SELECTION GUIDE: ENVIRONMENTAL CORROSION PROTECTION

Condenser Coils and Cooling/Heating Coils for Commercial Products

Turn to the Experts.℠

Carrier Corporation
Syracuse, New York

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INTRODUCTION

Corrosion is costly. By definition, corrosion is the destruction or deterioration of a metal or alloy due to a reaction with an environment.

In HVAC/R equipment, heat exchangers, including condensers, evaporators, and hydronic coils, must be protected from environments that may lead to localized and/or generalized corrosion. Corrosion of heat exchangers may lead to performance loss, unsightly appearance, and possible equipment failure.

Fortunately, the harmful effects of coil corrosion can be significantly delayed or avoided if the application environment is correctly identified and the appropriate corrosion protection option is selected.

This selection guide will provide information on the causes of corrosion and identify corrosive environments in order to aid in the selection of the proper coil.

CORROSION

There are many types of corrosion. The two forms of corrosion most common to HVAC/R equipment are known as localized (galvanic, pitting, or formicary corrosion) and general corrosion. Each of these corrosion types can lead to equipment failure, depending on conditions and the material systems used.

Localized Corrosion

ROUND TUBE PLATE FIN COILS

One form of localized corrosion is galvanic corrosion. The necessary conditions for galvanic corrosion occur when dissimilar metals, in contact, are exposed to an electrolyte, a substance that is electrically conductive when dissolved in water. The environment creates the electrolytes necessary for general and localized corrosion of materials.

Standard round tube plate fin (RTPF) condenser coils have copper tubes mechanically bonded to aluminum fins with wavy enhancements. Figure 1 shows a cross-section of a copper tube and several aluminum fins. High thermal efficiency is achieved through direct metallic contact between the tube and fin. As a result, maximum thermal performance is achieved with this high-efficiency coil design, provided there is no corrosion.

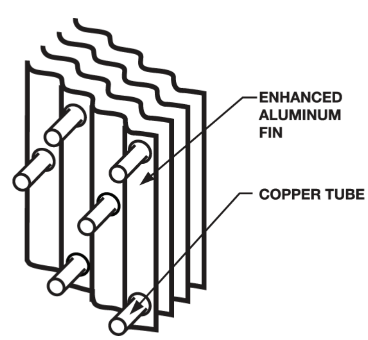


Fig. 1. Standard Coil Construction

Figure 2 shows a typical RTPF coil prior to galvanic corrosion.

During galvanic corrosion, the aluminum fin initially corrodes at the copper/aluminum interface as this is the point of electrical contact between the dissimilar metals. As corrosion of the aluminum fin progresses, the fin conductivity deteriorates which in turn reduces the coil thermal performance. Aluminum oxide deposits that are formed in the process (Fig. 3) can further reduce performance by impeding air flow through the coil.

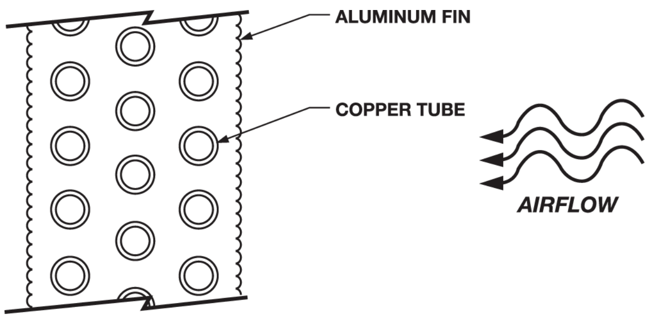


Fig. 2. Standard Copper Tube/Aluminum Fin Coil

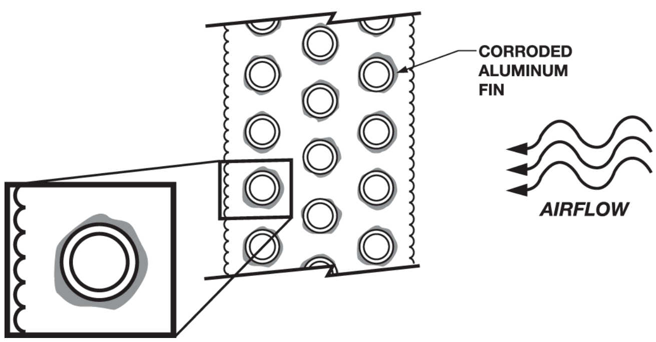


Fig. 3. Galvanic Corrosion Begins

One way of preventing galvanic corrosion of RTPF coils is through the effective elimination of the bi-metallic couple. An example of this approach is the all-copper RTPF coil. The use of an all-copper construction, i.e., copper tube/copper fin, virtually eliminates the presence of dissimilar metals, one of the necessary requirements for galvanic corrosion.

Another method commonly used to prevent galvanic corrosion is to isolate the two dissimilar metals from the electrolyte through use of a protective coating. The protective coating in effect creates a barrier between the dissimilar metallic couple and the electrolyte, thereby eliminating the electrolyte from this interface. A third way to prevent galvanic corrosion is to insulate the electrical connection of the copper and the aluminum through the use of a pre-coated aluminum fin. The pre-coating insulation removes the electrical contact of the dissimilar metals.

NOVATION® HEAT EXCHANGERS WITH MICROCHANNEL COIL TECHNOLOGY

Novation® heat exchangers with microchannel coil technology utilize several aluminum alloys in combination with a metallic coating. The alloys are carefully chosen to extend the life of the coil. Furthermore, the coil has been designed so that any galvanic couple within the coil has been carefully chosen to provide the maximum life possible for the coil.

The refrigerant carrying tube is essentially flat, with its interior sectioned into a series of multiple, parallel flow microchannels that contain the refrigerant (Fig 4). In between the flat tube microchannels are fins that have been optimized to increase heat transfer.

