# Tank 241-AN-107 Corrosion Coupon Labatory Analysis

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**U.S. Department of Energy Contract DE-AC27-99RL14047**

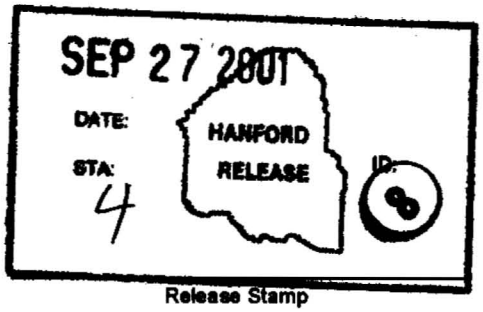
**EDT/ECN:** 630461 **UC:** NA
**Cost Center:** 7G500 **Charge Code:** 500464
**B&R Code:** EW01J2030 **Total Pages:** 287 AG

**Key Words:** 241-AN-107, Corrosion Coupon, Steel, Mass loss, ASTM G-1 - 90

**Abstract:** To support the corrosion study for Tank 241-AN-107, corrosion coupons consisting of C-rings and pins were removed from four detectors of the corrosion probe retrieved from the tank. The detectors were located as follows: one in the sludge layer, one in the liquid layer, one in the lower head space and the last in the upper head space. ASTM Method G-1 90 was used to determine the amount of corrosion product present.



9-27-01
Release Approval Date



Release Stamp

**Approved For Public Release**

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## Corrosion Test Results

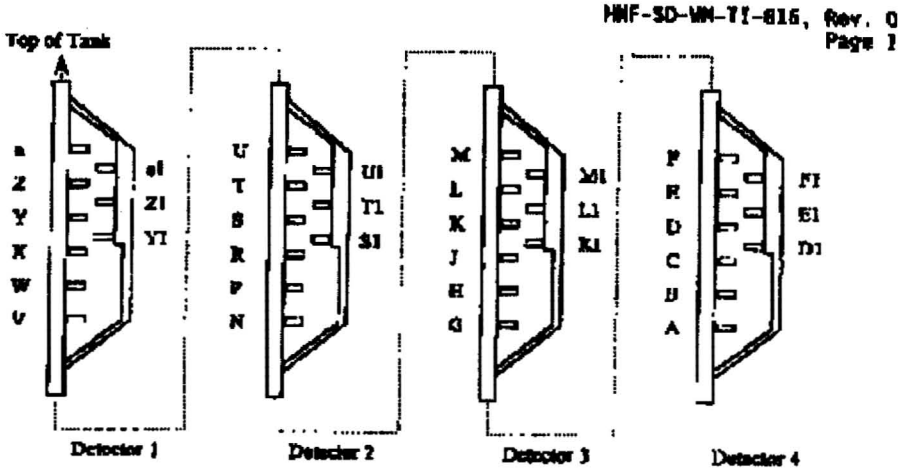
### Introduction

The corrosion sections were received at 222-S Laboratory on August 9, 2001. Each section was double-wrapped in yellow plastic. The test specimens were separated from each section. The specimen numbers are indicated in Table 1 and detector configuration is shown in Figure 1 (1).

**Table 1 Specimen Location**

| Specimen | Detector | Identification |
|---|---|---|
| Coupon | 1 | X |
| Pin | 1 | Y |
| Coupon | 2 | R |
| Coupon | 2 | N |
| Pin | 2 | U |
| Coupon | 3 | H |
| Pin | 3 | M1 |
| Coupon | 4 | C |
| Coupon | 4 | B |
| Pin | 4 | E |

**Figure 1 Detector Configuration**



**Initial Observation**

The only visible corrosion was on Detector 1, very slight effects. Of those specimens, the most affected (by visual inspection) coupon and pin were chosen for analysis. The rest of the detectors appeared bright. In fact, the material appeared as new stainless steel.

The O-rings were as new, pliable and no cracking or crazing associated with them.

