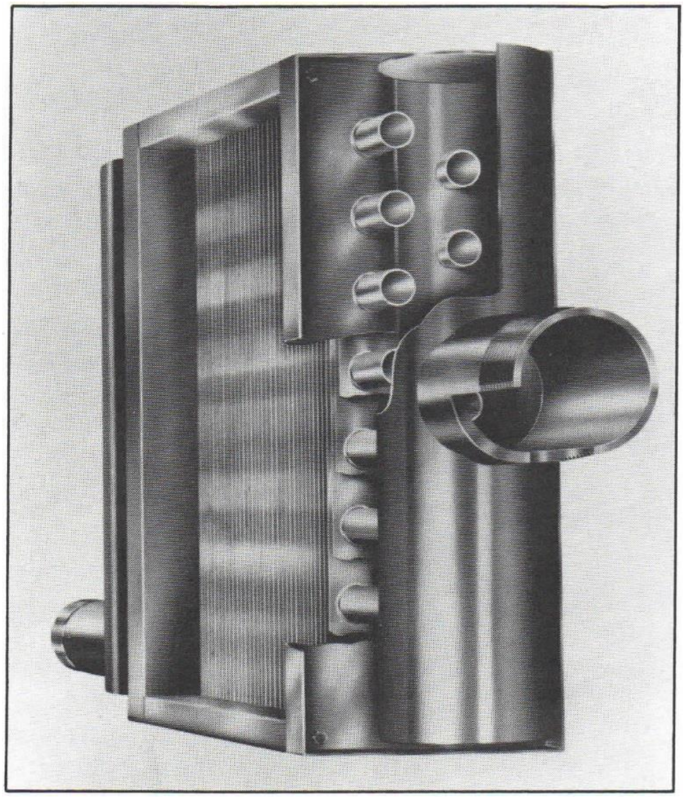

Tech Brief: Coils Series

Coil Failure Analysis

Tech Brief - Coil Failure Analysis

This tech brief is on coil failure analysis. This is an important topic for those responsible for replacing coils that have failed prematurely. Obviously, when coils need to be replaced, the designer or buyer has an opportunity to modify or upgrade new coils so that they will last longer and provide more trouble-free operation.

The following tech brief reviews some of the most common causes of coil failure. Of course, coils can fail from an almost unlimited variety of reasons, so it is recommended that a qualified professional be engaged to review specific applications.

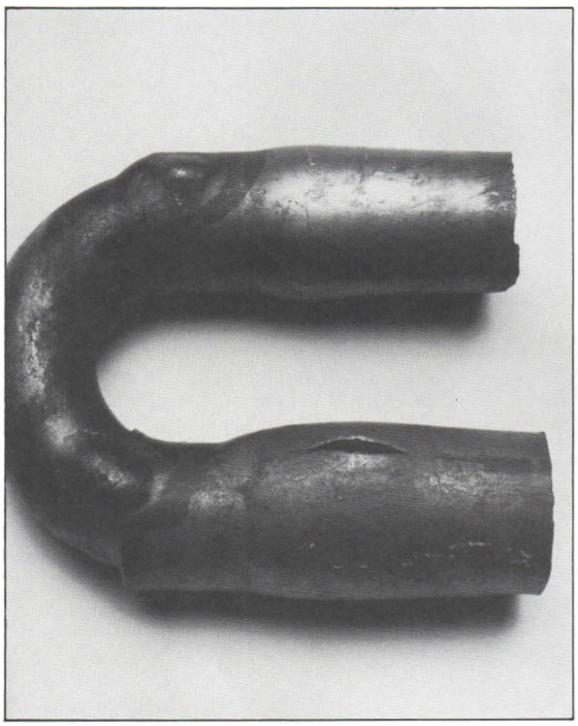

PHOTO 1:

Although freezing can burst any tube material, softer metals like aluminum, copper alloys ...or this copper tube shown here, often bulge around the split.

LEAKS IN THE COIL FACE

Leaks in the coil face area are usually caused by either corrosion problems or freezing. Occasionally, poor quality tubing is also responsible for leaks in a coil. However, with modern non-destructive test equipment and the methods of manufacturing, tube deficiencies are much less a consideration than they were several years ago.

Freezing Failures

Leaks in the coil face that are caused by freezing are easy to detect. The leaks show up as longitudinal splits ranging from 1'2" to 2" in length. Although all tube materials can freeze and burst, softer materials such as copper, copper alloys and aluminum, often bulge around the split. Freezing failures are not necessarily located in the lowest tubes in the coil. Often, they appear to be located randomly throughout the face of the coil.

SOLUTION - Steam distributing or non- freeze type coils can be employed to minimize freeze problems. No coil design, how- ever, is freeze proof, so it is important to employ an adequate design in the piping and coil installation). Also make sure systems are designed to minimize freeze potential (ie: minimize stratification, properly size preheat coils, use face & by-pass coil arrangements, employ emergency features to close dampers or open up steam valves, etc.)

Corrosion Failures

Leaks caused by corrosion in the finned area are more difficult to identify. Typically, corrosion failures show up as either pin holes or larger areas of uniformly corroded tube.

