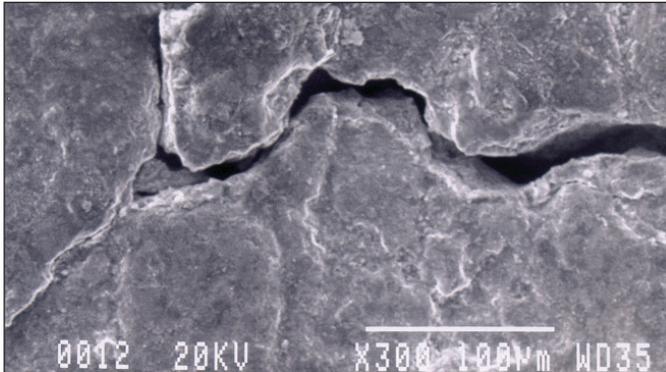


Chloride stress corrosion cracking (CSCC) is certainly not a new problem nor is it specifically related to tubing bundles. In fact, controlling or eliminating this type of failure is much more attainable in a premanufactured tubing bundle than with field construction.

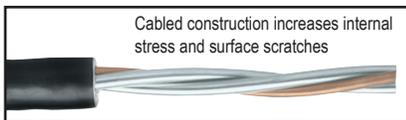


316SS and 304SS are particularly susceptible to this type of stress corrosion and 316SS is the most commonly used grade of SS tubing. A combination of factors must be present before CSCC is created. Generally these factors are agreed to be:

- Residual or applied stress in the tube.
- Temperatures above 180°F (70°C).
- Crevices or surface scratches.
- The presence of free chlorides.
- Alternating wet and dry or damp locations.

Residual or Applied Stress

The only way to completely eliminate this would be to fully anneal the tubing after it is installed which is not a practical solution. The next best solution is to minimize the amount of unrelieved stress in the tubing. The stress comes from two sources, bundle manufacturing and installation.



Simple logic tells us that there is more induced stress in a cabled tube bundle than in a bundle where

the tubes are laid in parallel. With parallel construction tubes are only bent in one plane as they are spooled and installed. With cabled construction the tubes are twisted together during assembly and then the twisted tubes are bent again as they are spooled and installed.

The more times a tube is bent the higher the internal unrelieved stress. The lower the level of unrelieved stress the more corrosion resistant the assembly.

Temperatures

There is no inherent advantage with different assembly or construction methods. The temperature will be determined by the process fluid and the application. The only consideration is that more is not better, keep temperatures as low as possible.

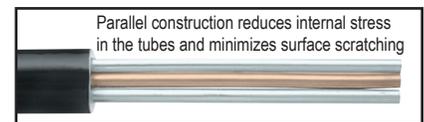
Crevices or Surface Scratches: Defects in the inside and outside surface of the tube provide sites where CSCC is more likely to begin. Care should be taken during manufacturing and installation to minimize scratches on the surface of the tube.

Tubing Type: Seamless tubing has fewer surface imperfections than welded tube.

Welded tubing has a heat affected zone around the weld which has a different metallurgy than the base material and is less corrosion resistant than seamless tubing.

Bundle Construction:

The manufacturing method of the tubing bundle also plays a roll in the surface condition of the tube. With cabled bundles the tubes are pulled together as they are twisted in place which leaves the surface covered with scratches and imperfections. Parallel construction may not eliminate all surface scratches but the construction method itself does not create new defects which promote corrosion.

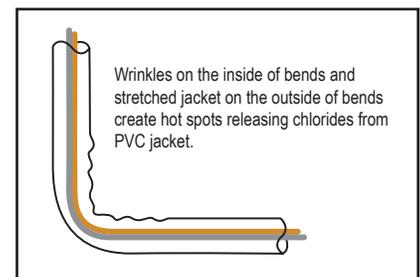


Presence of Free Chlorides

Chlorides can come from a variety of sources in a tube bundle: rain water leaching in through open ends or cracked jackets, PVC jacket, thermal insulation, PVC coated communications wires, even the ink used to mark tubes.

Jacket Materials: PVC (polyvinylchloride) jacketing is a common choice for bundle weatherproofing and wire insulation. Elevated temperatures cause the chlorides in the jacket or wire insulation are released and become 'free' to cause stress corrosion cracking.

PVC jacketed wires should never be put in contact with or close to any heated surface; pipe, steam line or electric tracer. Teflon coated wires should be used instead. Areas where the PVC jacket is subjected to elevated temperatures are at bends and under supports.

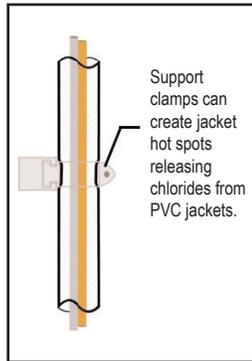


Chloride Stress Corrosion in Tubing Bundles

Manufacturers of PVC coated cabled tubing bundles have reduced their bending radius to match those with parallel tube construction. Since the PVC jacket is not as elastic as TPU Polyurethane it buckles on the inside of bends and pulls tight on the outside, both crush insulation and create localized areas where the jacket temperature is elevated.

Under support clamps the bundle may be compressed, reducing the insulation between the jacket and the heater. The clamp also acts as an insulator around the jacket. Both of these create localized areas where the jacket temperature is elevated. Chloride stress corrosion cracking of stainless steel tubing has been noted in the field at both of these details with PVC jacketed tubing bundle.

The best way to control this source of chlorides is to eliminate PVC by using a jacket material free of chlorides such as polyurethane.



Insulation: The thermal insulation materials used by all tubing bundle manufacturers contain some water soluble chlorides. It is thought that a chloride concentration less than 100 ppm is too low to promote chloride stress corrosion. The manufacturers of the insulation guarantee chloride content below 100 ppm. O'Brien, working with our suppliers, has been able to provide insulation averaging 45 ppm of water soluble chlorides within a range of 30 - 60 ppm.

The chlorides present in the insulation are only released in the presence of moisture. This is why the insulation must be kept dry at all times. As long as the insulation is dry the chlorides are not 'free' to induce stress cracking.

Moisture: All manufactures of tubing bundles stress the need to keep the insulation dry at all times including during installation. The ends of the tube bundle should always be capped during installation until the permanent end seal can be installed. Moisture entering the bundle during the initial installation is trapped when the end seals are installed. The moisture releases the water soluble chlorides in the insulation and rain water itself is a source of chlorides contributing to potential CSCC.

PVC jackets lose their plasticizers with age, exposure to UV and ozone (weather). Eventually PVC jackets become brittle and develop cracks which allow water into the bundle. Polyurethane has much better UV and weather resistance than the typical PVC and provides a much longer lasting weatherproof barrier.

Conclusion

Parallel construction induces less unrelieved stress in the process tubes than cabled bundles and has less likelihood of creating surface scratches on the tubes. Insulation must be kept dry at all times including construction. Heat shrink end seal boots should be used to seal all bundle ends. PVC coated communications wires should be eliminated and Teflon used in its place. Polyurethane jacket contains no chlorides that could contribute to stress corrosion cracking and has a much better weather and UV resistance than PVC.