March 25, 1999

Enclosed you will find the report you requested on the relative resistance to corrosion of:

1. *New galvanized friction bolts* from Skema Industries.
2. Galvanized friction bolts the same as the first except that they were installed at the NORCAT Underground Centre then *pulled out before corrosion testing.*
3. *plain steel bolts* without a galvanized coating

The tests show the clear advantage of galvanized over plain steel and that the damage done by installation has little effect on the corrosion performance of the bolts.

I would suggest that a next step would be longer term corrosion followed by a tensile test which would further substantiate the value of galvanized coatings on longevity. Your idea of corrosion in simulated or actual sulphide mine water would be interesting as well.

Signed by:
Philip J. Taylor P.Eng.
Department Head
NORCAT Support Services

The bolts that were installed and then pulled suffered minor damage in the process.

They were bent, scratched and abraded. Even so, this damage did not apparently increase corrosion, in fact the loss in weight of these bolts was actually less than the loss in weight of the new bolts. The plates of both types lost similar amounts of weight. According to theory, galvanized coatings which are not damaged are still protective of the underlying steel because of the electrical potential set up between the zinc and iron which prevents chemical attack of the iron. This appears to be borne out here and the damage inflicted during installation (and removal) would not appear to be deleterious.

**Details:**
The bolts were 6' long so they were cut to 24" to fit the corrosion cabinet at the required 30° angle from the horizontal. To ensure cut ends would not affect the test results the cut ends of all the specimens were painted with corrosion resistant paint. The bolts and plates were held in mechanical and electrical contact with each other as they would be in the field to ensure that any electrochemical effects between bolt and plate would approximate the installed condition. This was done with non-conductive glass tubing and rubber bands. The basic test parameters are shown in Table II.

**Table II: Test Conditions**

| PARAMETER | VALUE |
|---|---|
| Salt used | Sifto (special high-purity) |
| Water used | Demineralised by ion exchange |
| Salt solution strength | 5.0% by weight |
| Salt solution specific gravity | 1.035 |
| Salt solution pH, as prepared | 6.0 |
| Salt solution pH, boiled | 6.8 |
| Salt fog condensate pH | 6.9 - 7.0 |
| Salt fog condensation rate | 1.9 ml per hour |
| Tower temperature | 125°F |
| Jacket temperature | 95°F |
| Cabinet interior temperature | 36°C |

## *CORROSION TESTING OF FRICTION*

The specimens were randomly placed in the test cabinet in the order shown in Table III to avoid any systematic error due to variations in the test conditions in different parts of the salt-spray cabinet. The bolt-plate sets were supported on plastic racks at an angle of approximately 30° from the horizontal.

**Table III: Test Order**

| TEST | BOLT & PLATE |
|---|---|
| 6 | Galvanized, installed |
| 2 | Galvanized, new |
| 7 | Steel |
| 4 | Galvanized, installed |
| 8 | Steel |
| 1 | Galvanized, new |
| 5 | Galvanized, installed |
| 3 | Galvanize, new |
| 9 | Steel |

The initial weight and weight loss as a percentage of the initial weight is shown in Table IV for each specimen.

**Table IV: Weight and Weight Loss**

| TEST | BOLT | WT. | LOSS | PLATE | WT. | LOSS |
|---|---|---|---|---|---|---|
| | | g | % | | g | % |
| 1 | Gal. new | 953 | 1.26 | Galvan. | 519 | 0.77 |
| 2 | Gal. new | 784 | 1.40 | Galvan. | 522 | 0.57 |
| 3 | Gal. new | 793 | 1.13 | Galvan. | 524 | 0.57 |
| | | | **1.26** | | | **0.64** |
| 4 | Gal. install | 918 | 0.87 | Steel | 522 | 0.57 |
| 5 | Gal. install | 779 | 1.16 | Steel | 522 | 0.38 |
| 6 | Gal. install | 767 | 1.43 | Steel | 520 | 1.15 |
| | | | **1.15** | | | **0.70** |
| 7 | Steel | 780 | 2.56 | Steel | 729 | 2.06 |
| 8 | Steel | 776 | 2.71 | Steel | 732 | 2.05 |
| 9 | Steel | 764 | 1.96 | Steel | 729 | 1.51 |
| | | | **2.41** | | | **1.87** |