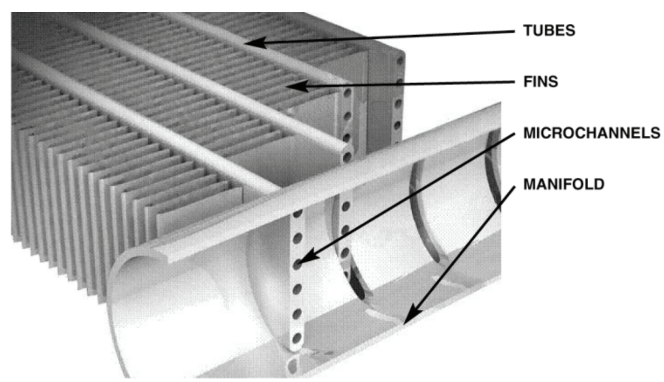


Fig. 4. Microchannel/Fin Center

The microchannel tubes in the heat exchanger have excellent heat transfer characteristics on the refrigerant side. On the air side, heat transfer is improved due to the enhanced surface area contact and the metallurgical bond between tube and fin. Fin design is optimized to enhance the fin heat transfer performance. The fin-to-tube bond reduces thermal resistance between tube and fin, resulting in better heat conduction.

The microchannel heat exchanger (MCHX) coil design uses zinc-enriched surfaces that perform in a manner similar to the zinc layer in galvanized steel. The zinc-enriched surface allows the tube to weather laterally, preventing corrosion pits from progressing deeply into the tube. The zinc layer will not be consumed during the effective service life of the MCHX coil when the coil is applied properly.

In corrosive environments an unprotected coil may face a rapid direct pitting attack of the tube and/or tube-to-manifold joint, which may lead to a catastrophic refrigerant leak and system failure. These conditions can be found in aggressive marine, industrial, urban, or highly alkaline environments. The latter condition can occur, for example, at new construction sites if the unprotected MCHX coil is exposed to excessive quantities of concrete dust and moisture.

A protective coating may be applied to MCHX coils for use in corrosive application environments.

General Corrosion

General corrosion is the degradation of metal caused by a reaction with the surrounding environment. Since general corrosion consumes metal and typically forms metal oxides, unsightly surface conditions usually result. Unprotected metal will continue to react with the contaminant resulting in corrosion. Under severe, prolonged conditions, the metal continues to corrode until the integrity of the material and equipment is jeopardized. Unprotected copper or aluminum tubes in polluted industrial environments can lead to tube leaks and failure of the refrigeration system. Sulfur and nitrogen based electrolytes in combination with chloride environments are often the cause of accelerated corrosion of these metals.

The environment in which HVAC/R equipment is applied varies throughout the globe and in some instances, even within a local area. Corrosive environments occur not only in coastal or marine climates and industrial areas, but also are present in urban or rural areas, localized microclimates, and combinations of these conditions. Factors including but not limited to the presence of flue gas, sewage vents or open sewage systems and diesel exhaust can all have a detrimental effect on HVAC/R coils.

These pollutants, in combination with other factors such as wind direction, humidity, water, fog, temperature, proximity to pollutant source, and dust or particle contamination, may result in the premature failure of equipment.

For both RTPF and MCHX coils it is therefore critical that the application environment is properly identified, and if needed, the appropriate corrosion protection is used.

CORROSIVE ENVIRONMENTS

As previously discussed, potentially corrosive outdoor environments include areas adjacent to the seacoast, industrial sites, heavily populated urban areas, some rural locations, or combinations of any of these environments. These macro environments are often characterized as rural, urban, coastal (marine), industrial, or industrial marine. In addition, some air-handling applications, indoor environments such as swimming pool areas, water treatment facilities, and industrial process areas can also produce corrosive atmospheres.

Local environments called micro environments must also be considered. Close proximity to laundry facilities, diesel-burning devices/exhaust piping, sewer vents, and traffic can lead to premature failure of improperly protected equipment, in a similar manner as the macro environmental conditions.

Contaminants in an environment typically result in the creation of electrolytes that facilitate the corrosion process. Electrolytes are substances that are electrically conductive when dissolved in water. Common electrolytes may contain chloride contaminants from sources such as seawater, road salts, cement dust, pool cleaners, laundry facilities, and household cleaning agents, which are typically sodium or calcium chloride-based compounds. Other relevant contaminants that contribute to the formation of electrolytes include sulfur and nitrogen bearing compounds from the combustion of coal and fuel oils. Chemical contamination from industrial processes, e.g., ammonia, can also contribute to the formation of an electrolyte.

In view of this it is necessary to identify each of these environments so that appropriate corrosion protection methods may be used.

Coastal/Marine

Many emerging HVAC/R markets have a majority of their populations located in coastal regions, leading to an increased number of applications in corrosive environments. Coastal or marine environments are characterized by the abundance of sodium chloride (salt) and sulfur compounds that are carried by sea spray, mist, fog, or prevailing winds. Sea spray, mist, and fog contain tiny droplets of salt water that can be transported many miles by ocean breezes and result in equipment contamination. The deposition of salt water spray onto metallic substances is the most corrosive aspect of the marine environment.

Several factors should be considered when choosing the best solution for a coastal or marine environment: land formation (e.g., islands, depending on size, often are influenced by coastal contaminations); distance from the coast and the direction of the prevailing winds (wind direction helps to determine the distance that contaminants can be carried); corrosion on other equipment or infrastructure in the area (an excellent indicator of the corrosiveness of the environment); common practices that have worked well in the area; and other pollution sources, such as industrial influences.

Industrial

Industrial environments are very diverse, with the potential to produce a variety of corrosive compounds. An industrial environment can exist on a macro or micro scale, each with the same detrimental effect. Sulfur and nitrogen containing contaminants are most often linked but not limited to industrial and high-density urban environments. Combustion of coal and fuel oils release sulfur oxides (SO_2, SO_3) and nitrogen oxides (NO_x) into the atmosphere. Other contributors such as ammonia and its salts and hydrogen sulfide can have a detrimental effect on materials. Many of these gases accumulate in the atmosphere and return to the ground in the form of acid rain or low pH (acidic) dew.

