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ALUMINUM COIL APPLICATION GUIDELINES

Background

Aluminum has been widely used in the construction of heat exchangers for the HVAC industry for decades. The metal is light weight, highly conductive, low cost, and has excellent corrosion resistance characteristics.

Traditionally, heating and cooling coils have been constructed of copper tubes and aluminum fins. The selection of copper for tubing has been based on the metals ease of forming and joining during manufacture, and its ease of repair by soldering in the field. Selection of aluminum for fins has been based on the metals light weight, low cost, and good thermal performance.

As the price of copper has escalated rapidly in recent months, aluminum as a tube material has generated significant interest as a means of mitigating increases in coil costs. A typical chilled water coil designed with aluminum tubes and fins can cost and weigh as much as 30% less (depending on tube wall thickness) than a copper tube aluminum coil having the same thermal capacity! While it is true that aluminum tubes are significantly less expensive than copper tubes, there are some limitations with regard to compatibility with certain working fluids, fluid velocities, temperatures, corrosive environments, and cleaning chemicals which need to be examined in order to insure adequate service life for coils made with aluminum tubes.

Working Fluids

Aluminum oxide is very stable and tenacious when exposed to most environmental conditions. When used in standard HVAC/R applications it is completely compatible with both chilled water and halocarbons (HCFC and HFC refrigerants), as well as refrigeration oils in common use (mineral, AB, POE, PAG). Aluminum is also compatible with anhydrous ammonia as a refrigerant. Aluminum is, therefore, an excellent material for use in chilled and hot water coils, DX and recirculated evaporators, and condensers. The metal can be used with ethylene and propylene glycol solutions; however, care must be taken to ensure working temperatures remain below about 150F. Colmac does not recommend using aluminum tubes in steam coils due to the corrosive characteristics of steam.

Fluid Velocities

If a fluid passes over the surface of a metal at a high enough velocity, the protective oxide layer of the metal will be stripped away and the metal lost by erosion. This type of metal loss is called erosion corrosion. In refrigeration applications, there are virtually no risks of erosion corrosion with aluminum in either evaporators or condensers. Refrigerant velocities are inherently limited by the performance penalty associated with pressure loss and reduced LMTD. Therefore, aluminum tubes are an excellent choice for any HCFC, HFC, or ammonia evaporator or condenser designs, provided the mechanical pressure limits of the tube diameter and wall thickness are not exceeded.

For water and glycol solutions, a good practical limit on tubeside velocity to avoid erosion corrosion is 4 ft/s (1.2 m/s). This limit is somewhat temperature sensitive and should be lowered at elevated temperatures above 150F (65C). In water coil applications, a tubeside velocity of 4 ft/s results in a Reynolds number well into the turbulent region (>4,000), which produces high values for the heat transfer coefficient and resultant good heat transfer performance.

Temperature

The yield strength of all metals (the characteristic strength which determines maximum allowable working pressure) decreases as temperature increases. Conversely, yield strength increases as temperature decreases. Unlike carbon steel, however, aluminum does not become brittle even at very low temperatures. Therefore, aluminum is ideally suited for

refrigeration evaporators operating even at cryogenic temperatures. For example, aluminum is commonly used for tubes in liquid nitrogen evaporators. Since aluminum loses its yield strength dramatically at temperatures above 350F (176C), Colmac does not recommend designing coils with aluminum tubes for use at temperatures over 300F (148C).

Maximum Allowable Working Pressure (MAWP)

MAWP is the safe allowable pressure for the working fluid expected during operation of the coil. Table 1 below shows MAWP for various aluminum tube diameters and wall thicknesses at varying temperature:

**TABLE 1
MAWP vs Temperature**

Tube Diameter x Wall Thickness, in	MAWP, psig		
	Up to 150F	150F < T < 250F	250F < T < 300F
3/8 x 0.025	506.6	483.5	437.6
1/2 x 0.035	540.1	515.5	466.6
5/8 x 0.049	614.4	586.4	530.8
7/8 x 0.065	584.9	558.2	505.2
1 x 0.065	508.6	485.4	439.3

Corrosive Environments

As mentioned above, aluminum oxide is very stable and tenacious, and generally speaking does not deteriorate or break down in the presence of liquids having pH between 4.0 and 9.0. Aluminum, therefore, resists corrosion when exposed to most mildly acidic and alkaline solutions. Aluminum oxide, however, does dissolve when exposed to solutions containing certain ions, namely chlorides and sulfides. Therefore, aluminum is not recommended in environments where the metal, whether on the finside or the tubeside, is exposed to chloride or sulfide salts.

Corrosion of metals is a complex phenomenon, and can involve a number of mechanisms acting simultaneously (galvanic, chemical, stress, crevice, erosion, etc). If an all aluminum coil to be placed in service in a potentially corrosive environment, consult a qualified Corrosion Engineer and/or Colmac factory applications engineers.

Cleaning Chemicals

Because aluminum oxide can be removed with exposure to highly acidic or highly alkaline solutions, exposure (either direct or indirect) to Sodium Hypochlorite (Chlorine Bleach) and/or Potassium Hydroxide (Caustic Soda) cleaners is not recommended. Aluminum is very quickly corroded and will be irreparably damaged if washed down with Caustic Soda, for example.

Field Repair

Colmac uses a number of different aluminum alloys for tubes, headers, and welding alloys, in the course of designing and building aluminum coils. It is important to use the correct materials (i.e. welding filler metal alloy) and procedures when making field repairs to avoid causing further damage. Consult the Colmac factory for assistance when repairs are required.

Conclusion

As noted above, aluminum is an excellent and versatile metal which, if applied properly, is well suited to many HVAC/R and industrial coil applications (chilled and hot water, refrigeration evaporators and condensers). It's low cost, light weight, and high thermal conductivity make it an ideal choice as an alternate material to copper, carbon steel, and stainless steel in many cases.

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