

NITRIC ACID CORROSION RATES ON STAINLESS STEEL,
FERROUS METAL AND NON-FERROUS METAL

The following is a study of various coatings and plates on actual parts which are to be used in the BSY or tunnel. In conducting the tests it took very little effort to observe and record visual changes at set intervals. This was an attempt to establish rates of corrosion or useful time of the various parts.

It is impossible to reproduce all the conditions or factors prevalent in the B.S.Y., therefore, only nitric acid corrosion is considered here. The equipment used was a dessicator with a ceramic plate. The lower portion of the dessicator had 70% (concentrated) HNO_3 acid diluted with an equal portion of distilled water making it a 35% solution. All parts were placed on the ceramic plate above the solution so that only the vapors would come in contact with the pieces. The room temperature of 74°F varies less than 4°F . In essence, it would be constant temperature and only air convections or air flow would come about by removal of the dessicator lid during observation.

1st Test 321SS with welds. No coating or plate.

A 321 S.S. beam line bellows welded to a pipe and flanges was sealed with rubber stoppers at both ends. This latter was to prevent vapors from condensing on the inside surface and to simulate conditions as nearly as possible to the ultimate use. Condensed vapors settled on the bellows within 48 hours. Some areas of the welds formed pockets where larger droplets clung. These, in time, turned darker and oxidized more readily than the rest of the assembly. After 94 days

the assembly was removed, cleaned and leak detected. It was vacuum tight. With LOX mag no corrosion was evident at the welds or adjacent areas on the assembly.

2nd Test. Brass coaxial parts with plates and a coat.

All machined brass coax parts were put in the same dessicator at the same time for comparison purposes. In some cases there were two parts of the same coating.

In some only one part. The parts were numbered to keep different treatments separate.

No. 1 - Two brass parts, no plate, no coat. (as a control)

No. 2 - Two brass parts with an unknown thickness of Silver plate.

No. 3 - Two brass parts and nickel plate (thickness unknown) and Microseal coating.

No. 4 - Samples were gold plated, but not submitted to the lab for this test. No further report on No. 4 samples.

No. 5 - Two brass parts plus nickel plate only (thickness unknown)

No. 6 - One brass part - different configuration plus nickel plate (thickness unknown)

No. 7 - Brass part of different configuration again plus nickel plate and Microseal coat.

Rates of reaction varied greatly on different coatings. The intent of the test was to continue it until all parts were beyond use. Pertinent observations and rates are noted below.

No. 1 - Brass(uncoated)was badly oxidized within 16 hours.

No. 2 - Brass + Ag plate showed oxidation started by 16 hours. Still useable.

All parts showed green-blue color from condensed droplets on the surfaces.

No visual detrimental effects to the surface otherwise.

After 10 days No. 1 was beyond use.

No. 2 - (Ag plate) was blistered badly - would not be useable for slip-fit and very probably the threads were long beyond use.

No. 3 - Coating was beginning to lift and change texture. Might possibly be able to disconnect, though.

No. 7 - (nickel plate and microseal) looked bad on O.D. (knurled surface) but fair on the I.D.

Nos. 5 and 6 - Showed blue-green discolor but surfaces still visually good.

By 31 days all parts were showing visual reaction with the vapors to varying degrees of deterioration.

All parts were removed after 35 days, photos were taken. (These can be seen in the lab). One part or a portion of it was mounted, polished and the microstructures photographed to determine depth of penetration. (These also can be viewed in the lab).

The uncoated brass had the greatest depth of penetration, followed by Silver plated brass. Microseal coating over nickel looks very poor visually on the surface, but microstructures did not show great depth of penetration. Those parts with only nickel plate were fair on the surface, while the depth of reaction is greater than any except uncoated brass. Vapors, undoubtedly, really worked on the pores in the plating.

3rd Test. S.S. and ferrous metal under compression with various coats and plating.

All holders for the springs were 17-4PH stainless steel. All springs were of SAE 9254 valve spring steel. All springs were under compression during the test in nitric acid vapors.

Spring No. 1 was plated 0.0003" with electroless nickel, followed by 0.0005" of Gold plate. It was tested approximately 13 days.

Spring No. 2 was chem-cleaned, surface not blasted, dip coated in Sperex (radiation resistant paint) baked at 250° F for 15 minutes then taken up to 650° F where it was held for one and one-half hours. The color of the Sperex paint at this stage was bright red. At the end of two days the paint color had changed to tan-brown and corrosion had started at lower part of spring near the contact with the holder. This spring was in the dessicator for 10 days.

Spring No. 3 was either sand or wet blasted, then dip coated with Sperex and had the same heat treatment.

Spring No. 4 was placed in dessicator at same time as No. 3. It had no treatment, just out of the box into the compression holder. This latter spring showed corrosion attack within one hour and forty-five minutes. The last two springs were tested just under 8 days.

Photos were taken of these immediately after removal from the dessicator. Next they were removed from the 17-4 PH holder, flushed with running tap water, rinsed with alcohol and air dried. Photo No. 2 was then taken. The gold plated spring was also photographed as a close-up. (All photos may be seen in the lab.)

Microstructure cross sections of the springs were concentrated on the surface of the spring. The control spring and both Sperex coated springs show extreme rough surfaces. The gold plated spring has a smooth surface but is the only one showing a crack into the body of the spring. This may account for the spots where corrosion is evident on that spring.

No firm conclusions can be drawn at this time as to which coating or plate is best. The tests are continuing and will be reported in the future. Certain observations have led to the belief that surface preparation can enhance the

resistance to corrosion. Economics and dimensional tolerances will dictate the use of some coatings and eliminate others. At this time no one plate or coat or combination has presented itself as a cure-all for the problem.