Photos were taken, as the detectors were unwrapped. Unfortunately, the film broke and there is no photographic record associated with the receipt of the coupons. To ensure a photographic record, digital photos were taken along with emulsion photography during the specimen analysis.

**Specimen Observation**

Upon visual inspection, the coupons and pins associated with Detectors 2,3, and 4 appeared as new stainless steel (Figures 2 though 7). However, the specimens associated with Detector 1 did exhibit corrosion (Figures 8 and 9).

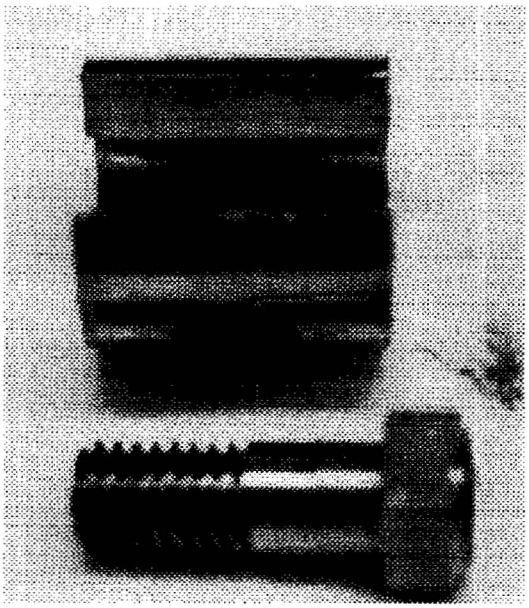


**Figure 2** C-Ring Detector 4 (Sludge Layer)

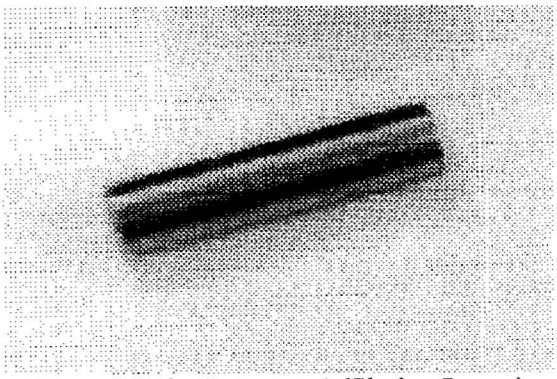


**Figure 3** Pin Detector 4 (Sludge Layer)

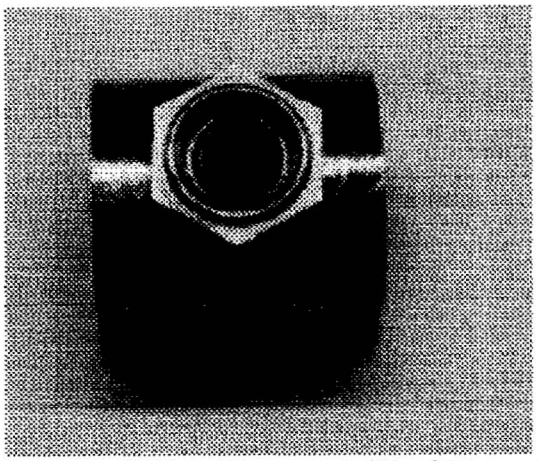


**Figure 4** C Ring Detector 3 (Liquid Layer)

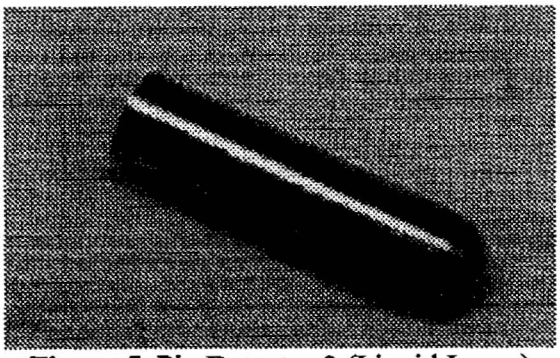


**Figure 5** Pin Detector 3 (Liquid Layer)

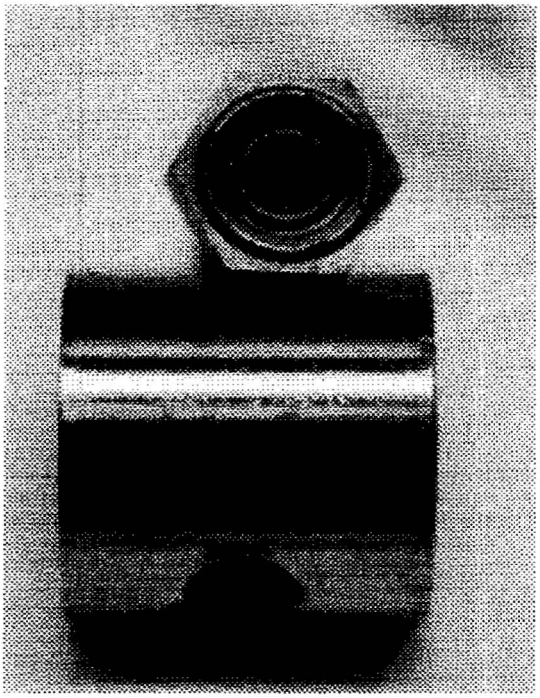


**Figure 6** C Ring Detector 2 (Above Liquid Layer)

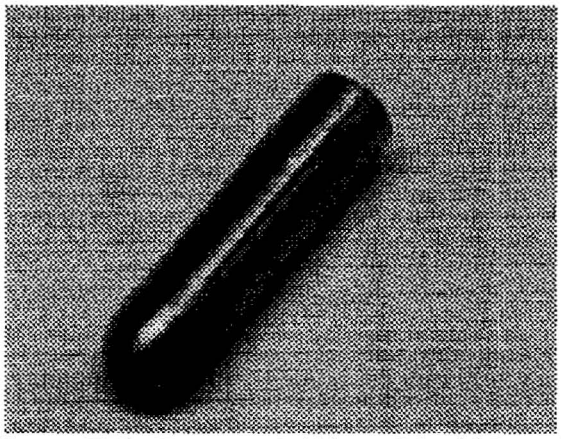


