

### Diesel Fuel

## Installation Precautions for Metal Tanks

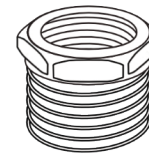
Metal tanks – aluminum, stainless steel, steel – are best protected from all forms of corrosion by taking three precautions:

### 1. avoid galvanic corrosion

Aluminum, stainless steel, and steel must not be in contact with more noble metals, such as brass or bronze.

- use non-metallic, carbon-reinforced plastic (Marelon) tank fittings
- use non-metallic, carbon-reinforced plastic (Marelon) bushings between tank and any metal fittings, such valve or hose barbs

non-metallic  
bushing



### 2. keep tanks dry and clean

Keep water away from the tanks:

- avoid water dripping onto a tank
- leaks from portlights
- bilge water (especially salt water) reaching the bottom of tanks
- water puddling on the top of a tank
- keep tanks clean of dust, sand etc. which can harbour moisture

Condensation on the exterior of fuel tanks may be unavoidable in cooler weather and will not cause corrosion provided the tank surfaces can dry out through evaporation – the free flow of air around a tank is the best protection

### 3. encourage air circulation around tanks

Keeping a flow of oxygen (air) over the surfaces of aluminum or stainless steel fuel tanks will maintain the natural oxide layer (aluminum oxide or chromium oxide) and allow it to regenerate if damaged (eg. scratched):

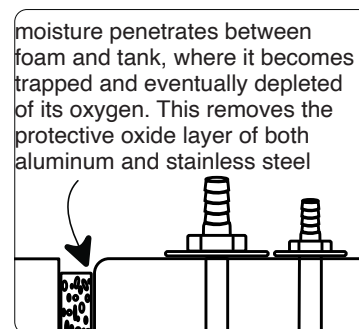
- avoid encasing a tank in foam. Foam will likely trap dirt and moisture, promoting corrosion and making inspecting and repair next to impossible.
- any paint coating must be 100% intact. Scratches must be repaired – if the damage is not retouched with paint, the damaged area may become anodic (the anode) to the whole of the tank (cathode) resulting in rapid corrosion.
- (See *Concentration Cell Corrosion*, page xx).

### 4. avoid using foam around metal tanks

Using pour-in or spray-in polyurethane foam (same as urethane foam) around metal tanks (fuel or water) is not a good practice for the long-term durability of the tanks. This is because moisture will eventually wick between the foam and the metal surfaces. This type of foam has open-cells which can absorb moisture. Trapped moisture, and free-standing water, will become oxygen-depleted over time – setting up ideal conditions for pitting corrosion to create holes in the tank.

This process may take many years or can happen rapidly depending on the grade of metal used in construction, quality of foam installation and the amount of moisture or free water that becomes trapped against the metal surfaces of the tank.

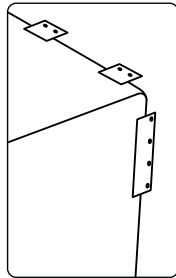
See *Metal Tanks – Understanding and Preventing Corrosion* page XX



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### Fuel Tank Installation

**5. protect steel diesel tanks** – the exterior of steel tanks must be protected from rusting (oxidation) with at least two coats of an epoxy paint (two-part epoxy paint provides the best protection). Repair any scratches before installation. Using foam around a steel tank increases the risk of moisture or free water causing rusting. A free flow of air around the tank provides good protection from rusting. (See *Rusting, Oxidation – steel* on page XX)



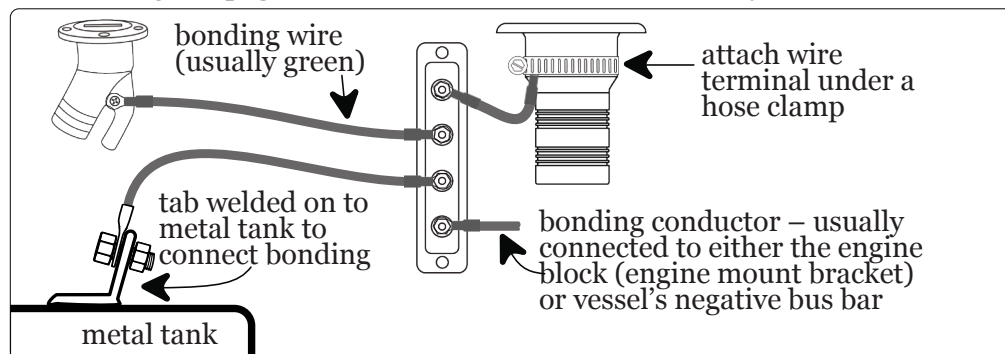
**6. weld flanges on metal tanks** – flanges can be welded to aluminium, stainless steel or steel tanks and through-bolt to bulkheads, stringers and structural elements:

