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Wear and Galling Tests of Plug Seal Tubing

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ABSTRACT

To determine the effect of chromium plating on the wear and galling characteristics of the plug seal tubing laboratory tests simulating the sliding action of the rotating plug during raising and lowering operations have been completed in sodium at 500°F.

Chromium plated and as drawn tubing sections, loaded to deflections of 15 and 30 mils, were drawn over plates representing the container wall under conditions simulating 355 plug raising and lowering operations.

Results indicate that seizing due to galling is unlikely in SIR and that for deflections in the range of 0 to 20 mils as drawn tubing has satisfactory resistance to wear and scoring. Above 20 mil deflections chromium plating will reduce the amount of scoring and wear experienced by both tubing and container wall.

Wear and Galling Tests of Plug Seal Tubing

INTRODUCTION

During raising and lowering of the rotating plug the plug seal tubing will slide against the container wall for 1/4-in. in each direction. The action will take place in sodium up to a maximum temperature of 500°F and tube contact deflection may be as great as 30 mils.

To determine the behaviour of 0.010-in. wall by 3/8-in. diameter Type 347 stainless steel tubing under these conditions and to evaluate the effect of chromium plating in reducing any adverse wear and galling effects laboratory tests have been performed in equipment simulating the sliding action that will occur in plug raising and lowering operations.

PROCEDURE

The tests were run in a standard stress rupture container with a modified top to which were fastened the fixed parts of the slide assembly (Photograph 1132122). A 5/8-in. rod, guided through a cleave bearing and sealed by a bellows unit, was attached to a pitman arm on the shaft of a 300:1 reduction gear, driven by a 1725 rpm, 1/6 hp motor (Photograph 1132121). This turned the crank at 5.75 rpm. Each test was run for 30 minutes with a vertical stroke of 1/2 in. The total travel for each test was 172.5 in., corresponding to 355 plug lowering and raising operations.

The loading procedure was as follows: A 3 3/4 in. x 1 1/2 in. x 1/4 in. stainless steel plate (a in Figure 1) was held in a small vice (b). The specimen (c) was placed in a 3/8 in. x 9/32 in. groove (plug tubing groove dimensions) in a 3 in. x 1/2 in. x 1/2 in. sliding arm (d). Another stainless steel plate (e), representing the fixed or container wall surface was attached to the specimen holder (d) by four 1/4-20 bolts. Each bolt was tightened to give the required specimen deflection.

Following loading the slide assembly was placed in a standard stress rupture container, which was filled with two to three pounds of sodium. The container was then placed in a static furnace; when the sodium temperature reached 500°F, the drive was started and continued for 30 minutes.

Before and after each test, the surface roughness of the plate and tubing was recorded on a Brush surface analyzer. The scale used is indicated next to each chart (Figures 2 - 5).

On the XO.1 scale, each division should be multiplied by 100 and on the XO 01 scale by 10 to give the correct readings in microinches.

After each test a macrophotograph of the specimen was taken with a magnification of 10X (Figures 6 and 7)

RESULTS AND DISCUSSION

The surface analyses (consolidated in graph form in Figure 8) indicate little advantage for chromium plating in reducing scoring at a deflection of 15 mils. This is further illustrated in the macrophotographs (Figure 6) of the 15 mil deflection tubing sliding surfaces. However, chromium plating is beneficial at a deflection of 30 mils (Figure 7), where it has markedly reduced the amount of scoring experienced by the as drawn tubing.

No freezing due to galling occurred during the tests.

As the SIR Plugs are not expected to be raised and lowered 355 times, these tests represent conditions of maximum damage to the seal tubing and container wall for the life of the unit.

Tube deflections of 30 mils were also tested in air at 500°F. The results are shown in Figure 9 and indicate, when compared with Figure 7, that sodium does have some slight lubricating effect.

CONCLUSIONS

1. No freezing due to galling of the plug seal tubing is likely.
2. At deflections of 15 to 20 mils chromium plating offers no advantage over as drawn Type 347 tubing.
3. At deflections higher than 30 mils chromium plating will reduce wear and scoring of the plug seal tubing and of the container wall.

113212

876 995

1132121

- (a) fixed plate
- (b) vise
- (c) specimen - seal tubing
- (d) tube specimen holder (sliding arm)
- (e) specimen plate - container wall

SCHEMATIC VIEW OF
LOADING EQUIPMENT

Figure 1

876-007

**As Drawn Tubing
Specimen No. 10**

Plate

**Before
wgt 0.8360 g**

Before

**After
wgt 0.8360 g**

After

Surface roughness of as drawn Type 347 stainless steel tubing and of the fixed plate against which it travelled under 15 mils deflection for 172.5 in. in sodium at 500°F.

.01 scale

FIGURE 2

Chromium Plated
Specimen No. 3

Plate

Before
wgt 0.7326 g

Before

After
wgt 0.7323 g

After

Surface roughness of chromium plated Type 347 stainless steel tubing and of the fixed plate against which it travelled under 15 mils deflection for 172.5 in. in sodium at 500°F.

.01 scale

FIGURE 3

**Chromium Plated Tubing
Specimen No. 2**

Plate

**Before
wgt 0.7303 g**

Before

CHART NO. BL 908

THE BRUSH DEVELOPMENT CO.

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**After
wgt 0.7300 g**

After

Surface roughness of chromium plated Type 347 stainless steel tubing and of the fixed plate against which it travelled under 30 mils deflection for a total of 172.5 in. in sodium at 500°F.

.01 scale

FIGURE 4

**As Drawn Tubing
Specimen No. 11**

Plate

**Before
wgt 0.8288 g**

Before

**After
wgt 0.8287 g**

After

Surface roughness of as drawn Type 347 stainless steel tubing and of the fixed plate against which it travelled under 30 mils deflection for 172.5 in. in sodium at 500°F.

.01 scale

FIGURE 5

Specimen No. 10. As Drawn Tubing.
15 mil Deflection in Sodium at 500°F. 10X

Specimen No. 3. Chromium Plated Tubing.
15 mil Deflection in Sodium at 500°F. 10X

FIGURE 6

Specimen No. 11. As Drawn Tubing.
30 mil Deflection in Sodium at 500°F. 10X

Specimen No. 2. Chromium Plated Tubing.
30 mil Deflection in Sodium at 500°F. 10X

FIGURE 7

figure 8

mils deflection

Specimen No. 12. As Drawn Tubing.
30 mil Deflection in air at 500°F. 10X

Specimen No. 1. Chromium Plated Tubing.
30 mil Deflection in air at 500°F. 10X

FIGURE 9

Distribution

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