Not only are industrial emissions potentially corrosive, but many industrial dust particles can be laden with harmful metal oxides, chlorides, sulfates, sulfuric acid, carbon and carbon compounds. These particles, in the presence of oxygen, water, or high humidity can be highly corrosive and may lead to many forms of corrosion including general corrosion and localized corrosion such as pitting and formicary corrosion.

Combination Coastal/Marine and Industrial

Salt-laden seawater mist, combined with the harmful emissions of an industrial environment (either on a macro or micro level), poses a severe threat to the life of HVAC/R equipment. The combined effects of salt contamination and industrial emissions will accelerate corrosion of any improperly protected coil. This harsh environment requires superior corrosion resistant properties for HVAC/R components to maintain acceptable product quality. Complete encapsulation of the coil surfaces (such as e-coating for MCHX coils) is strongly recommended. When identifying this type of environment it is essential that local influences not be overlooked. Open sewage systems, vents, diesel exhaust, emissions from dense traffic, landfills, aircraft and ocean vessel exhaust, industrial manufacturing, chemical treatment facilities (cooling tower proximity), and fossil fuel burning power plants are potential contributors to consider.

Urban

Highly populated areas generally have high levels of automobile emissions and high rates of the byproducts of the combustion of building heating fuels. Both conditions elevate sulfur oxide (SO_x) and nitrogen oxide (NO_x) concentrations. Corrosion severity in this environment is a function of pollution levels, humidity, average temperature, and equipment usage, which in turn depend on several factors including population density for the area, emission control, and local pollution standards. In areas with rapid growth, such as many areas in China and India, contamination levels can change drastically; thus, the future direction of a region should be considered when looking at the best corrosion protection system.

Note that any HVAC/R equipment installed near diesel exhaust, incinerator discharge stacks, fuel-burning boiler stacks, areas exposed to fossil fuel combustion emissions, or areas with high automobile emissions should be considered industrial applications.

Rural

A rural environment typically is unpolluted by exhaust and sulfur containing gases. Rural environments are usually sufficiently inland so that contamination and high humidity from coastal waters are not present. Coil protection in these environments is typically not required beyond the standard MCHX coil or aluminum fin/copper tube offerings.

However, rural environments may contain high levels of ammonia and nitrogen contamination from animal excrement, fertilizers, and high concentrations of diesel exhaust. In this case, these environments should be considered industrial applications and would require e-coated coil protection.

Localized Environment - Corrosivity of the Surroundings

All of the above environments are subject to microclimates that can significantly increase the corrosivity of the environment. Care should be taken to ensure that the localized environment surrounding the HVAC/R equipment does not contain contaminants that will be detrimental to the equipment. An example would be equipment placed near a diesel vehicle loading area or a diesel generator. Although the general area in which the building is located may meet the scope of a coastal or marine environment, the localized elements that surround the equipment may actually classify the application as industrial or industrial marine, and protection of the coil should be planned accordingly.

Localized environments can result from a variety of contaminants, including but not limited to those originating with:

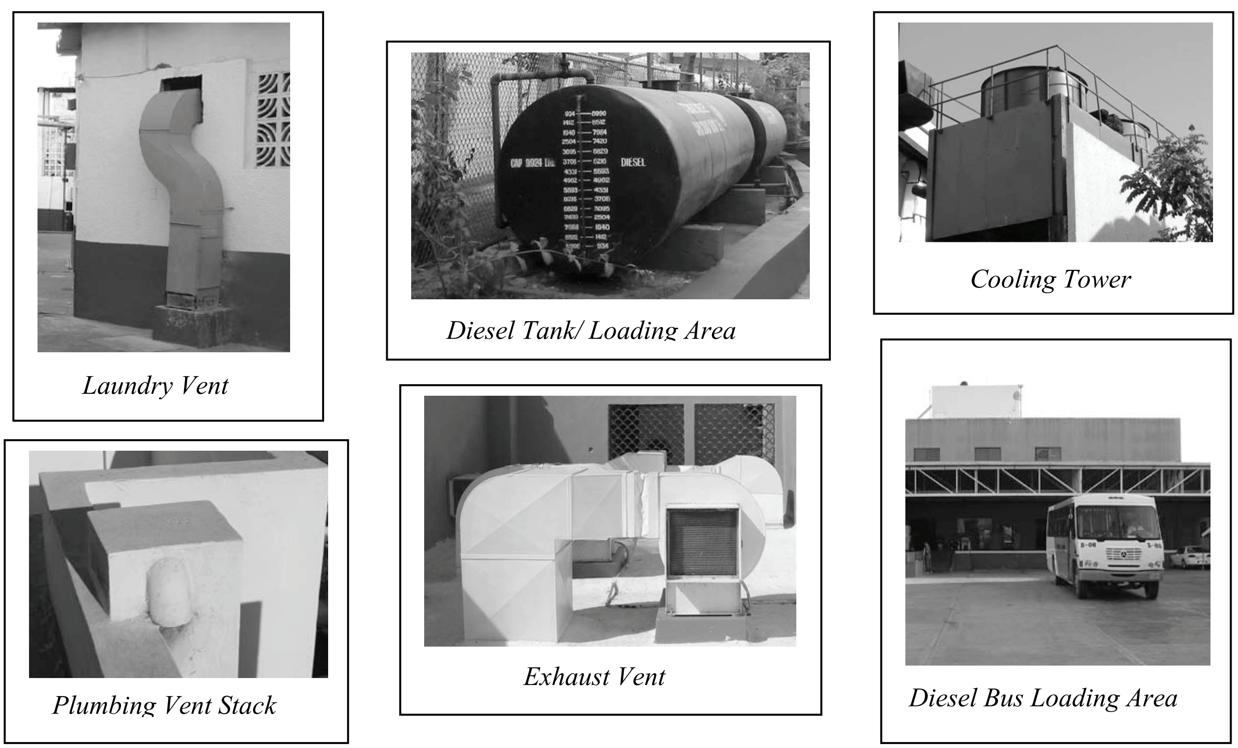
- Traffic
- Airports
- Power plants
- Power generators
- Factories and chemical plants
- Breweries and food processing plants
- Wastewater treatment plants
- Dumps and incineration plants
- Cruise ships and shipping traffic
- Swampy areas (rotting vegetation)
- Farms and nurseries
- Fisheries