- flanges should be strong enough (and with enough installed) to support 4 x the weight of the tank when full.
- corrosion is likely to be localized to the weld area, sparing the tank itself
- repairs to flanges may be easier than repairing the tank itself

**7. connect metal tanks and metal fittings to vessel bonding system** – metal fuel tank(s) and metal deck fuel fitting(s) should be connected to the vessel's bonding system (if fitted). Use 8.5 mm<sup>2</sup> (AWG#8) wire. Fuel tank and deck fill should be connected separately to the bus bar connected to the vessel's bonding system (and the anode).

(Plastic deck fuel fitting with metal chain should not be connected).

See *Bonding*, on page XX for a fuller discussion of this subject)



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*Diesel Fuel*

Metal Tanks – Understanding and Preventing Corrosion

Galvanic corrosion

Galvanic corrosion occurs when a metal with a higher electrical potential loses electrons to a metal that is less reactive (more *noble*).

Three conditions are required for galvanic corrosion to occur:

1. two or more dissimilar metals (with lower and higher electrical potentials)
2. metals are connected electrically – touching or wired together (eg. bronze propeller on a stainless steel shaft, or tin solder inside a bronze heat exchanger)
3. metals are immersed in (or touching) a liquid that conducts electricity (*electrolyte*), such as fresh water, seawater or coolant.

If precautions are not taken, metal fuel tanks can be corroded by tank fittings made of more noble metals, such as brass or bronze. Galvanic corrosion can attack any metals on a boat, such as propeller shafts, saildrives, heat exchangers.

Movement of Electrons from Less Noble to More Noble Metal

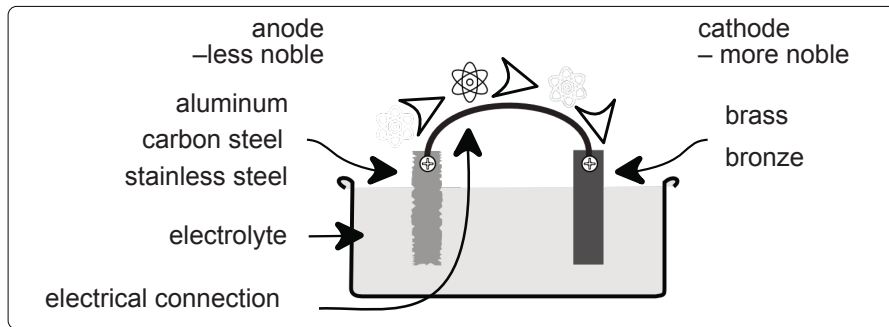
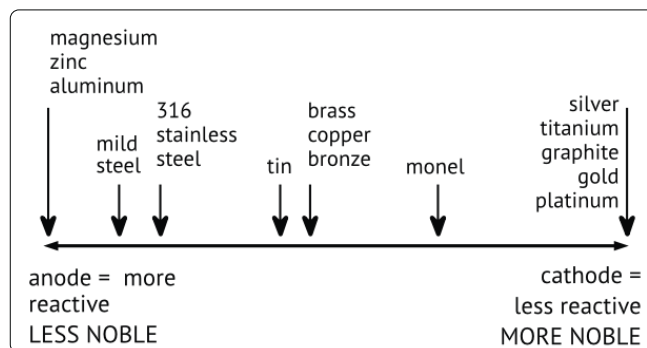


Table of Galvanic Values



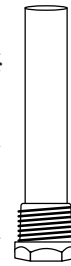
Metals can be protected from galvanic corrosion by :

1. removing one or more of the conditions that allow galvanic corrosion:
  - keep the metals dry – remove the electrolyte – do not allow water to collect on or stand around the metals
  - separate dissimilar metals so that they are not electrically connected – use non-metallic threaded bushings to connect fittings
  - use metals with the same or very close electrical potential
2. deliberately sacrificing a metal that is less noble (*anode*) compared to the metal to be protected (*cathode*).

