This information is taken from PREVENTION OF MATERIAL DETERIORATION: CORROSION CONTROL COURSE, LOGISTICS ENGINEERING DIRECTORATE, JUNE 1985

This course was presented by U.S. Army Armament Munitions and Chemicals Command Rock Island Arsenal, Illinois (Note this command name has changed and is unknown at this time. I am told there is no update to this course book. It is considered by many as the finest course ever conducted by the Army.)

GRAPHITE

Graphite, a natural occurring mineral is singularly one of the most insidious causes of corrosion in military equipment. It is an electrical conductor and is cathodic to all of the common metals with the exception of gold and platinum. It is this property that results in galvanic corrosion of metal structures to which it has been applied when an electrolyte is present. The voltage generated is sufficient to cause a rapid corrosive reaction. An example of this reaction is seen in the common dry cell where graphite and zinc develop a potential of approximately 1.5 volts. The voltage is produced by the corrosion reaction within the battery.

When applied on bearing surfaces the galvanic corrosion action destroys the very surface requiring lubrication and forms abrasive corrosion products which further hasten wear or seizure of mating parts. While graphite is generally considered .to be a lubricant it is a lubricant only in the presence of absorbed moisture or certain gases. Under conditions of vacuum or at subzero temperatures it is actually an abrasive. It is therefore unsuited for lubrication in space applications or high altitude aircraft unless combined with other materials capable of supplying the needed gas.

The graphite problem is compounded by the fact that many commercial solid film lubricants contain graphite in a mixture of powdered heavy metals, molybdenum disulfide or other lubricative solids. Many of these products qualify under a number of military specifications written primarily to obtain lubricant properties with little or cursory regard for the corrosivity of the product. Typical specifications are MIL-L-8937 or MIL-L-23398. The problem is made more complex by the fact that many nongraphite products qualify but the specification is not sufficiently stringent in respect to corrosion tests. A list of corrosive graphite lubricant specifications is found in Incl. 1.

Serious problems involving potential loss of human life as well as equipment are accelerated by the use of graphite lubrication hinge pins for critical control surfaces for aircraft. Graphite has been applied by mechanics to aid in installation of these long thin pins through multiple hinge tabs. Pitting, stress corrosion cracking, and ultimate seizing and breaking of the high strength aluminum hinge tabs results.

Major corrosion problems have been encountered when graphite-petrolatum compound was used in the “Lube-torque” wheel lug bolt torquing procedure on aircraft landing gear wheels, particularly with magnesium wheels.

A high incidence of corrosion is invariably found in wheel-well areas of aircraft where graphite from the brake lining combines with dirt and water and contacts critical structural members. There is no known qualified brake lining that does not contain graphite. Therefore, the solution of this problem is “cleansing” maintenance.

Problems of graphite induced corrosion were encountered in the M28 Armament Subsystem for Helicopters. In this equipment graphite containing qualified solid film lubricant meeting requirement of MIL-L-8937 was designated as the lubricant to be applied to a 7075T6 cam ring. After a brief period of exposure in field operation, severe stress corrosion cracking was encountered which required replacement of a number of the cam rings.

Layout pencils containing graphite were used in sheet metal fabrication for aircraft caused corrosion of aircraft in service and resulted in issuance of a US Air Force Specification for layout pencils with no graphite or conductive carbon content.

Corrosion problems were encountered on aluminum deck structures aboard naval ships in England and on launch facilities at Cape Kenney where graphite “lead” pencils were used for extraneous marking on the surfaces.

Graphite added to wheel-bearing grease used on the F-4 Phantom aircraft main landing gear caused severe corrosion of the bearings in as little as three months of service.

Graphite grease used in lubricating arresting cables aboard aircraft carriers contributes to the severity of corrosion of carrier based aircraft when landing gear wheels pick up graphite form the deck surface during rainy weather and spray it into wheel well areas and other surfaces of the rear of the wheels. “Cleansing”: maintenance will reduce the severity of the problem.

Solid film lubricants which meet the lubricant requirement s without graphite are available for most applications (see Incl. 1). Use of the corrosive graphite types is justified only in certain high temperature applications.

TABLE 1

GRAPHITIC (CORROSIVE) LUBRICANTS	USE	NON-CORROSIVE REPLACEMENT
TT-A-580	Antiseize	MIL-L25681 (Note 4)

SS-G-659	Dry Lubricant	MIL-M-7866
JAN-A-669	Antiseize	MIL-L-25681 (Note 4)
VV-G-671	Dry Lubricant	MIL-M-7866
MIL-A-907	Antiseize	MIL-L-25681 (note 4)
MIL-T-5544	Antiseize	MIL-L-25681
MIL-T-5544	General Lubricant	MIL-L-21164 (note 1)
MIL-G-13912	Antiseize	MIL-L-25681 (note 4)
MIL-L-3572	Oil Lubricant	MIL-M-7866

CANCELLED SPECIFICATIONS

MIL-G-6711 (Cancelled 4 Mar 71)	Dry Lubricant	MIL-M-77866
MIL-G-7187 (Cancelled 12 Nov 65)	General Lubricant	MIL-G-211164(Note 1)

SOLID FILM LUBRICANTS

MIL-L-8937	Heat Cure	MIL-L-46010 (Note2)
MIL-L-23398	Air Dry	MIL-L-46147 (Note 2)

MISCELLANEOUS SPECIFICATIONS

MIL-L-24131	Dry Lubricant	Note 3
MIL-L-81329	Solid Film Lubricant	Note 3
MIL-L-5542	Antiseize	Note 3
MIL-L-17745	General Lubricant	Note 3

TABLE 1 NOTES

Note 1: Where there are problems with noncompatibility of elastomers and this synthetic lubricant, use MIL-G-23549.