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Pin hole leaks (pitting) usually occur because of contamination in the fluid or gas passing through the tubes. In the case of steam coils, oxygen is normally the culprit. With circulating fluids, oxygen along with other soluble contaminates such as sulfur chlorine or fluorine are often responsible. Of course, external conditions can also promote pitting corrosion. This is particularly true with cooling coils that condense water onto the coil surfaces. In this instance, contaminants in the air can combine with the condensed water to form very corrosive solutions.

In any case, pitting corrosion shows up as small pin hole leaks that may group to create rather large leaks or may remain as a single isolated event. See photo 2.

Uniform corrosion also causes corrosion problems in some applications. This form of corrosion causes uniform thinning in the tube wall. Eventually, the tube wall thins to the ex- tent that normal operating pressures cause the tube to fracture. The fractures are normally longitudinal and may look much like a freeze failure except that the edges are jagged and thin. See photo 3.

In the case of steam coils, uniform corrosion is usually caused by concentrations of car- bon dioxide that become carbonic acid in the condensate. The condensate flows down the bottom half of the tube which causes the bottom half of the tube to thin over time.

In the case of circulating fluid coils, any number of contaminates in the fluid flowing through the tubes is capable of uniformly corroding the tube. Of course, the contaminates involved and the material of construction will determine whether the rate of uniform corrosion is at an acceptable level. Keep in mind that all materials will, over time, corrode. The ideal situation is to have the materials corrode uniformly at an acceptable rate.

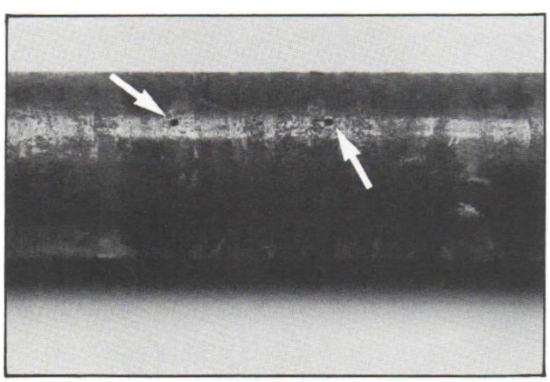
SOLUTION - Identify and eliminate the corrosive responsible for the corrosion or alter materials to other materials resistant to the corrosive.

LEAKS IN THE HEADER JOINTS

From a mechanical point of view, the area in and around a tube joint is the most susceptible to tube failure. Failures are usually caused by one, or a combination of the following factors.

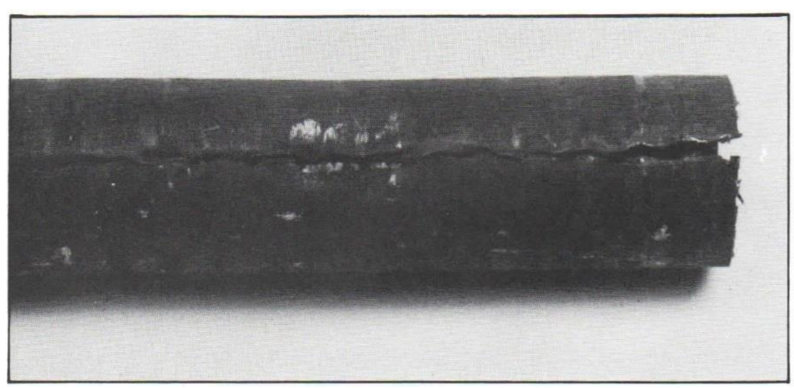
1. Cyclic stresses arising from the thermal expansion/contraction of the coil and piping to and from the coil are concentrated at the tube/header joint.

2. The "heat affected zone", which is the metal that has been significantly heated during the welding process, often exhibits different characteristics than the parent metal (ie: it's weaker, lower corrosion resistance, etc.).



PHOT02:

Pitting corrosion often shows up as either Isolated pin hole leaks like these or many of them grouped together to form a larger leak.



PHOT03:

Though it may look like a freeze failure, the tube shown here fa/led due to "uniform corrosion".

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3. A welded, or brazed joint is a manual process subject to human error.

4. It is not normally practical to inspect the joint fully without destroying it.

Fatigue Related Failures

Failures that are significantly influenced by cyclic stresses typically show up as radial cracks in the joint itself or the foot of the tube joint. The location of the fracture can tell a lot about the origin of the stress. For example, Figure 1 illustrates the direction of stress when tube cracks are perpendicular to the coil face. Figure 2 indicates the stress direction when cracks are parallel to the coil face.

SOLUTION - Eliminate the cause of the stress by using expansion joints or swing joints. For end tube failures, reduce the fin height of the coil or use a coil design that can accommodate header expansion and con- traction.

Corrosion Related Failures

Corrosion failures that occur in brazed joints usually show up as pin hole leaks. The leaks can be caused by a host of corrosives tha.t may be internal or external to the tube joint. Of course, the specific braze alloy has much to do with the corrosiveness of the joint. High silver braze alloys (like BAg5 or BAg24) are thought to be more resistant than other alloys such as Phos/Copper alloys (like BCuP2 or BCuP3).

