YORK® BY JOHNSON CONTROLS	Air Cooled Liquid Chillers Condenser Corrosion Protection	
ENGINEERING SUPPLEMENT	Supersedes: 150.12-ES1 (696)	Form 150.12-ES1 (412)

GENERAL

This recognizes air cooled condenser corrosion problems, which occur in coastal and/or salt mist environments. Islands or areas like Florida are surrounded by sea water. They have upper atmospheric winds continually traveling across them. These winds are typically laden with humidity, salt mist or other chemical contaminants (A similar situation can exist where chemicals are produced or areas where waste water accumulates). This results in equipment being exposed to a very mild salt solution or other chemicals even when the equipment is not operating. When operating, the unit's fans are inducing this moisture laden air across the hot condenser coils. These conditions accelerate condenser corrosion. This deteriorates the air cooled condenser and also results in the loss of performance. Consulting Engineers need to take steps to resist or slow the corrosion process. This supplemental is designed to help understand this and what can be done to "beef-up" condenser coils going into these location.

CORROSION

Corrosion will occur in two ways on air cooled condensers:

1. Edge corrosion of the aluminum fin coils; and
2. Galvanic corrosion.

Edge corrosion is purely caused by the salt air coming in contact with the leading edges of the condenser coils. It starts from the outer edges and progresses toward the center of the coil at a slow, normally, insignificant rate in a salt air environment (This can be more rapid if other highly corrosive chemicals are also present) The galvanic corrosion occurs at the junction of the copper tubes and aluminum fins (this is also known as the fin collar). The galvanic corrosion seems to be the more severe of the two. Two dissimilar metals (copper tubes and aluminum fin stock) in the presence of an electrolyte (salt mist or moisture) promote this galvanic corrosion.

Chemical books reference the galvanic series in salt water and will typically illustrate it as follows.

Corroded End (Anode)
Magnesium
Zinc
Aluminum
Steel
Lead
Tin
Brass
Copper
Bronze
Stainless Steel

Protected End (Cathode)

Decreasing Tendency
to Corrode

The less noble metal (Anode or aluminum in this case) is attacked or corroded by the presence of the more noble metal (Cathode or copper in this case). The further the metals are separated from each other within this galvanic series; the greater the galvanic potential and the greater the galvanic corrosion. Thus, corrosion is more severe at the junction of metal contact than elsewhere on the metal surfaces, especially in the presence of an electrolyte (salt mist). The moist salt air is induced by fans across the air cooled coils. This causes galvanic corrosion to start at the fin collar and it spreads to the edges. The metal to metal contact is lessened and heat transfer is decreased. Power consumption increases and equipment operates less efficiently than when the equipment was installed. The equipment will no longer be operating at the minimum ASHRAE 90.1 or the original EER levels.

INDUSTRY OPTIONS

All major manufacturers offer options to resist corrosion in harsh environments. The following table illustrates what IS available

BRAND	STANDARD ALUMINUM FINS	COPPER FINS	PHENOLIC COATED FINS	EPOXY COATED FINS
CARRIER	LOUVERED	OPT.	OPT.	NO
MCQUAY	LANCED	OPT. SINE WAVE (NOT LANCED)	OPT. (ALSO WITH COPPER FINES)*	NO
TRANE	SLIT	NOT AVAILABLE	NOT AVAILABLE	BLUE FIN
YORK	LOUVERED	OPT. SINE WAVE (NOT LANCED)	LOUVERED	BLACK FIN

*Louvered, lanced, and slit fins all have similar construction

YORK OPTIONS ENGINEERING INFORMATION

York offers customers a wide variety of corrosion resistance options. The possibilities are:

Copper Fin Coils - Copper fins of 0 0055” are stamped and applied with the copper tubes and galvanized end sheets to form these coils These have been traditionally used in coastal locations for years. However, they tend to be very costly. They can still be subject to corrosion if other chemical pollutants are present in the atmosphere. Copper fins are not available in the louvered or slit configuration due to manufacturing difficulties with copper.

Phenolic Coated Coils - These are Phenolic based coatings for which York has two approved suppliers (Technicoat or Heresite). Technicoat has been the sole supplier recently. The Technicoat ‘’10-1’’ process involves dipping the entire coil (fins, end sheets and refrigerant stub out connections) into a phenolic bath. It is blown to prevent fin bridging and cured at an elevated room temperature to enhance curing. This results in an average dry thickness of 1.5 to 2 mils for the entire coil The coils have a brown color when dry.