The contaminants in the preceding list must be considered in combination with other contributing factors, including but not limited to:

- Distance from contaminant source. The most detrimental effect in a micro environment occurs within 50 ft (15 meters); in a macro environment, within 1 mile (1.6 km)
- Prevailing wind direction
- Acid rain (note that sources may be hundreds of miles away)
- Condensation
- Temperature
- Humidity

The following are examples of contaminants that can create a micro environment within 50 ft (15 meters). (See Fig. 5.):

- Heavy/frequent fertilizer or insecticide usage
- Chemical/cleaner storage areas
- Bus or truck loading areas or heavy traffic
- Power generators
- Fan-powered exhaust vents
- Cooling towers due to drift of chemical treatments



Laundry Vent

Diesel Tank/ Loading Area

Cooling Tower

Plumbing Vent Stack

Exhaust Vent

Diesel Bus Loading Area

Fig. 5. Sources of Contaminants in Micro Environments

CORROSION PROTECTION

The choices available for Carrier's commercial products offer protection for most common aggressive environments. Note that not all options are available for all products. For information on coil options for specific products, consult your Carrier sales office.

Condenser Coils

MCHX COILS

MCHX coils are constructed utilizing all-aluminum alloys with brazed fin construction. Microchannel heat exchangers provide high thermal performance per unit volume. Unprotected MCHX coils should never be applied in corrosive environments.

E-Coated MCHX Coils

E-coated coils provide superior protection against many corrosive atmospheres. E-coated MCHX coils have an extremely durable and flexible epoxy coating uniformly applied over all coil surfaces for complete isolation from the contaminated environment. A consistent coating is achieved through a precisely controlled electrocoating process that bonds a thin, impermeable epoxy coating to the specially prepared coil surfaces. A detailed description of the proprietary Carrier e-coating process is provided on page 9.

RTPF COILS

The standard aluminum fin/copper tube coil generally provides high performance for non-corrosive environments (e.g., non-polluted rural environments). Application of this coil in any environment containing corrosive elements is not recommended because of the likelihood of deterioration resulting from corrosion.

Pre-Coated Aluminum-Fin Coils

Pre-coated aluminum fin/copper tube coils have a durable coating applied to the fin. This design offers protection in mildly corrosive coastal environments, but is not recommended in severe industrial or coastal environments.

Aluminum fin stock is coated with a baked-on coating prior to the fin stamping process (Fig. 6). Coating of the fin material prior to the fin stamping process is known as "pre-coating." The pre-coated fin material is then stamped to form the desired fin pattern for optimum thermal performance.

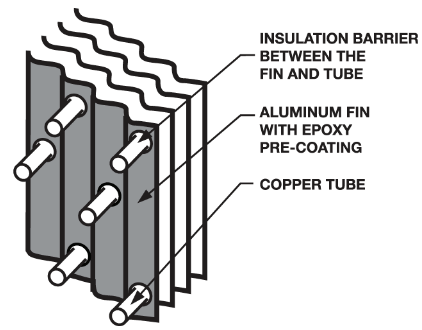


Fig. 6. Pre-Coated Coil Assembly

A thin layer of a non-metallic pre-coating material insulates the dissimilar metals of the coil (copper tube and aluminum fin) from one another. As a result, the electrical connection between the copper and aluminum is disrupted, thus minimizing galvanic corrosion. In mild coastal environments pre-coated coils are an economical alternative to e-coated coils and offer improved corrosion protection beyond the standard uncoated copper tube/aluminum fin coil.

Copper-Fin Coils

Typically, a copper wavy fin pattern is mechanically bonded to the standard copper tube. Protective isolators are installed between the coil assembly and sheet metal coil support pan to further protect the coil assembly from galvanic corrosion. (See Fig. 7.)

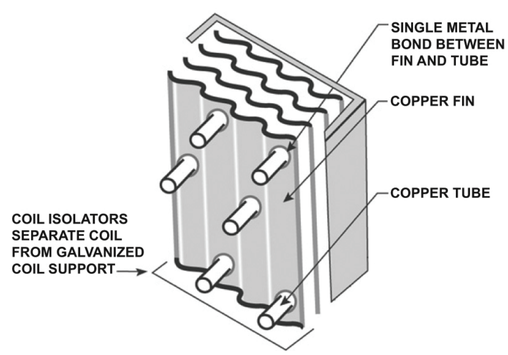


Fig. 7. Copper-Fin Coil Assembly

Copper is generally resistant to <u>unpolluted</u> coastal environments due to a natural protective film that is formed on the copper surfaces. Furthermore, galvanic corrosion is not an issue in these mono-metal coils. However, copper-fin coils are priced significantly higher than other coil options since material costs for copper are greater than those for aluminum. Other alternatives (see summary guide) provide preferred solutions for most applications.

Uncoated copper coils are not suitable for dense urban, polluted coastal applications, industrial applications, or industrial marine applications since many pollutants attack copper putting both the fin and the tube at risk. The use of uncoated copper in these applications is not recommended. E-coated aluminum fin/copper tube or e-coated MCHX coils should be considered for such applications.

E-Coated Aluminum-Fin Coils

E-coated coils provide superior protection against many corrosive atmospheres with the exception of formic acid and nitric acid environments.

The aluminum fin/copper tube coils are e-coated using the same proprietary process described above. A very flexible and durable epoxy coating is uniformly applied over all coil surfaces for complete isolation from the contaminated environment (Fig. 8). A consistent coating is achieved through a precisely controlled electrocoating process that bonds a thin, impermeable epoxy coating to the specially prepared coil surfaces.

