WA (US); **Delbert A. Morris**, Colville, WA (US)

(73) Assignee: **Colmac Coil Manufacturing, Inc.**, Colville, WA (US)

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F28F 9/04 (2006.01)

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(58) **Field of Classification Search** 165/174, 165/178; 62/525

See application file for complete search history.

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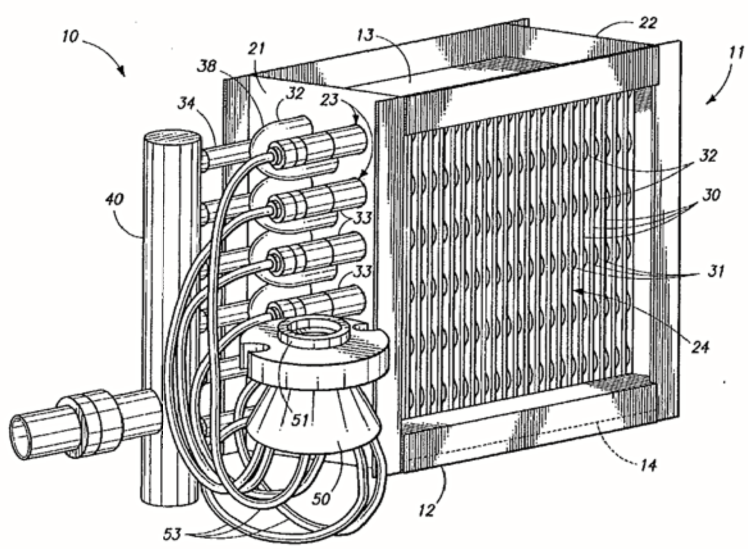
Primary Examiner—Teresa J Walberg
(74) *Attorney, Agent, or Firm*—Wells St. John P.S.

(57) **ABSTRACT**

A heat exchanger system is described and which includes a metal tubular heat exchanger; a fluid distributor conduit fabricated from a metal dissimilar to that of the heat exchanger, and wherein the fluid distributor conduit is connected in fluid flowing relation relative to the metal tubular heat exchanger; and a fluid distributor made of a metal that is similar to that of the fluid distributor conduit, and which is connected in fluid flowing relation relative to the fluid distributor.

8 Claims, 5 Drawing Sheets



US007712327B2

(12) United States Patent
Nelson et al.

(10) **Patent No.: US 7,712,327 B2**
(45) **Date of Patent: May 11, 2010**

(54) **HEAT EXCHANGER AND METHOD FOR DEFROSTING A HEAT EXCHANGER**

(75) Inventors: **Bruce I. Nelson**, Colville, WA (US); **John L. Wold**, Springdale, WA (US); **Roger B. Williams**, Colville, WA (US); **Jeremy P. Olberding**, Colville, WA (US)

(73) Assignee: **Colmac Coil Manufacturing, Inc.**, Colville, WA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 323 days.

(21) Appl. No.: **11/725,689**

(22) Filed: **Mar. 19, 2007**

(65) **Prior Publication Data**

US 2008/0229763 A1 Sep. 25, 2008

(51) **Int. Cl.**
F25D 21/06 (2006.01)
F28F 7/00 (2006.01)

(52) **U.S. Cl.** **62/276**; 62/275; 165/81; 165/82; 219/535

(58) **Field of Classification Search** 62/275, 62/276; 165/81, 82; 219/535, 520, 2, 3, 219/522, 543

See application file for complete search history.

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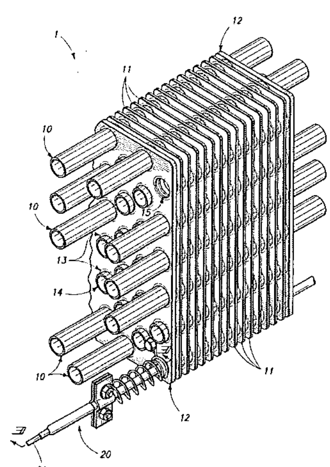
Primary Examiner—Frantz F Jules
Assistant Examiner—Alexis K Cox
(74) *Attorney, Agent, or Firm*—Wells St. John, P.S.

(57) **ABSTRACT**

A heat exchanger and method for defrosting a heat exchanger is disclosed and which includes a heat exchanger having a fluid receiving conduit, and at least one space which is defined, at least in part, by the fluid receiving conduit, an expandable and contractible heating element which is received within the space, and which is located in heat transmitting relation relative to the fluid receiving conduit, and a biasing member mounted on the heat exchanger and the heating element and which longitudinally, and resiliently restrains the movement of the heating element relative to the heat exchanger during the expansion and contraction of the heating element relative to the heat exchanger.

6 Claims, 6 Drawing Sheets



US007958738B2

(12) **United States Patent**
Nelson

(10) **Patent No.: US 7,958,738 B2**
(45) **Date of Patent: Jun. 14, 2011**

(54) **DIRECT EXPANSION AMMONIA REFRIGERATION SYSTEM AND A METHOD OF DIRECT EXPANSION AMMONIA REFRIGERATION**

(75) Inventor: **Bruce Ian Nelson**, Colville, WA (US)

(73) Assignee: **Colmac Coil Mfg., Inc.**, Colville, WA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 547 days.