Note 2: Requests have been made for standardization action removing graphite from MIL-L-8937 and MIL-L-23398. Until this action is accomplished;, Air Force use of these specifications shall be withdrawn. Wide use of MIL-L-8937 and MIL-L-23398 has been made on supplier lubricated parts. We have found much corrosion/galling of the MIL-L-8937 or MIL-L-23398 types should be changed out under TCTO directives. Where this is impractical, its hold be made positive that replacement parts be solid film lubricated by non graphitic lubricants.

NOTE 3: In order to select a suitable substitute for these miscellaneous materials, the specific application just be known. Each specific use of these materials should be checked through San Antonio ALC/SFQTE, Autovon 945-7613.

NOTE 4: Do not use this silicone lubricant in fuel tank areas where sealing of fasteners is critical or in areas where paint adhesion is critical. Where sealing, paint adhesion, or torque values are involved, contact Warner Robins ALC/MMEETC, Autovon 468-3284, for substitute.

Note 5: Where use of a silicone oil base lubricant is impractical, (see Note 4), MIL-G_81322 also may be substituted for MIL-L-3572, except where use of an oil is mandatory, i.e., poor access, configuration, etc. Checked these instances with the ALC prime on the equipment.

Note 6: Rock Island Arsenal Purchase Description 703 air dry solid film will be furnished when MIL-L-46147 is ordered. There is no QPL for MIL-L-46147. Until a QPL is issued, specify RIA PD 703.   This product is available in 12 oz aerosol containers (9150-00-142-9309) and one gal bulk containers (9150-00-142-9361).

Below is a list of metals that react with each other in the presence of water. Sea water is generally the worst scenario. The metals are listed from one end of the potential the other. To put it simply the worst is at the top and the further down the list the contact metal is the more problems you get. Metals that are next to each other in the ladder will have the least amount of reaction in the presence of moisture. Metals that are further apart will have the most reaction. The metals highest on the list attract to those lower and interact trying to go to the lower metal.

You will note GRAPHITE always wins. Graphite will be the last thing left as everything else is below it. You may have noticed aluminum pots that have had water left in them long term will show pitting. The aluminum in the presence of water is attracted by the copper in the mixture and when the aluminum breaks away heading for the copper it floats away leaving pitting.

Magnesium
Zinc

Beryllium
Aluminum Alloys
Cadmium
Mild Steel, Cast Iron
Low Alloy Steel
Austenitic Nickel Cast Iron
Aluminum Bronze
Naval Brass, Yellow Brass, Red Brass,
Tin
Copper
Pb-Sn Solder (50/50)
Admiralty Bras, Aluminum Brass
Manganese Bronze
Silicon Bronze
Tin Bronzes (G&M)
Stainless Steel Types 410, 416 Note: 1
Nickel Silver
90-10 Copper – Nickel
80-20 Copper –Nickel
Stainless Steel Type 430 Note 1
Lead
70-30 Copper-Nickel
Nickel-Aluminum Bronze
Nickel-Chromium alloy 600 Note 1
Silver Braze alloys
Nickel 200
Silver
Stainless Steel Types 302, 304, 321, 347 Note 1
Nickel-Copper Alloys 400, K-500
Stainless Steel Types 316, 317 Note 1
Alloy "20" Stainless steels, cast and wrought
Nickel-Iron-Chromium alloy 825
Ni-Cr-Mo-Cu-Si alloy B
Titanium
Ni-Cr-MO alloy C
Platinum
GRAPHITE

Note 1: IN LOW-VELOCITY OR POORLY AERATED WATER, AND AT SHIELDED AREAS MAY BECOME ACTIVE AND EXHIBIT A POTENTIAL NEAR -0.5 VOLTS.

Case in point our fire department needed a new tanker and we had a bunch of 6065 aluminum. I was concerned about galvanic action and the pitting of the aluminum so I called my friend at

Rock Island and he told me what to do. He also pointed out that the tank would still fail at some point in the future because of the difference in the welding materials used to weld the plates together. Or in other words the tank would fail along the edge of the welds. But it will take longer as both the tank material and the aluminum is mostly aluminum and close to each other so the action will be slower. If the tank was laid out with **GRAPHITE** pencils the tank would fail at the pencil marks. Or as a bumper sticker I once saw said, “If you think education is expensive, try ignorance”

I remember one case in point they covered in the class. There was a major explosion at Cape Canaveral years ago that could not be explained. As they were going through thousands of pictures taken during construction one showed a drawing of a cat on the outside of a high pressure fuel elbow that was stored next to a phone booth. While someone was talking on the phone or waiting for a call they took a pencil and drew the cat. When they found that they pulled the design drawings out and dug up every high pressure elbow on the facility. They accounted for every elbow but one, the one with the cat was never found.

Under bloopers they told us about one of the major steel companies in the US decided they needed a stainless steel yacht. It sunk tied up at the dock. When they checked it out they found that the rivets they used were not stainless but normal steel rivets. In the water they reacted, the rivets dissolved and the plates broke loose and the yacht sunk.

When they assemble aircraft they have to apply material between the skin coverings and all around the rivets (dissimilar aluminum) to retard the galvanic action. You will recall all the excess aircraft are stored in the southwest (very low moisture in the air and very little rainfall) and they last in nice condition for years. This is why the newest aircraft contain few or no rivets in their construction.

Since I took that course every time I boarded a plane I looked at the construction and looked for rivets. Remember all the US planes used to be bright and shiny back in the 50s? Now they are all painted.

Now you know why the inside of your wheel wells are coated or are plastic as the GRAPHITE in your break linings splash all over the underside. Also this is why aluminum/mag wheels are coated with plastic.