The proprietary Carrier e-coating process is described in further detail on page 9.

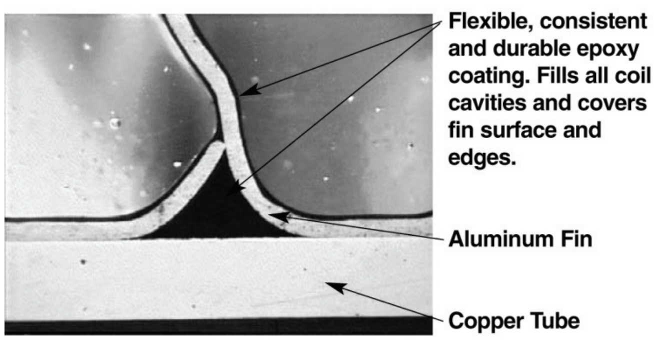


Fig. 8. Magnification of E-Coated Aluminum Fin/Copper Tube Coil

E-Coated Copper-Fin Coils (not available with all products)

E-coated copper fin/copper tube coils have the same durable and flexible epoxy coating uniformly applied over all coil surfaces as the e-coated aluminum-fin coils (Fig. 9). However, these coils combine the natural resistance of all-copper construction with complete encapsulation from the e-coat process. As noted previously, e-coated copper fin/copper tube coils may be specified for severe marine environments that are void of industrial contaminants.

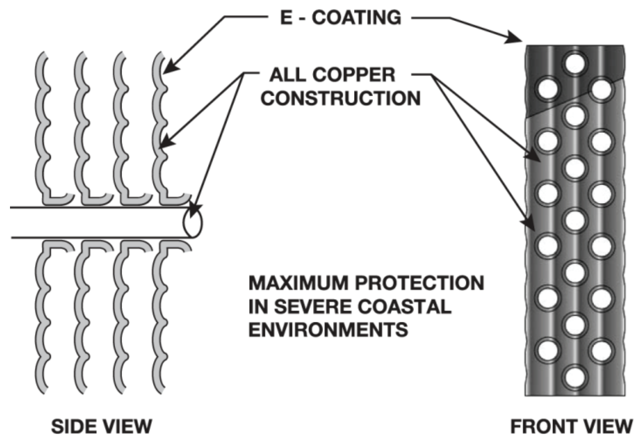


Fig. 9. E-Coated Copper Coil

Cooling/Heating Coils

Standard Coil Construction

The standard cooling/heating coil (water, steam or direct expansion) has copper tubes mechanically bonded to aluminum fins. The fin pack is assembled with galvanized steel tube sheets and coil case. This assembly has classic galvanic corrosion components with multi-metal bonds between the fin-and-tube and tube-and-tube sheet.

In cooling applications, condensate accumulates on the coil surfaces when dehumidification occurs. Wet coil surfaces resulting from condensation in the presence of a contaminated airstream will lead to galvanic corrosion if not properly protected.

Potentially corrosive airstreams may not be suitable for building occupants. If a contaminated airstream can lead to corrosion, special consideration with respect to indoor air quality and potentially harmful side effects to building occupants is recommended.

Copper Fin/Copper Tube Coils

Much like the all-copper condenser coil, all-copper cooling/heating coils eliminate the bi-metallic bond found on standard coils. A copper fin with wavy pattern is mechanically bonded to the standard copper tube to ensure a single-metal assembly. Most air-handling equipment is available with copper or stainless steel tube sheets and coil cases to improve the corrosion durability of the entire coil assembly. As a result of the reduction of the bi-metallic couples, the potential for corrosion within the coil assembly is reduced.

E-Coated Coils

E-coated cooling/heating coils have the same e-coating as the condenser coils. All e-coated coils have a durable and flexible epoxy coating uniformly applied over all coil surfaces, including tubesheets and coil cases. The coating provides a barrier between the coil surfaces and the corrosive effects of the atmosphere.

In considering e-coated coils, it is important to also consider the effects of moisture carryover. Moisture carryover occurs when accumulated condensation is blown from the coil surface during cooling coil applications. The extent of carryover is a function of airstream velocity across the coil, fin spacing, fin geometry and material of construction. When e-coating is applied to a cooling coil, carryover will occur at lower coil face velocities. Recommendations shown in Table A should be considered when selecting chilled water or DX (direct expansion) coils to ensure moisture carryover will be prevented.

Table A
Maximum Recommended Face Velocity (FPM)*

Fin Spacing (FPI)	Aluminum-Fin Coil	Copper-Fin Coil	E-Coated Coil
8	650	500	500
11	650	425	425
14	575	375	375

FPI - Fins per Inch
FPM - Feet per Minute

*External fouling on cooling coils will adversely affect the maximum recommended face velocities. Data based on clean coils with proper filtration and periodic cleaning of coil surfaces.

Carrier's E-Coating Process

Electrocoating is a multi-step process that ensures ultra clean coils are properly coated, cured, and protected from environmental attack (Fig. 10). This process includes complete immersion cleaning to remove contamination and ensure all surfaces are ultra clean. The water bath rinses residual dust and contamination away in preparation for the e-coating process. The fundamental principle of electrocoating is that the materials with opposite electrical charges attract each other. An electrocoating system applies a DC charge to the coil immersed in a bath of oppositely charged epoxy molecules. The molecules are drawn to the metal, forming an even, continuous film over the entire surface. At a certain point, the coating film insulates the metal, stopping the attraction, and preventing further coating deposition (self-limiting nature of the coating process).

The final rinse bath removes and recovers residual coating material to ensure a smooth coating and minimize process waste. A precisely controlled oven bake cures the coating uniformly to ensure consistent adhesion on all coil surfaces. This electrocoating process creates a smooth, consistent, and flexible coating that penetrates deep into all coil cavities and covers the entire coil assembly including the fin edges. The process in conjunction with the coating material results in a less brittle, more resilient, and more durable coating without bridging between adjacent fins. E-coated coils provide superior protection in the most severe environments.

