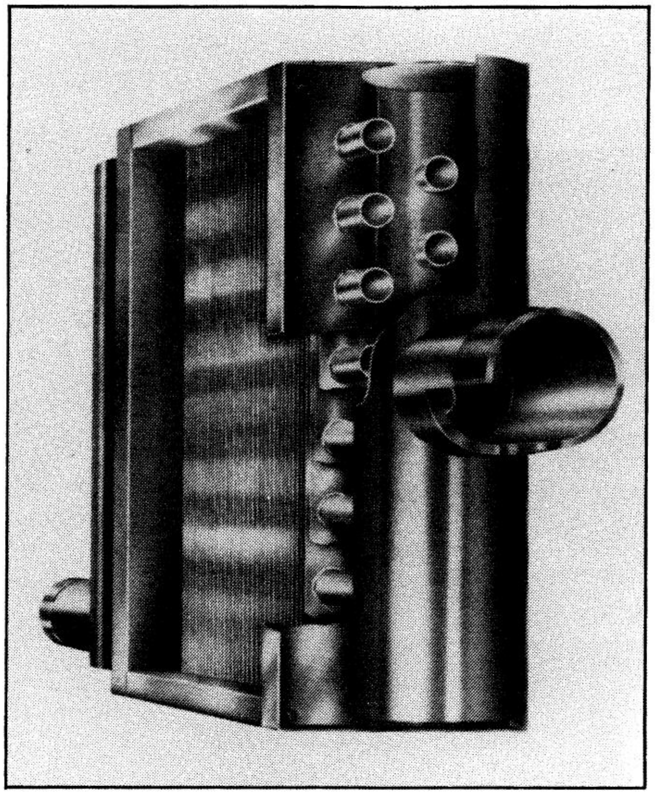


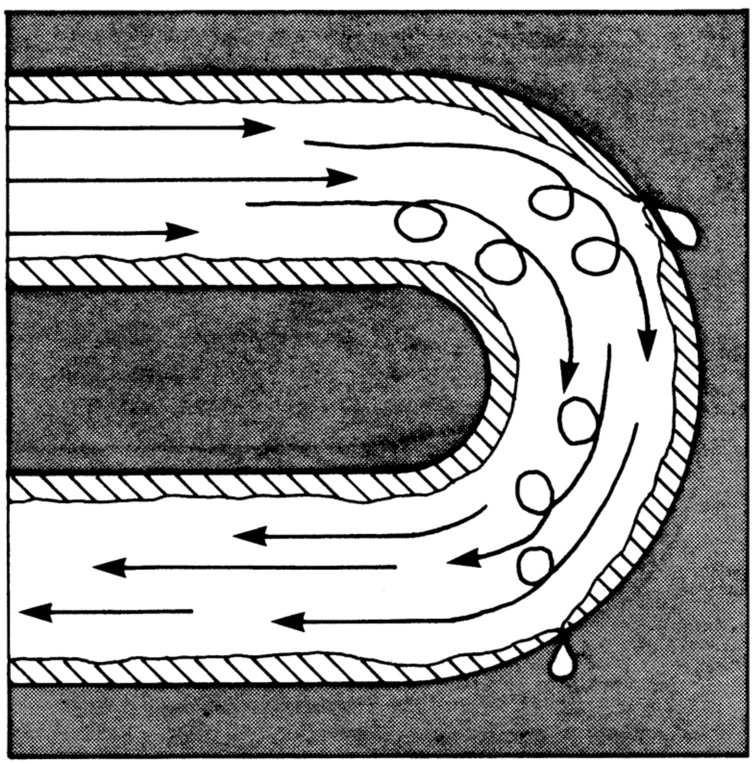
Tech Brief: Coils series

Coil Corrosion

Tech Brief – Coil Corrosion

A successful coil installation requires that; the proper coil is selected to start with the coil is installed correctly and the coil is adequately maintained. In the first series of articles we want to address some of the issues involved in making the "proper" coil selection. We will cover; corrosion considerations, temperature/ pressure considerations, specific environments, coil types and their applications.

This Tech Brief will discuss one of the most elusive potential coil problems facing the engineer which is corrosion. Corrosion considerations are difficult because of the large variety of chemicals involved in processes and cleaning solutions, as well as minerals dissolved gases and pollutants in the air and water. To complicate matters the coil construction, velocities and temperature will significantly vary the impact of those corrosive elements. Hopefully, this Tech Brief will help to explain the major corrosion concerns.



Corrosion problems that occur within several inches of the tube to header joints or in the return bends are usually velocity-related. These areas are subject to increased turbulence and failures normally show up as pinhole leaks on the outer tube surfaces. The figure above shows how the inner tube surfaces are usually rough and pitted.