*Corrosion in Metal Fuel Tanks*

Three types of sacrificial anode are commercially available:

- aluminum – used in all types of water; salt water, brackish, polluted and fresh water; made of alloys containing zinc and trace amounts of other metals
- zinc – used on boats in salt or brackish water. Not for use in fresh water because they are prone to developing a white calcareous coating which prevents them from working
- magnesium – used in fresh water; the alloy may contain zinc and aluminum



Galvanic corrosion can also occur between areas of the same metal where there is a difference in the concentration of oxygen or metal ions which causes concentration cell corrosion.

(See *Concentration Cell Corrosion*, p XX )

**Concentration Cell Corrosion**

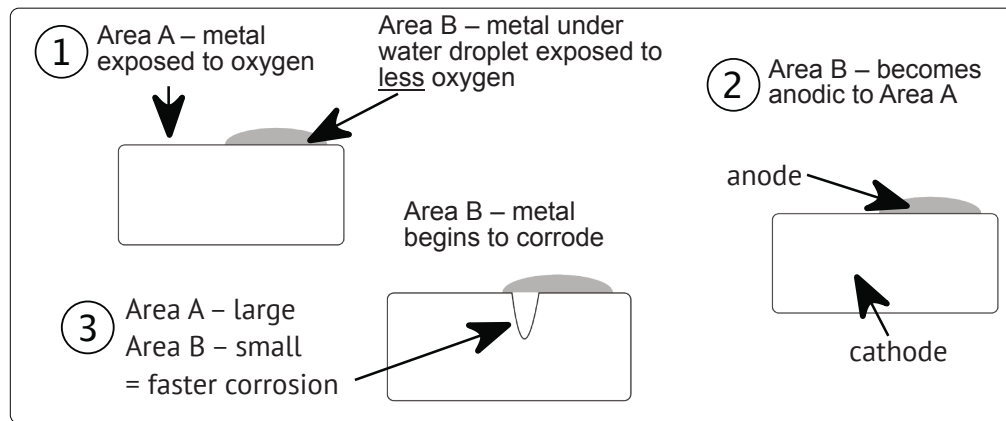
Corrosion can occur if different areas of the same metal are exposed to:

- different levels of oxygen (one area becomes oxygen-deprived)
- different levels of metal ions

Stagnant water or moisture must be present.

The difference in levels of oxygen or metal ions creates anodic/cathodic conditions in which electrons flow from the anodic zone to the cathodic zone. The anodic area is eroded, the same as in galvanic corrosion).

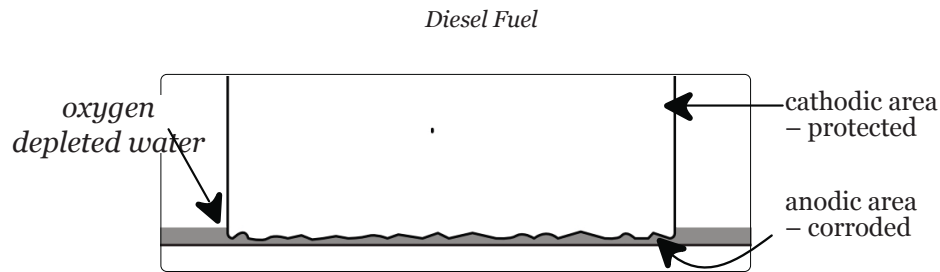
(See *Galvanic Corrosion*, p XX)



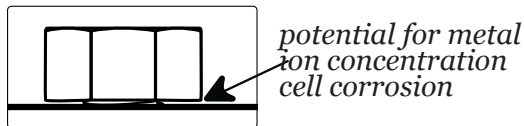
Concentration cell corrosion can occur:

- in spots/areas of metal covered by stagnant water (oxygen-depleted)
- cracks, crevices or gaps filled with water
- part of a metal item submerged in oxygen-depleted water, such as stagnant bilge water under a metal tank
- scratches and adjacent surfaces (eg. welds) where the concentration of metal ions is different, causing an imbalance in electrons

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The process of metal ion corrosion is the same, except that the anodic/cathodic condition is created by the imbalance of metal ions between adjacent surfaces.



