SERVICE LIFE FACTORS

The following describes various service life factors in corrugated metal hose applications. The information is based on our experience as a manufacturer of metal hose, braid products and metal hose assemblies. While this information is intended to be a general guide, each application should be evaluated individually because of the many variables that affects service life of metal hose assemblies.

General Corrosion

Uniform attack through the entire corrugated length of the metal hose assembly is mostly described as general corrosion. Attack on the alloy is affected by chemical concentration, temperature and the type of alloy from which the metal hose is manufactured. Some typical areas of attack include the root or bottom of the corrugation and in the heat affected weld area.

Most stainless alloys form a protective film of stable oxides on the surface when exposed to oxygen gas. The rate of oxidation is dependent on temperature. At normal temperatures, a thin film of oxide is formed on the alloy surface. Higher temperatures will cause oxidation to proceed more rapidly.

The oxides that form on copper or nickel alloys are of a nonporous oxide formation. A nonporous oxide formation will provide a protective layer on the surface but if the layer is removed, no protection is provided to the underlying metal.

Factors when selecting piping and corrugated metal hose assembly materials should consider that the piping is a rigid member and the hose assembly will be subject to flexing. As outlined later in the Service Life Factors section, several factors associated with flexing affect the service life of a metal hose.

Service life may be affected by factors external to the metal hose assembly. Consideration should be give to the chemical composition of the environment surrounding the hose assembly as well as the media being transferred when selecting an alloy.

OmegaFlex does not publish corrosion resistance data because of the many variables present in metal hose applications. Many reference materials are available and provide accurate corrosion data. The Corrosion Data Survey published by the National Association of Corrosion Engineers (NACE) is one of many sources of reference for corrosion resistance information.

High Velocity/Chemical Abrasives

Turbulent flow of abrasive chemical media over the alloy surface may cause accelerated corrosion or erosion-corrosion. Liquids or gases that have suspended solid particles will wear or remove the oxide protective film and leave the alloy exposed and more susceptible to corrosion. Some forms of flow assisted corrosion include terms such as cavitation or impingement. Reducing the velocity or incorporating a liner in the metal hose assembly may reduce the effects of this type of abrasion.

High Cycle/Chemical Media

Applied stresses such as flexing or cyclic motion may reduce the oxide film surface effectiveness against corrosion. Cracks, resulting from cycling of the hose assembly, form in the protective oxide layer on the surface of the alloy thus reducing the effectiveness against corrosion. The introduction of a corrosive environment often eliminates the fatigue limit of the alloy creating a finite life regardless of stress level.

Stress Corrosion

The detailed mechanism of stress corrosion is complicated and not well understood. The process of stress corrosion seems to be one of initial formation of corrosion pits and crevices, and subsequent fracture due to stress concentrations associated with the crevices. Stress corrosion cracks often follow crystal boundaries in the grain structure of the alloy. Visual examination of high cycle/chemical media and stress corrosion failures appears similar. Application data specifying media, temperature and movements is very useful in order to determine the exact cause for failure.

Chlorides and caustics are the media most frequently found to cause stress corrosion cracking. Relieving stresses or selection of an alloy know for resistance to the conveyed media are possible ways to reduce this type of failure.

SERVICE LIFE FACTORS (Continued)

Intergranular Corrosion/Attack

Corrosion along the grain boundaries of the metal may occur and the grains of metal separate from the mass causing loss of strength and ductility. Failure due to loss of ductility is also know as brittle fracture. Alloys such as 304L or 316L have been developed to reduce the effects of intergranular corrosion. These low carbon alloys have a grain structure that is more resistant to corrosion.

Intergranular attack may occur when certain grades of stainless steel such as 304 or 316 are subjected to temperatures beyond 800°F. Chromium can precipitate out of solution, bonding with carbon and forming chromium carbides on grain boundaries at this temperature and above. Reduced protection from the loss of chromium when combined with corrosive media leaves the grain structure exposed to possible corrosive attack.

Using a stabilized grade of stainless steel, such as T321, is an effective method for preventing sensitization. Stabilized alloys sacrifice the stabilizing element to the carbon thus preventing loss of chromium in the grain structure.

Pitting Corrosion

Highly localized attack with the appearance of a relatively sharp or well-defined boundary and a surrounding area that appears unattacked is referred to as pitting corrosion. Pitting may occur in crevices, inclusions, imbedded iron or other metals, also items such as marine organisms in sea water adhering to metal surfaces or grease.

Fatigue

Progressive damage due to the flexing of the corrugations is known as fatigue. Stress generated by flexure, pulsation, torsion, vibration and flow induced vibration are some causes for fatigue failure. Continual small cracks form in the metal. Fatigue cracks often originate at small imperfections, such as non-metallic inclusions, within the metal. Stress will concentrate at the crack and further cycling will increase the size of the crack until a complete fracture occurs. Fatigue damage normally occur as a circumferential crack at the top or bottom of the corrugation.

Additionally, high flow velocity may cause the corrugations to vibrate at a high frequency and resonance vibration may occur. See High Flow Velocity below. Increasing the bend radius will decrease the stress level in the individual corrugations. Changes in corrugation count of the hose or control of the motion may also increase hose life.

High Flow Velocity

Applications where the flow of a liquid or gas is above manufacturer recommended levels and a liner is not incorporated into the hose assembly design often results in premature fatigue failure. The high flow velocity causes the corrugations to vibrate at a high frequency and, if the vibration is near the natural frequency of the hose, failure will occur very quickly.

Spider web type cracks and fractured pieces of metal breaking from the corrugations are typical appearances for this type of failure. Reducing the velocity by increasing the hose diameter or the use of an interlocked type liner are possible ways to avoid high flow velocity failures.

Torsion

Rotation about the longitudinal axis develops a shear stress in the metal that can cause premature damage. Twisting the metal hose assembly during installation or as a result of movement in two planes can produce cracks that start circumferentially on the crown or outside of more than one corrugation and progress longitudinally. Torsion is one of the most common causes for premature metal hose failure. Incorporating a lay line on the metal hose assembly will provide means for determining if the hose is rotating about the longitudinal axis.

Vibration

Vibration damage start as very small or irregular cracks, primarily close to the vibration source, around the circumference of the corrugation . The cracks may progress to the corrugation wall in the form of a "Y." Extreme braid wear on the crown or top of the corrugation is usually present. If the vibration is near the natural frequency of the hose, failure will occur very quickly. Corrugated metal hose may be harmonically tuned to compensate for damaging frequencies.

Low Pressure Applications

Caution must be used when unbraided metal hose assemblies are used in low-pressure applications such as engine exhaust. Proper installation practices, as outlined by the Expansion Joint Manufacturers Association (EJMA), utilizing piping guides and anchors must be observed to prevent premature damage of the metal hose assembly. The addition of braid should be considered for vibration attenuation.

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