Black Fin Coils - The coils are built with copper tubes with Alcoa coated fin stock Alcoa has had 27 years of experience of coating metal This is the third generation of coated fin stock which has been available for about three years. It is a modified epoxy coating. It is applied to rolled .0055” thick, “O” soft temper, 1100 aluminum alloy fin stock using a Roto-Gravure process (at a high temperature under high pressure). The fin stock is cured at a very high temperature of 470°F to 550°F. This assures adhesion with an average coating of 0.1 mil thick on each side of the fin. The excellent adhesion allows the black epoxy to remain intact on the fin collar even after punching. This black color coating provides a barrier at the fin collar to stop galvanic corrosion action between the aluminum fin and copper tube.

PERFORMANCE FACTORS

The unit capacity and compressor power input should be adjusted for the different fin construction as follows.

FIN TYPE	TONS X	COMPRESSOR KW X
STD. ALUMINUM FIN	NO CHANGE	NO CHANGE
BLACK FIN*	0.995	1.000
PHENOLIC FIN	0.990	1.005
COPPER SINE WAVE FIN*	0.970*	0.990*

* While copper’s thermal conductivity is slightly better than aluminum, the above adjustment factors are due to the use of the sine wave (or corrugated as it is referenced sometimes) fin construction instead of the louvered construction.

PRICING RELATIONSHIP

Coated fin coils can be more first cost attractive than the traditional copper fin coil approach. The table below illustrates the cost impact for the various options and based on a 150 ton size unit.

FIN COILS	% PRICE INCREASE
ALUMINUM	STANDARD
BLACK	+7%
PHENOLIC	+17%
COPPER	+29%

DELIVERY IMPACT

Here is how the production cycles compare for the air cooled chillers built with the different fin options.

FIN COILS	PRODUCTION CYCLE IMPACT
ALUMINUM	STANDARD
BLACK	STANDARD
COPPER	STANDARD + 2 WEEKS
PHENOLIC	STANDARD + 6 WEEKS

FIN TYPE EXAMPLES

Your Johnson Controls Sales Office has examples of the above YORK fin options which show how they compare. Please contact a Sales Engineer to view these options.

PROJECTED COASTAL ENVIRONMENT LIFE

Environmental conditions can be greatly affected by many things such as coal burning power plants, manufacturing plants, trash/waste burning facilities, storage of chlorinated pool chemicals, high levels of traffic emissions, distance from the salt water, prevailing winds and acid rain. In addition, the environmental conditions will change because of the addition of new facilities, adjacent property or neighborhood construction, and changes in wind/weather patterns. Because of these, it makes it extremely difficult to project condenser coil life. The following table provides the relative life expectancy between the different materials.

RELATIVE LIFE EXPANCTY OF VARIOUS MATERIALS IN DIFFERENT ENVIRONMENTS

FIN COILS	RELATIVE LIFE EXPENTANCY OF VARIOUS MATERIALS (YEARS)
ALUMINUM	1 TO 2
BLACK	2 TO 5
COPPER	4 TO 6
PHENOLIC	3 TO 6

APPLICATION & EQUIPMENT SPECIFICATION CONSIDERATIONS

Here are a few reasonable tips to consider when applying air cooled condenser equipment in harsh environments.

1. Limit the impact of direct ocean spray on equipment.
2. Locate units as far away from the salt water as possible.
3. Use the building as an wind shield to limit the prevailing ocean breezes from hitting the equipment.
4. Install the unit as far away from the chlorinated swimming pool and its chemical storage building to limit the exposure to these at hotels and motels, especially at beach side locations.
5. Copper coils are not recommended for applications exposed to acid rain as either the phenolic or Black Fin coils would be a better choice.

Some form of condenser coil corrosion resistance is recommended and should be included in Engineering Specifications for equipment to be installed in salt mist environments.

ON-GOING EXPERIENCE

Our coating suppliers and York periodically test the coils for durability. The demanding test follows American Society for Testing and Materials, Standard ASTM B117. The Standard sets forth the conditions required in the salt spray (fog) testing and the apparatus required for performing the test. The test samples are exposed to a neutral pH, 5% NaCl, salt spray solution, which is maintained at 95°F for long periods of time. This high chloride environment has long been a standard test for these materials and is particularly conducive to galvanic corrosion. In addition, we have been shipping air cooled condenser designs into coastal areas of the United States, Caribbean, Middle-East and the Far-East. The Phenolic and Black Fin coils are been seen as good coating candidates which are extending the life of the air cooled condensers in these areas.

CONDENSER CORROSION PROTECTION

Consulting Engineers and owners are looking for ways to extend the life of their air cooled condensers and preserve the original equipment EER. This supplement focuses on the environmental factors which affect these. It reviews the available options which can add to the durability of the equipment. Specifiers should appreciate and compare these options to find their best choice of corrosion protection. This can be a significant step in extending their investment for this type of equipment in harsh salt mist environments.

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