Corrosion failures can also occur in welded joints even though the weld alloy has the same corrosion resistance as the parent material for several important reasons.

1. Weld joints are often accompanied by crevices that encourage corrosion to start.

2. The use of non-L grade stainless steel in the tube, header or weld alloy increases the susceptibility of the material to corrosion.

SOLUTION - Identify and eliminate the corrosive responsible for the corrosion or alter materials and/or braze/weld alloy to more resistant materials.

Joint Design/Construction

The design and construction of the tube joint can also cause premature failure. These failures are often caused by one of the following conditions.

1. Excessive joint clearance which greatly re- duces the strength of a brazed joint.

2. Lack of braze weld penetration (it should be at least 2 times the tube wall).

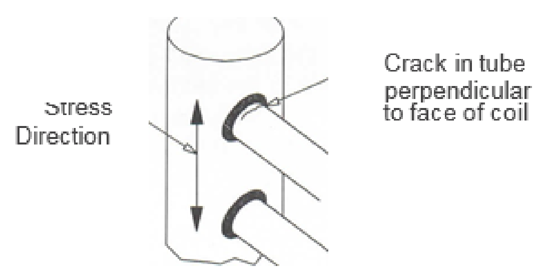

FIGURE 1:

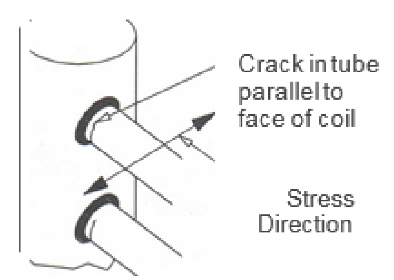

FIGURE 2:

FIGURES 1 and 2:

The specific location of tube cracks at the header joint indicate in which direction the offending stress is running. See "Fatigue Related Failures " for corrective measures.

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3. Lack of adhesion due to poor preparation, incorrect flux, or inadequate heating. See photo 4.

LEAKS IN RETURN BENDS

Return bend leaks are usually caused by coil freeze up or erosion/corrosion problems.

Freeze-Ups

In return bends, freeze-ups usually occur in water coils and show up as longitudinal splits in the end of the return bend. Occasionally, the tubes directly adjacent with the return bend bulge and/or fail as well. See photo 1.

SOLUTION - Follow recognized practices to drain coils and properly install to eliminate possible freeze-ups.

Erosion/Corrosion

Often occurs at the outer wall of the return bend since the tube wall is much thinner at that point due to the method of manufacturing return bends. Failures of this type show up as either pin holes in one or more return bends. If severe enough, the re- turn bend may split if the wall be- comes thin enough so that it can't withstand normal operating conditions.

SOLUTION - Eliminate the corrosive if possible. Increase the wall thickness of the re- turn bend (should be at least 11/2 times the normal tube wall) or use more corrosive resistant materials.

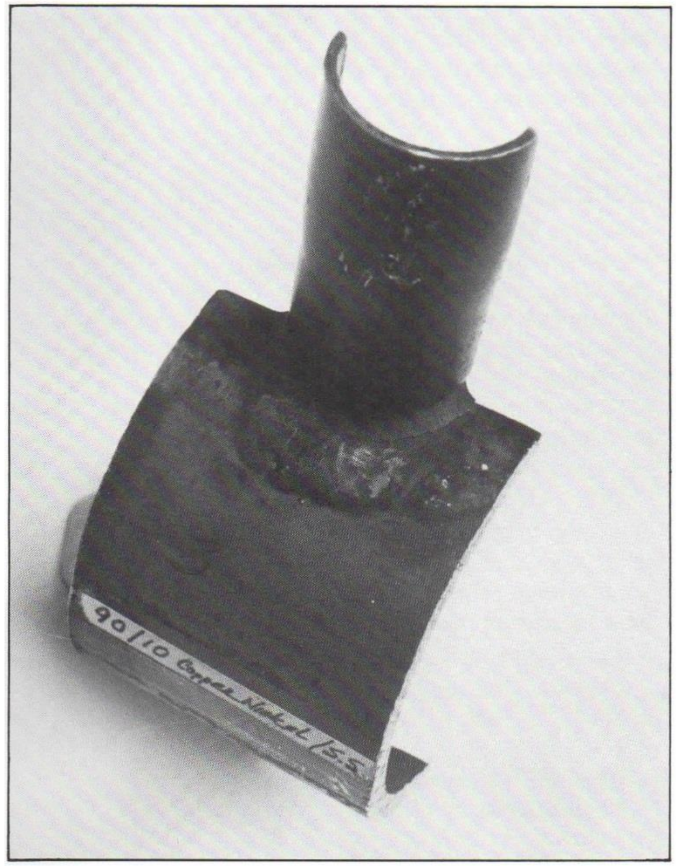

PHOTO 4

Joint failures like this one are caused by either: excessive joint clearance, poor braze weld penetration, or poor adheasion due to incorrect flux and/or inadequate heating