Vacuum Interrupters, Inc.
A Group CBS Company

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IMPORTANT PRODUCT TECHNICAL BULLETIN

Under certain circumstances, a vacuum interrupter may fail after placed back in service due to saltwater exposure.

Electrical equipment exposed to water can be extremely dangerous if re-energized without proper reconditioning or replacement. Reductions in integrity of electrical insulation due to moisture, debris lodged in the equipment components, and other factors can damage electrical equipment by affecting the ability of the equipment to perform its intended function. Ocean water and salt spray can be particularly damaging due to the corrosive and conductive nature of the salt water residue. [1]

Vacuum interrupters are designed with metal bellows to allow movement of one of the two contacts. Typically, these bellows are made of an austenitic stainless steel and have a thickness of only a few thousandths of an inch. Under ideal conditions, the mechanical life of the bellows can range from 10,000 operations for vacuum circuit breakers and recloses to 106 operations in vacuum contactors. However, there are numerous factors which can severely reduce the mechanical life of the bellows including corrosion caused by exposure to saltwater.

Stainless steels are alloys that contain no less than 10.5% chromium. The chromium reacts with oxygen to form a passive film that is about 130 x 10-10 meters in thickness. This thickness is thousands of times thinner than a human hair.

The passive film is self-healing. That is, chemical reactions that cause corrosion in other materials do not damage the stainless steel because the chromium chemically protects it. As long as there is a sufficient oxygen supply, the passive film protects the steel from corrosion.

The chlorides and salt in seawater attack the passive film. If the stainless steel object is submersed or wet from saltwater, there is little oxygen between the moisture and the passive film. Consequently, the passive film cannot reform quickly enough and the steel will corrode.

All of the stainless steels except the best of the specialty alloys will suffer from pitting or crevice corrosion when immersed in seawater.

One of the best 300-series stainless steels is type 316. Even this alloy will, if unprotected, start corroding under soft washers, in o-ring grooves, or any other tight crevice area in as little as one day, and it is not unusual to have penetration of a tenth of an inch in a crevice area after only 30 days in seawater. If water flows fast past a stainless steel, more oxygen is delivered to the stainless steel and it corrodes less. For this reason, stainless steels have been successfully used for impeller blades and propellers. These need to be protected from corrosion when there is no flow (Figure 1).

Corrosion in stainless steel bellows comes in two main forms: galvanic and chloride corrosion. Galvanic corrosion occurs as a result of two dissimilar metals being in contact with each other in a conducting, corrosive environment [2]. For example, the stainless steel bellows and copper-based brazing material in a vacuum interrupter will experience galvanic corrosion after being exposed to saltwater (Figure 2). Galvanic corrosion is observed as pitting in the materials. The driving force of galvanic corrosion is the differential voltage between the two materials.

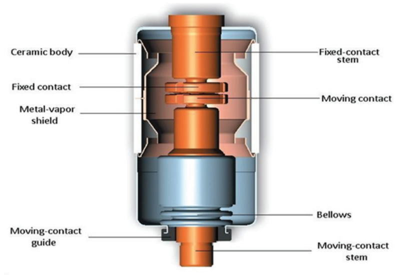
When exposed to environments with chloride ions—such as coastal air, saltwater, chemicals used for cleaning, and lubricants—stress corrosion cracking can occur in stainless steels as a result of chloride corrosion. Regardless of the type of corrosion, the mechanical life of the bellows in a vacuum interrupter is severely reduced when corrosion occurs.

Failure of the bellows in a vacuum interrupter will result in loss of vacuum. Without a proper vacuum, a vacuum interrupter will not be able to properly insulate the applied voltage, possibly resulting in catastrophic failure. If vacuum circuit breakers have been exposed to saltwater, whether partially or fully, the mechanism should be properly reconditioned, or preferably replaced.

[1] National Electrical Manufacturers Association, "Guidelines for Handling Water-Damaged Electrical Equipment," 2005.

[2] American Society of Testing and Materials, Galvanic corrosion, H. P. Hack, Ed., Ann Arbor: ASTM International, 1988.
https://www.upstreampumping.com/article/production/five-considerations-pressure-transmitter-use?page=4

External view of typical vacuum interrupter.



Cutaway drawing of typical vacuum interrupter.

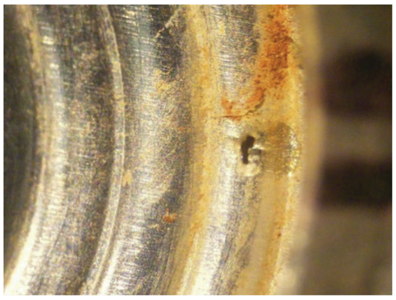


Figure 1. Galvanic corrosion in stainless steel bellows.

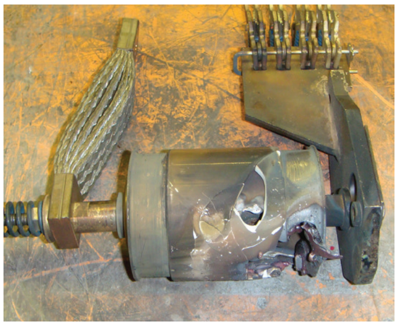


Figure 2. Vacuum interrupter exposed to salt water then placed back into service failed catastrophically 180 days later.