**Figure** 7 Pin Detector 2 (Above Liquid Layer)

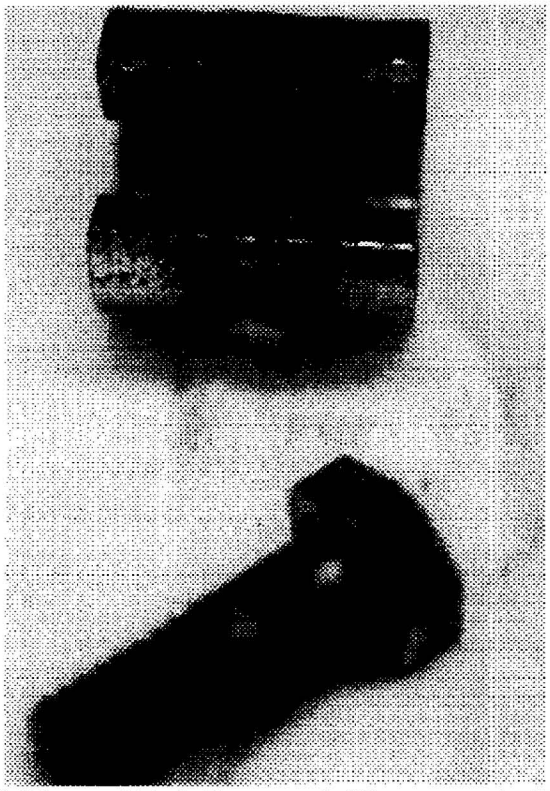


**Figure 8** C-Ring and Bolt Detector 1 (Uppermost in Head Space)

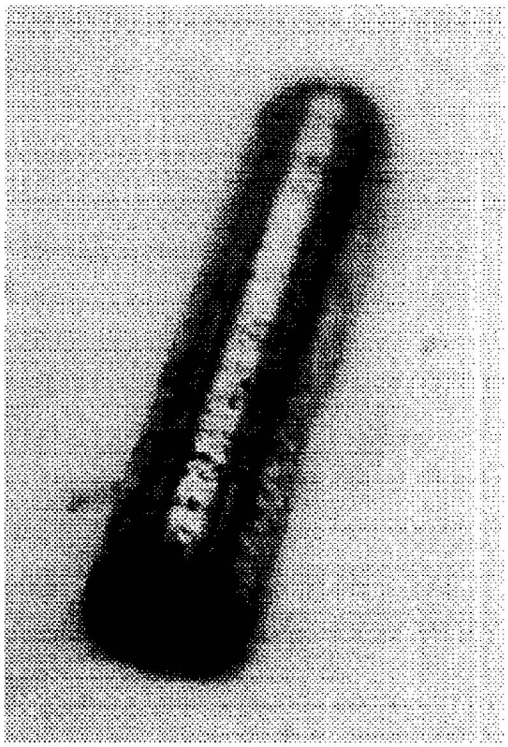


**Figure 9** Pin Detector 1 (Uppermost in Head Space)

**Weight Data**

Table 2 gives the before and after tank exposure mass of the selected specimens. From that data the volume loss is calculated using a density 7.86 g/cm$^3$ (carbon steel). The exposed surface area of the C-ring and bolt (these were tared together before installing in AN-107) were estimated to be 45 cm$^2$ (35cm$^2$ C-ring and 10.00 cm$^2$ bolt), and the exposed area of the pin was estimated at 5.0 cm$^2$, Appendix A.

**Table 2 Weight Data**

| Specimen (Type/Detector) | Tare Mass (g)[a] | Mass After AN-107 (g) | Mass Difference (g) | Volume Loss (cm$^3$) | Surface Area (cm$^2$) | Mil of material Removed |
|---|---|---|---|---|---|---|
| X (C-ring/1) | 74.3170 | 74.3058 | 0.0112 | 1.42E-03 | 45 | 0.0124 |
| Y (Pin/1) | 4.9734 | 4.9327 | 0.0407 | 5.18E-03 | 5.0 | 0.4078 |