### Concentration Cell Corrosion – Crevice, Pitting and Poultrice Corrosion

Crevice, pitting and poultrice corrosion are all forms of concentration cell corrosion:

1. breakdown of the metal's natural oxide layer, eg. a scratch
2. lack of oxygen preventing regeneration of the the oxide layer
3. moisture or water reacts as electrolyte setting up anode/cathode
4. acid is formed by the electrochemical reaction
5. acid dissolves the metal, creating pitting or deepening crevices

**Aluminum** – naturally forms a protective skin of *aluminum oxide* when in contact with oxygen in the air, which protects the metal from corrosion. (Industrial anodizing uses this same natural process to protect products such as masts). If this oxide layer is damaged (eg. by scratching), the protective layer regenerates taking oxygen from the surrounding air. However, this protection will not regenerate if oxygen is not available.

**Stainless steel** – chromium in stainless steel forms a thin layer of *chromium oxide* which protects the metal from corrosion. This protection is lost if the metal is deprived of oxygen.

Water trapped in a tiny crevice can become oxygen-depleted, allowing corrosion to start eventually causing pinhole leaks

This can happen if water or moisture becomes trapped against the metal:

- under blistered paint
- between foam, wood or other porous materials and the tank
- covered by dirt, dust which absorb humidity or water
- under loose tank supports, such as rubber pads.

The trapped moisture reacts with the aluminum to become *aluminum hydroxide*, an acid that dissolves the metal, leaving a white powder.

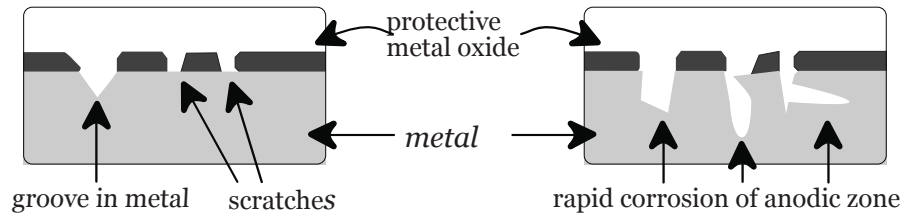
### Crevice corrosion

Low spots in welding, small gaps between surfaces etc. or spaces under bolt heads, that trap moisture promote concentration cell corrosion. Anodic corrosion of the metal is accelerated by the large area of the cathodic metal (eg. a fuel tank) compared to the small anodic area in a crevice, or under a water drop, grains of sand or dirt.

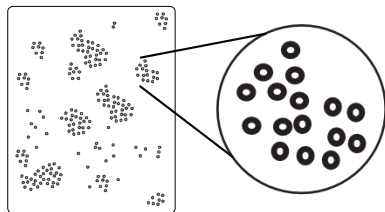
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*Corrosion in Metal Fuel Tanks*

Close-up Cross-section of Metal Showing Protective Metal Oxide and Corrosion

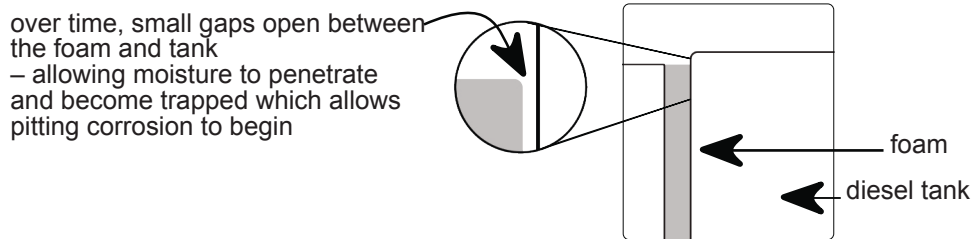


Pitting corrosion



Pitting corrosion is a form of concentration cell corrosion – the result of localized rapid anodic erosion of the metal. Pitting is usually caused by oxygen-depleted water or moisture trapped against the metal. Pits can eventually penetrate through a metal, eg. resulting in leaks from a tank.

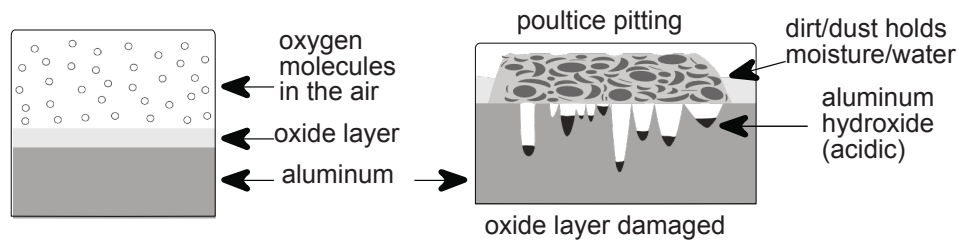
Using foam to secure a metal fuel tank will likely eventually result in holes in the tank.