EFFECTS OF VELOCITY

The effects of velocity on corrosion depends on the metals involved and the environments to which the metal is exposed. In most environments, such as sea water, the effect of velocity depends on the characteristics of the film that a given metal develops. Those metals capable of developing very tough films with a relatively low resistance to fouling will fare better with high velocities. In the same environment, metals that develop films with good anti-fouling characteristics may be velocities sensitive. These metals will perform better with low velocities. Some general guidelines are listed in Table I.

Velocity related corrosion problems usually occur within several inches of the tube to header joints or in the return bends because these areas are subject to increased turbulence.

The failures normally show up as pinhole leaks n the outer tube surfaces. The corresponding inner tube surfaces are usually rough and pitted. In severe cases, the pitting may be horseshoe-shaped.

Table 1. Water velocities of various metals.

	FRESH WATER	SEA WATER
Copper & Brass	1-6 FPS	1-2 FPS
Admiralty Brass	1-6 FPS	1-6 FPS
9011O Cupro Nickel	1-8 FPS	4-8 FPS
70130 Cupro Nickel	1-12 FPS	5-12 FPS
Steel	1-10 FPS	Not Rec'd.
Stainless Steel	1-15 FPS	5-15 FPS
Aluminum	1-4 FPS	Not Rec'd.

EFFECTS OF TEMPERATURE

Increasing temperature increases corrosion activity in nearly all cases. In some instances, temperature increases can dramatically increase corrosion rates. Temperature in-creases of less than 60°F., for example, can double corrosion rates in waters containing oxygen and carbon dioxide, (two common contaminants in water and steam systems). Consequently, the effects of temperature in a given application must be carefully considered in selecting materials. This is particularly true when operating temperatures are more than 120°F.

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EFFECTS OF STRESS

Corrosion Fatigue

Corrosion fatigue is a combined action of corrosion and cyclic stresses which cause failure that would not occur with either factor separately. Failure in such instances results in cracking, usually in or near the tube/header joint. In most cases, the cyclic stresses are a result of temperature changes causing expansion and contraction of the tube and/or header. The magnitude of cyclic stresses required to initiate fatigue corrosion depends on the intensity of the corrosive activity as well as the frequency of the cyclic stresses.

In typical comfort heating/cooling coil applications, steam coils exposed to outside air temperatures are more susceptible to this type of failure than water or refrigerant coils. All coils, however, regardless of materials or design, are susceptible to this type of failure given the proper environment. When conditions are present for corrosion fatigue failures, coil de- sign with formed headers tying multiple rows of tubes together should be avoided. In terms of materials, with all other factors being equal, carbon steel has a lower coefficient of expansion and would be more desirable as the tube and header material.

Stress Corrosion Cracking

Stress corrosion cracking is a corrosion failure resulting from the combined effects of corrosion and tensile stresses. Stresses are present due to processes of manufacturing coils and operational considerations, most notably, temperature changes causing dimensional changes in the tube. Of the materials most common to coil construction, (i.e., copper, cop- per alloys, aluminum, steel and stainless steel), copper alloys containing more than 15% zinc and stainless steels are the most susceptible to attack. Pure metals, such as copper and 1100 aluminum, are nearly immune to stress corrosion cracking.

As a rule, the causes of stress corrosion cracking are not well understood. Environments that cause stress corrosion cracking, however, are relatively well defined. Copper alloys are subject to stress corrosion cracking in environments containing ammonia and am- mines, either in solution or moist atmospheres and in the presence of moist S02. Stain- less steels are subject to stress corrosion cracking in environments containing acidic chlorides and fluorides.

Temperature, contaminate concentrations and the magnitude of the stresses will, in a complicated manner, determine the susceptibility of a given material to stress corrosion cracking. However, increasing any of these factors will increase the severity and of the attack. At high temperatures, over 200°F., stress corrosion cracking can occur with very small concentrations or contaminates. Usually this form of corrosion occurs in or around the tube/header joint or other welded areas. The small cracks that develop because of stress corrosion cracking must be confirmed through microscopic examination.

MISCELLANEOUS INFLUENCES ON CORROSION

Galvanic Corrosion

Galvanic corrosion occurs when dissimilar metals are in electrical contact with an electrolyte. In such instances, active metals are sacrificed (corroded) to passive metals. In galvanic corrosion of coils, the conductivity of the