| R (C-ring/2) | 72.9774 | 72.9451 | 0.0323 | 4.11E-03 | 45 | 0.0359 |
| N (C-ring/2) | 74.3109 | 74.2255 | 0.0854 | 1.09E-02 | 45 | 0.0954 |
| T1 (Pin/2) | 5.1834 | 5.1767 | 0.0067 | 8.52E-04 | 5.0 | 0.0671 |
| H (C-ring/3) | 71.9258 | 71.9047 | 0.0211 | 2.68E-03 | 45 | 0.0235 |
| M1 (Pin/3) | 5.2468 | 5.2402 | 0.0066 | 8.40E-04 | 5.0 | 0.0066 |
| B (C-ring/4) | 72.6529 | 72.6363 | 0.0166 | 2.11E-03 | 45 | 0.0184 |
| C (C-ring/4) | 73.4843 | 73.4756 | 0.0087 | 1.11E-03 | 45 | 0.0097 |
| E (Pin/4) | 5.3126 | 5.3121 | 0.0005 | 6.36E-05 | 5.0 | 0.0050 |

[a] Edgemon

The surface area for the C-ring and bolt was based on dimensions given in Drawing Number 0007-HEF-117A (HiLine Engineering). For the calculations, the assumptions that the bolt threads were negligible for surface area contributions and that part of the bolt covered by the C-ring was not exposed to AN-107 chemistry. The pin was estimated by measurement of a control specimen. The pin estimate was conservative in that the control specimen was like the pin in Figure 3.