Poultice corrosion

As its name implies, poultice corrosion occurs when a poultice (layer) of dust, dirt, sand etc. holds moisture – depriving the aluminum (or stainless steel) of oxygen and allowing water to form an acid with the metal which deepens pitting.

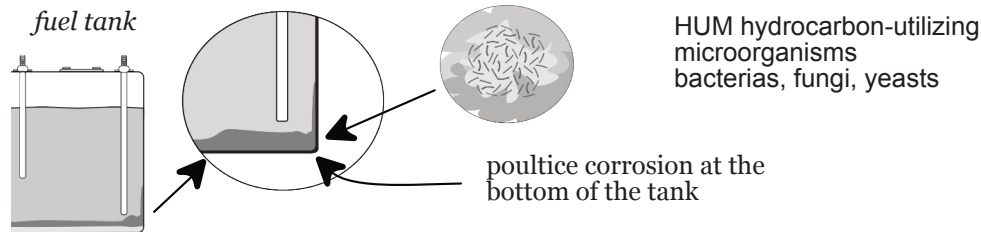
Poultice Corrosion of an Aluminum Tank



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Diesel Fuel

Microbiologically Influenced Corrosion (MIC)



Sludge of hydrocarbon utilizing microorganisms can create oxygen-depleted areas of concentration cell corrosion causing pitting and eventually holes in a tank. (See *Hydrocarbon Utilizing Microorganisms (HUM)*, page XX)

Rusting, Oxidation – steel

Steel rusts when exposed to oxygen in the presence of water or humidity. The process of oxidation converts the steel (or iron) to *iron oxide hydrate*, with the characteristic brown flaking. Steel underwater (eg. a boat hull) rusts more slowly because of the lack of oxygen in water (about 1%) compared to 21% oxygen in air.

The outside of a diesel tank must be protected from oxygen in the air to prevent rusting. The inside of a diesel tank is generally protected by the fuel or a coating of fuel over the steel plating. Modern two-part epoxy paints provide excellent, long-lasting protection, provided the paint coating is not scratched. Paint should be applied during manufacture to prevent rust forming within hours. Care must be taken during transport and installation to avoid damage or scratches;

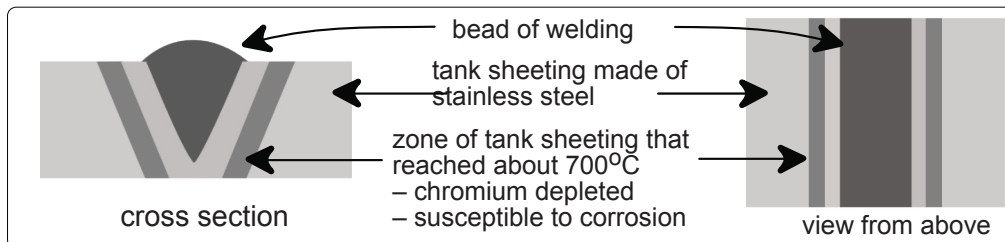
- damage to the paint should be repaired before final installation to avoid problems (such as holes!) developing over time.

Weld Decay, Intergranular Corrosion – stainless steel

Chromium in stainless steel protects the metal from rusting. However, when stainless steel is heated (ie. by welding) the area of the metal that reaches about 700°C (1300°F) can suffer *heat sensitization*. This makes it prone to corrosion (oxidation). The process is a chemical reaction within the metal.

Carbon in the metal attracts the chromium to form chromium carbide. The area that has lost its chromium becomes *anodic* (the anode) to the stainless steel which still chromium intact (the cathode).

Humidity or standing water can create conditions for galvanic corrosion; this may be accelerated because of the large area of the tank sheeting (cathode) relative to the small area of chromium-depleted metal (anode).



Weld decay can be avoided if *low carbon* stainless steel (306L) and rods are used. Much depends on the specifications and work standard of the tank fabricator when a tank is being made.