Finally, a UV protective topcoat is applied to shield the finish from ultraviolet degradation and to ensure coating durability and long life.

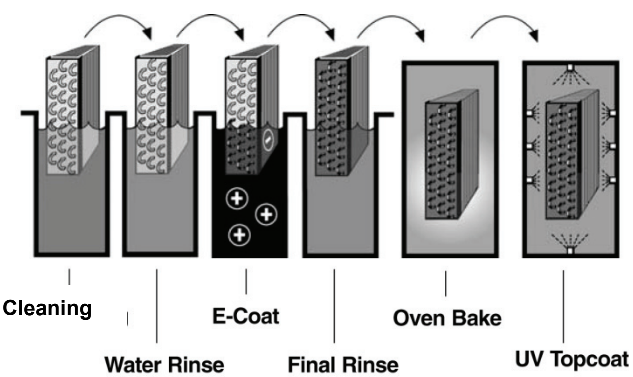


Fig. 10. E-Coating Process

E-Coated Material and Chemical Resistance

Chemical resistance of the e-coating material is described in the appendix, "E-Coating Chemical Resistance Guide." Application of an e-coated coil should only be considered when the contaminant is listed in the Appendix guide. If the e-coating is NOT resistant to the contaminant listed or if the contaminant is not listed in the appendix, application in this environment is not recommended. Contact your Carrier representative for further guidance.

Some common industrial processes and their related contaminants that are resisted by the e-coated coils are shown in Table B.

Table B
Industrial Contaminants

Type of Industry/Application	Source of Contaminant	Contaminant
Pulp, Paper and Lumber Plants	Process Emissions	Nitrogen Oxides Sulfur Oxides
	Pulp Bleaching	Dichloromethane Chloroform Methyl Ethyl Ketone Carbon Disulphide Chlormethane Trichloroethane
	Sulphite Mill Operations	Sulfur Oxides
	Kraft Pulping and Recovery Processes	Volatile Organic Compounds
	Chip Digester and Liquid Evaporator	Terpenes Alcohols Phenols Methanol Acetone Methyl Ethyl Ketone
	Products of Combustion	Nitrogen Oxides Sulfur Oxides Carbon Monoxide Particulate Matter Fly Ash
Incineration Facilities Fuel Burning Power Generation Diesel/Gasoline Engine Operation	Products of Combustion	Sulfur Oxides Nitrogen Oxides Sulfur Trioxide Sulfuric Acid Ammonium Sulfate Ammonium Bisulfate Carbon Dioxide Sulphate Nitrate Hydrochloric Acid Hydrogen Fluoride Particulate Matter Ozone Volatile Organic Compounds
Cleaning Agent Processing	Process Emissions	Chlorine Chlorides
Salt Mining/Processing Swimming Pool Agents	Process By-Products	Bromine Chlorine Sulfate Sodium Bisulfate Phosphate Chlorides
Fertilizer Manufacturers	Process By-Products	Hydrogen Fluoride Sulfites Sulfuric Acid Hydrofluoric Acid Phosphoric Acid Fluorosiliac Acid Ammonia Ammonia Salts
Waste Water Treatment Facilities	Waste Digestion	Methane Sulfur Dioxide Nitrogen Oxides Volatile Organic Compounds Chlorine Chlorine Dioxide Ammonia Ammonia Salts
	Sludge Processing	Hydrogen Sulfide
Agriculture	Animal Waste and Fertilizers	Sulfur Nitrous Oxide Nitrogen Oxides Methane Hydrogen Sulfide Ammonia Ammonia Salts

Field-Applied Coatings

Field-applied sprayed-on coatings will not provide sufficient protection in corrosive environments and should not be used on Carrier coils. The use of field-applied coatings on Novation® heat exchangers may negatively affect the Carrier warranty. Possible reasons for inadequate protection include:

- Coil cleanliness is crucial for proper adhesion. Adequate field cleaning techniques are often overlooked. In addition, the coil must be void of any corrosion. Encapsulation of existing corrosion makes the coating ineffective by leading to continued deterioration and eventual coating delamination.
- Field application cannot ensure continuous coating of coil surfaces on multiple row coils. It is difficult to ensure uniform coating quality throughout the depth of the fin pack.
- Interior coil surfaces remain untreated when sprayed-on from unit exterior; often, spray applicators cannot reach deep into the coil assemblies, leaving inconsistent thickness or areas of no coverage.
- Inconsistent coating thickness can minimize or negate coating protection. Recommended coating thickness cannot be ensured with field application on multiple row coils. Film thickness measurements are often overlooked.

SELECTION SUMMARY

Selection Tables

Tables C through F provide guidelines for coil selection. To use the tables, first clearly identify the operating environment for the intended installation. Then determine the severity of each environmental factor associated with the installation site. Choose the protection option based on the most severe environmental factor anticipated for the given site.

NOTE: In these tables, acceptability of a coil option is based solely on corrosion performance. Other factors, including cost, should be considered in making the final coil selections.

For MCHX coils, the Carrier Electronic Catalog (E-CAT) can be used to obtain confirmation on whether or not corrosion protection is recommended for particular applications in coastal/marine environments.

Selection Example

Following is an example of the selection process as applied to a coastal environment.

Step 1 – Identify the operating environment according to the factors described in Table C.
For this example:

a. Site is on the coastline (distance from the coast is <0.01 miles).
b. Condenser coil is facing the ocean, with the direction of the prevailing wind from the coast to the unit.
c. No noticeable corrosion on other equipment.

Step 2 – Determine the severity of each environmental factor; always choose the option for the most severe environmental factor present.
There is no noticeable corrosion on the unit, which means low severity for this factor; however, the distance from the coast and the prevailing wind are both in the severe category, so coil selection should be guided by recommendations in the last column on the right, at the severe end of the range.