Table 3 shows the mass loss after digestion with dibasic ammonium citrate using ASTM method G-1 (2). The digestion solution (0.88 M) was changed after each detector. This allowed digestion to occur with several orders of magnitude difference between the molarity of the digested material versus the molarity of the digestion solution.

Instrument technicians from the 222-S Laboratory maintenance group calibrated the balance before the work ensued. Furthermore, the balance was measured against check weights during the course of the four-day laboratory effort.

**Table 3 Mass Loss**

| Specimen (Type/Detector) | Beginning Mass (g) | Mass loss at inflection point[a] (g) |
|---|---|---|
| X (C-ring/1) | 74.3170 | 0.367 |
| Y (Pin/1) | 4.9734 | 0.038 |
| R (C-ring/2) | 72.9774 | 0.089 |
| N (C-ring/2) | 74.3109 | 0.098 |
| T1 (Pin/2) | 5.1834 | 0.028 |
| H (C-ring/3) | 71.9258 | 0.089 |
| M1 (Pin/3) | 5.2468 | 0.008 |
| B (C-ring/4) | 72.6529 | 0.045 |
| C (C-ring/4) | 73.4843 | 0.068 |
| E (Pin/4) | 5.3126 | 0.025 |

[a] Taken from Figures 10 – 19.

Figures 10 – 19 indicate the response and inflection point for each specimen. Although not confirmed, it is thought that the data exhibited in figures 17 and 18 is due to the effect of the soak solution on the C-ring metal, that is, corrosion was practically non-existent on those specimens.