(21) Appl. No.: **12/156,980**

(22) Filed: **Jun. 6, 2008**

(65) **Prior Publication Data**

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(51) **Int. Cl.**
F25B 15/00 (2006.01)

(52) **U.S. Cl.** **62/112**; 62/504; 62/509

(58) **Field of Classification Search** 62/112, 62/498, 504, 509; 165/104.26, 302; 122/366
See application file for complete search history.

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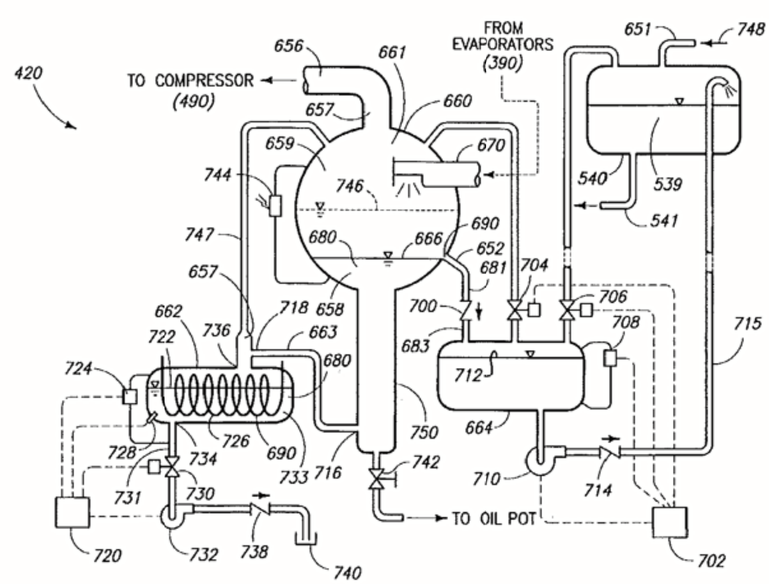
Primary Examiner — Mohammad Ali
(74) *Attorney, Agent, or Firm* — Paine Hamblen, LLP

(57) **ABSTRACT**

A direct expansion ammonia refrigeration system and a method of direct expansion ammonia refrigeration is described and which includes a source of liquid ammonia refrigerant which is delivered in fluid flowing relation to a plurality of evaporator tubes which incorporate wicking structures, and which through capillary action facilitated by the wicking structures are effective for drawing liquid ammonia refrigerant along the inside facing surface of the evaporator tubes so as to substantially reduce any stratified and/or wavy flow patterns of the liquid ammonia refrigerant within the evaporator tubes. The invention further includes a novel accumulator vessel and heat exchanger vessel which are coupled in fluid flowing relation relative to the direct expansion ammonia refrigeration system and which facilitate the removal of water from the ammonia refrigerant in order to enhance the operation of the direct expansion ammonia refrigeration system.

46 Claims, 13 Drawing Sheets



US008474276B2

(12) United States Patent

Nelson

(10) Patent No.: US 8,474,276 B2

(45) Date of Patent: *Jul. 2, 2013

(54) DIRECT EXPANSION AMMONIA REFRIGERATION SYSTEM AND A METHOD OF DIRECT EXPANSION AMMONIA REFRIGERATION

(75) Inventor: **Bruce I. Nelson**, Colville, WA (US)

(73) Assignee: **Colmac Coil Mfg., Inc.**, Colville, WA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 182 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **13/064,770**

(22) Filed: **Apr. 13, 2011**

(65) **Prior Publication Data**

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Related U.S. Application Data

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(51) **Int. Cl.**
F25B 15/00 (2006.01)

(52) **U.S. Cl.**
USPC **62/112**; 62/509

(58) **Field of Classification Search**
USPC 62/112, 498, 504, 509, 434; 165/104.26, 165/302; 122/366
See application file for complete search history.

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Primary Examiner — Mohammad M Ali

(74) *Attorney, Agent, or Firm* — Paine Hamblen, LLP

(57) **ABSTRACT**

A direct expansion ammonia refrigeration system and a method of direct expansion ammonia refrigeration is described and which includes a source of liquid ammonia refrigerant which is delivered in fluid flowing relation to a plurality of evaporator tubes which incorporate wicking structures, and which through capillary action facilitated by the wicking structures are effective for drawing liquid ammonia refrigerant along the inside facing surface of the evaporator tubes so as to substantially reduce any stratified and/or wavy flow patterns of the liquid ammonia refrigerant within the evaporator tubes. The invention further includes a novel accumulator vessel and heat exchanger vessel which are coupled in fluid flowing relation relative to the direct expansion ammonia refrigeration system and which facilitate the removal of water from the ammonia refrigerant in order to enhance the operation of the direct expansion ammonia refrigeration system.

19 Claims, 13 Drawing Sheets