Step 3 – Identify coil options.
The acceptable coil options are as follows: copper fin/copper tube, e-coated aluminum fin/copper tube, e-coated microchannel heat exchanger coil, or e-coated copper fin/copper tube coil.

Table C
Coastal Environment Protection Option

Global Coil and Coating Options*	Severity of Environmental Factors: Low → Severe Distance from Coast** → Inland > 5 mi Direction of Prevailing Winds: From Unit to Coast Corrosion Present on Other Equipment: None Present	5 to 2 mi	Coastline < 2mi to <0.01 mi From Coast to Unit Noticeable Corrosion
Standard: Aluminum Fin / Copper Tube	ACC	ACC	NR
Microchannel Heat Exchanger†	ACC	ACC	NR
Pre-Coated Aluminum Fin / Copper Tube	ACC	ACC	NR
Copper Fin / Copper Tube	ACC	ACC	ACC
E-Coated Aluminum Fin / Copper Tube	ACC	ACC	ACC
E-Coated Microchannel Heat Exchanger†	ACC	ACC	ACC
E-Coated Copper Fin / Copper Tube	ACC	ACC	ACC

ACC - Indicates that the option is acceptable for the application and conditions shown; in some cases, the level of corrosion protection provided by this option may be higher than required. Acceptability is based solely on corrosion performance. Other factors, including cost, should be considered in making the final selections.

NR - Not recommended

*Other coating options may be available within a given region.
†Information in this table is provided as a guide; contact a Carrier Sales Engineer for an E-CAT selection.
**Refer to the E-CAT program for exact distance requirements for MCHX coils.

Note: The distances stated relate to land distances to ocean. Additional coating may be required for Marine Applications on-board a ship.
Environments immediately adjacent to diesel exhaust, incinerator discharge stacks, fuel burning boiler stacks, or areas exposed to fossil fuel combustion emissions should be considered a Combined Coastal/Industrial application. Recommendations presented for Industrial and Combined Coastal/Industrial Environments should be followed.

Table D
Industrial Environment Protection Option

Global Coil and Coating Options*	Severity of Environmental Factors: Low → Severe Contaminant Concentration†† 0 to 50 ppm Corrosion Present on Other Equipment: None Present	51 to 100 ppm	>100 ppm Noticeable Corrosion
Standard: Aluminum Fin / Copper Tube	ACC	NR	NR
Microchannel Heat Exchanger†	ACC	NR	NR
Copper Fin / Copper Tube	NR	NR	NR
Pre-Coated Aluminum Fin / Copper Tube	ACC	ACC	NR
E-Coated Aluminum Fin / Copper Tube	ACC	ACC	ACC
E-Coated Microchannel Heat Exchanger†	ACC	ACC	ACC
E-Coated Copper Fin / Copper Tube	NR	NR	NR

ACC - Indicates that the option is acceptable for the application and conditions shown; in some cases, the level of corrosion protection provided by this option may be higher than required. Acceptability is based solely on corrosion performance. Other factors, including cost, should be considered in making the final selections.

NR - Not recommended

*Other coating options may be available within a given region.
†Information in this table is provided as a guide; contact a Carrier Sales Engineer for an E-CAT selection.
††See "E-Coating Chemical Resistance Guide" in Appendix. Testing for contaminants may be performed by Draeger tube procedure.

Table E
Combined Coastal/Industrial Environment Protection Option

Global Coil and Coating Options*	Severity of Environmental Factors Low →		Severe
	Distance from Coast** Inland > 5 mi	5 to 2 mi	Coastline < 2 mi to <0.01 mi
	Contaminant Concentration†† 0 to 50 ppm	51 to 100 ppm	>100 ppm
	Direction of Prevailing Winds From Unit to Coast →		From Coast to Unit
	Corrosion Present on Other Equipment None Present →		Noticeable Corrosion
Standard: Aluminum Fin / Copper Tube	ACC	NR	NR
Microchannel Heat Exchanger†	ACC	NR	NR
Copper Fin / Copper Tube	NR	NR	NR
Pre-Coated Aluminum Fin / Copper Tube	ACC	ACC	NR
E-Coated Aluminum Fin / Copper Tube	ACC	ACC	ACC
E-Coated Microchannel Heat Exchanger†	ACC	ACC	ACC
E-Coated Copper Fin / Copper Tube	NR	NR	NR

ACC - Indicates that the option is acceptable for the application and conditions shown; in some cases, the level of corrosion protection provided by this option may be higher than required. Acceptability is based solely on corrosion performance. Other factors, including cost, should be considered in making the final selections.

NR - Not recommended

*Other coating options may be available within a given region.
†Information in this table is provided as a guide; contact a Carrier Sales Engineer for an E-CAT selection.
**Refer to the E-CAT program for exact distance requirements for MCHX coils.

††See "E-Coating Chemical Resistance Guide" in Appendix. Testing for contaminants may be performed by Draeger tube procedure.

Note: The distances stated relate to land distances to ocean. Additional coating may be required for Marine Applications on-board a ship.
Environments immediately adjacent to diesel exhaust, incinerator discharge stacks, fuel burning boiler stacks, or areas exposed to fossil fuel combustion emissions should be considered a Combined Coastal/Industrial application. Recommendations presented for Industrial and Combined Coastal/Industrial Environments should be followed.

Table F
Urban Environment Protection Option

Global Coil and Coating Options*	Severity of Environmental Factors Low →		Severe
	Pollution Levels (SO_2 levels in Cities with >50K Inhabitants)*** Low <20 to 50 μg/m^3	51 to 125 μg/m^3	High >125 μg/m^3
	Corrosion Present on Other Equipment None Present →		Noticeable Corrosion
Standard: Aluminum Fin / Copper Tube	ACC	ACC	NR
Microchannel Heat Exchanger†	ACC	ACC	NR
Copper Fin / Copper Tube	NR	NR	NR
Pre-Coated Aluminum Fin / Copper Tube	ACC	ACC	NR
E-Coated Aluminum Fin / Copper Tube	ACC	ACC	ACC
E-Coated Microchannel Heat Exchanger†	ACC	ACC	ACC
E-Coated Copper Fin / Copper Tube	NR	NR	NR

ACC - Indicates that the option is acceptable for the application and conditions shown; in some cases, the level of corrosion protection provided by this option may be higher than required. Acceptability is based solely on corrosion performance. Other factors, including cost, should be considered in making the final selections.