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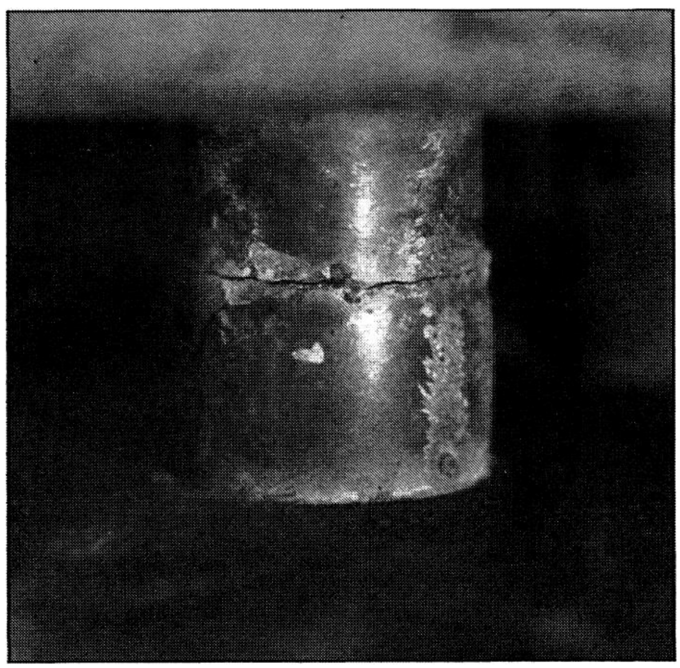


corrosion and tensile stresses. The combination of temperature, contaminate concentrations, and the magnitude of the stresses all impact the susceptibility of a given material to stress corrosion cracking.

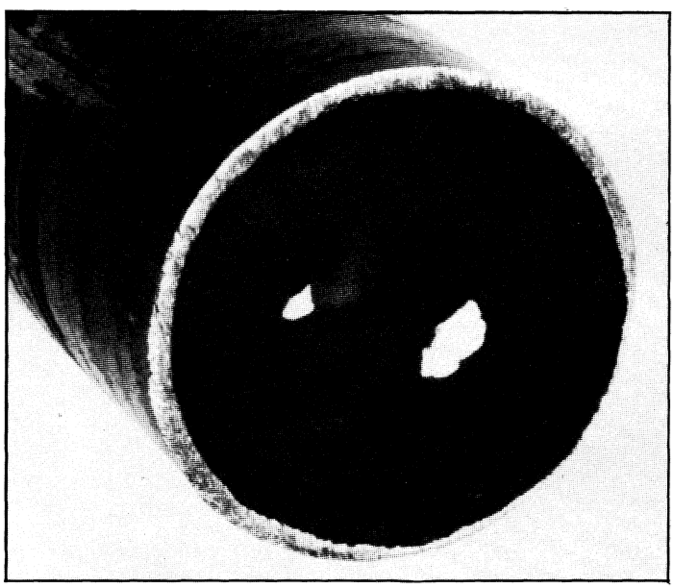
electrolyte (liquid) is important. Salt water, for example, is much more conductive than dis- tilled water and as a result, promotes galvanic corrosion. Generally, coils handling fresh waters do not ordinarily pose severe galvanic corrosion problems. In such systems, copper tubes/steel headers are used successfully. In more conductive mediums, however, the joining of unlike metals may initiate galvanic corrosion problems.

In some cases, atmospheres can also initiate galvanic corrosion problems. As with the medium in the tubes as discussed above, the conductivity of the electrolyte is important. Condensation from sea air may galvanically corrode unlike material combinations, such as aluminum fins on copper tubes or copper tubes with steel headers.

In practice, copper and copper alloys can usually be mixed without causing galvanic corrosion problems.

Crevice Corrosion

Crevice Corrosion is responsible for many, if not most, premature corrosion failures of coils. This form of corrosion causes deep, localized pitting on the tube surfaces, often leaving the metal surrounding the pitting virtually uncorroded. Once started, the corrosive activity in the pits can happen hundreds of times



Crevice Corrosion results in deep, localized pitting on the tube surfaces. Often, the surrounding metal may remain virtually uncorroded. This type of corrosion is often caused by variations in oxygen concentrations or by soluble contaminates such as sulfur, chlorine, or fluorine in contact with the tube surfaces.

faster than the general rates of corrosion and penetration through the tube wall can occur in very short periods of time.

Crevice corrosion is usually caused by variations in oxygen concentrations or by soluble contaminates such as sulfur, chlorine, or fluorine in contact with the tube surfaces. Variations of oxygen often occur when scale, sand, dirt, marine organisms or other solid matter is deposited on the tube surfaces causing a restricted access of oxygen to those surfaces.

With crevice corrosion, tube side velocities can play an important role. Moderate to high velocities tend to reduce the incidence of this form of corrosion since solid matter is more likely to be suspended in the liquid and not de- posited on tube surfaces and because higher velocities tend to provide more uniform access of oxygen to the tube surfaces. Low velocities or stagnate conditions increase the incidence of crevice corrosion for the opposite reasons. Consequently, crevice corrosion of- ten occurs during coil shutdowns or other occasions when coils are taken out of service and left with fluid in them.

When conditions likely to cause crevice, corrosion are known to exist, cleanable tube coils should be considered along with scheduled cleaning of the coil.