NR - Not recommended

*Other coating options may be available within a given region.
†Information in this table is provided as a guide; contact a Carrier Sales Engineer for an E-CAT selection.

***SO_2 levels shall be determined in accordance with ASTM D2914, ISO/FDIS 10498.

Note: Environments immediately adjacent to diesel exhaust, incinerator discharge stacks, fuel burning boiler stacks, or areas exposed to fossil fuel combustion emissions should be considered an Industrial application. Recommendations presented for Industrial Environments should be followed.

JOB SITE COMMISSIONING AND PROPER EQUIPMENT STORAGE

An important factor that is often overlooked is the proper storage of HVAC/R equipment, including equipment with coated or uncoated coils, prior to start-up at new installations. It is not unusual for equipment to arrive on site several months prior to the actual installation and start-up, resulting in a potential for premature corrosion to occur if the equipment is not stored in a proper manner. Equipment should be stored so that it is not exposed to excessive construction debris and concrete dust, industrial contaminants, coastal contaminants, or high levels of humidity and moisture.

Improper storage can lead to premature corrosion prior to start-up and can reduce the overall life of the equipment.

Extra care should be taken to ensure that equipment located on the ground level remains free from debris prior to start-up.

COIL MAINTENANCE AND CLEANING RECOMMENDATIONS

Routine cleaning of coil surfaces is essential to maintain proper operation of the unit. Elimination of contamination and removal of harmful residues will greatly increase the life of the coil, optimize equipment performance, and extend the life of the unit. Maintenance requirements and correct cleaning procedures for MCHX and RTPF coils may be found in the Service instructions provided with each unit and should be followed carefully.

APPENDIX

E-Coating Chemical Resistance Guide

The coating material used for e-coat is resistant to fumes from the chemicals listed below. However, Carrier does not recommend direct coil immersion service for any of these chemicals. The chemical resistance guidelines were determined by a 24-hour spot test exposure of the chemical listed. Resistance was determined for these chemicals at the concentrations identified.

E-coat is resistant to the following fumes:

- Acetates (ALL)
- Acetic Acid 99%
- Acetone
- Alcohols
- Amines (ALL)
- Amino Acids
- Ammonia
- Ammonia Salts
- Ammonium Bisulfate
- Ammonium Sulfate
- Ammonium Hydroxide
- Benzene
- Borax
- Boric Acid
- Bromine
- Butric Acid
- Butyl Alcohol
- Butyl Cellosolve
- Calcium Chloride
- Calcium Ilypochloric
- Carbon Dioxide
- Carbon Disulphide
- Carbon Monoxide
- Chlorides
- Chlorine
- Chlorine Dioxide
- Chlorine Gas
- Chloroform
- Chromic Acid 25%
- Citric Acid
- Cresol
- Dichloromethane
- Diesel Fuel
- Diethanolamine
- Ethyl Acetate
- Ethyl Alcohol
- Ethyl Ether
- Fatty Acid
- Fluoride
- Fluorine Gas
- Fluorosiliac Acid
- Formaldehyde 27%
- Fructose
- Gasoline
- Glucose
- Glycol
- Glycol Lither
- Hydrazine
- Hydrochloric Acid 37%
- Hydrofluoric Acid 30%
- Hydrogen Fluoride
- Hydrogen Peroxide 5%
- Hydrogen Sulfide
- Hydroxylamine
- Iodine
- Isobutyl Alcohol
- Isopropyl Alcohol
- Kerosene
- Lactic Acid
- Lactose
- Lauryl Alcohol
- Magnesium Chloride
- Magnesium Sulfate
- Maleic Acid
- Menthanol
- Menthol
- Methane
- Methyl Ethyl Ketone
- Methyl Isobutyl Ketone
- Methylene Chloride
- Mustard Gas
- Naphthol
- Nitrate
- Nitric Acid 25%
- Nitrogen Oxides
- Nitrous Oxide
- Olale Acid
- Oxalic Acid
- Ozone
- Perchloric Acid
- Phenol 85%
- Phosgene
- Phosphate
- Phosphoric Acid
- Phenolphthalein
- Phosphoric Acid
- Potassium Chloride
- Potassium Hydroxide
- Propionic Acid
- Propyl Alcohol
- Propylene Glycol
- Salicylic Acid
- Salt Water
- Sodium Bisulfate
- Sodium Bisulfite
- Sodium Chloride
- Sodium Hypochlorite 5%
- Sodium Hydroxide 10%
- Sodium Hydroxide 25%
- Sodium Sulfate
- Sorbitol
- Stearic Acid
- Sucrose
- Sulfates (ALL)
- Sulfides (ALL)
- Sulfites (ALL)
- Sulfur Dioxide
- Sulfur Oxides
- Sulfur Trioxide
- Sulfuric Acid 25-85%
- Starch
- Terpenes
- Toluene
- Trichloroethane
- Triethanolamine
- Urea
- Vinegar
- Volatile Organic Compounds
- Xylene

NOTE: All data, statements, and recommendations are based on research conducted by the e-coat manufacturer and are believed to be accurate. It is the responsibility of the user to evaluate the accuracy, completeness or usefulness of any content in this paper. Neither Carrier nor its affiliates make any representations or warranties regarding the content contained in this paper. Neither Carrier nor its affiliates will be liable to any user or anyone else for any inaccuracy, error or omission, regardless of cause, or for any damages resulting from any use, reliance or reference to the content in this paper.

Turn to the Experts.℠

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