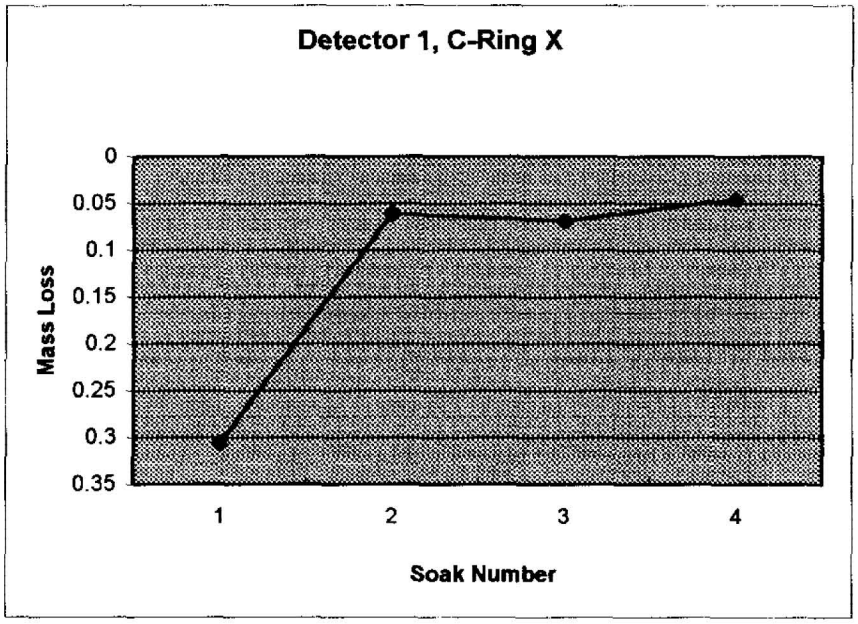



**Figure 10, Detector 1 Ring X**

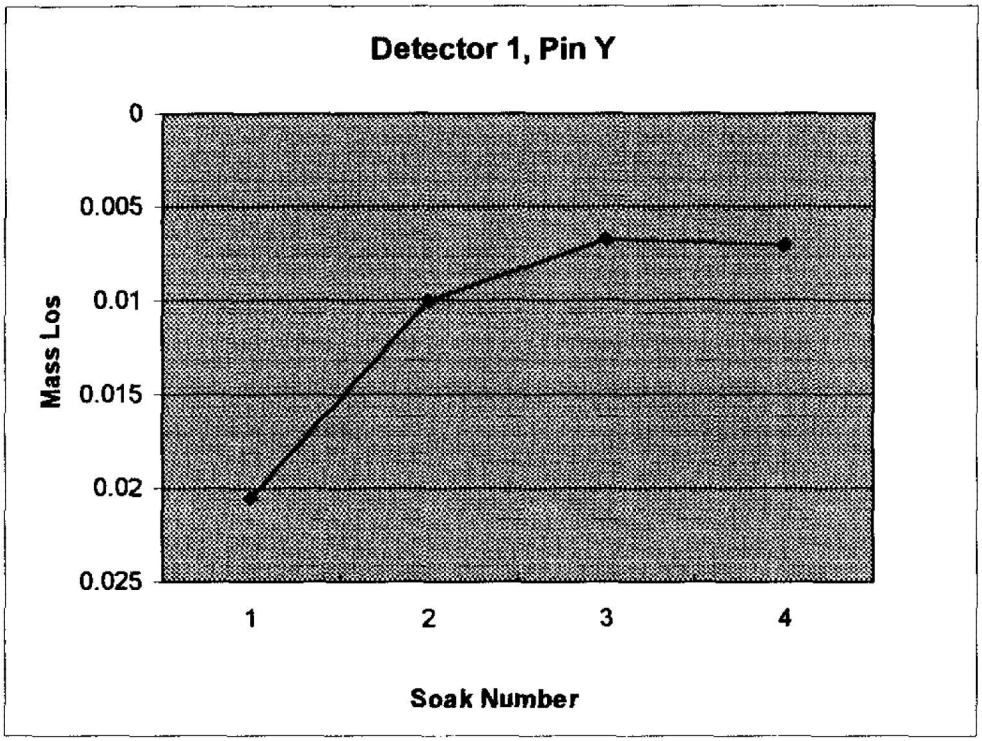



**Figure 11, Detector 1 Pin Y**

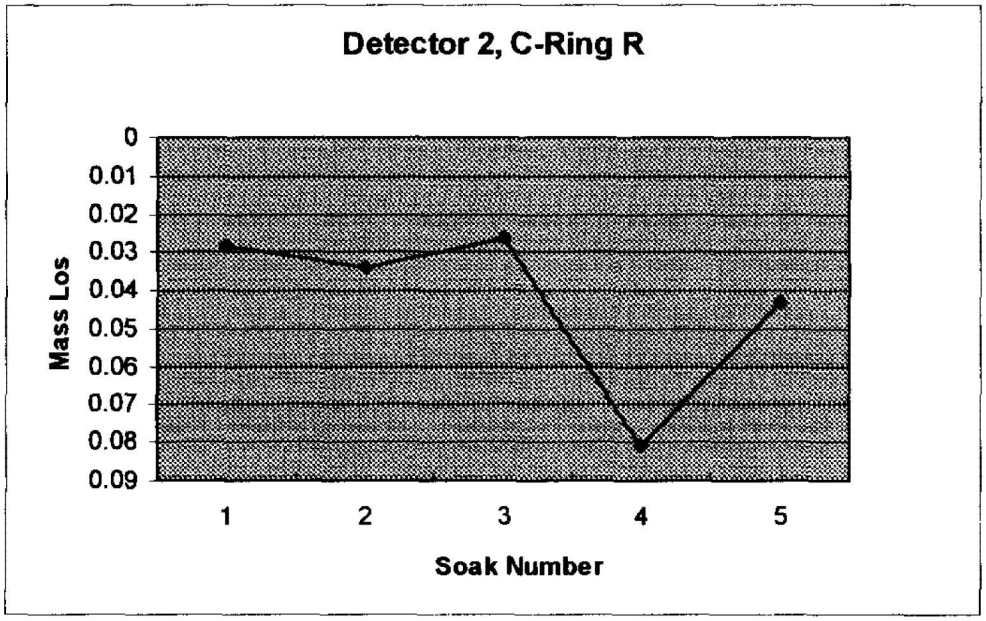



**Figure 12 Detector 2, Ring R**

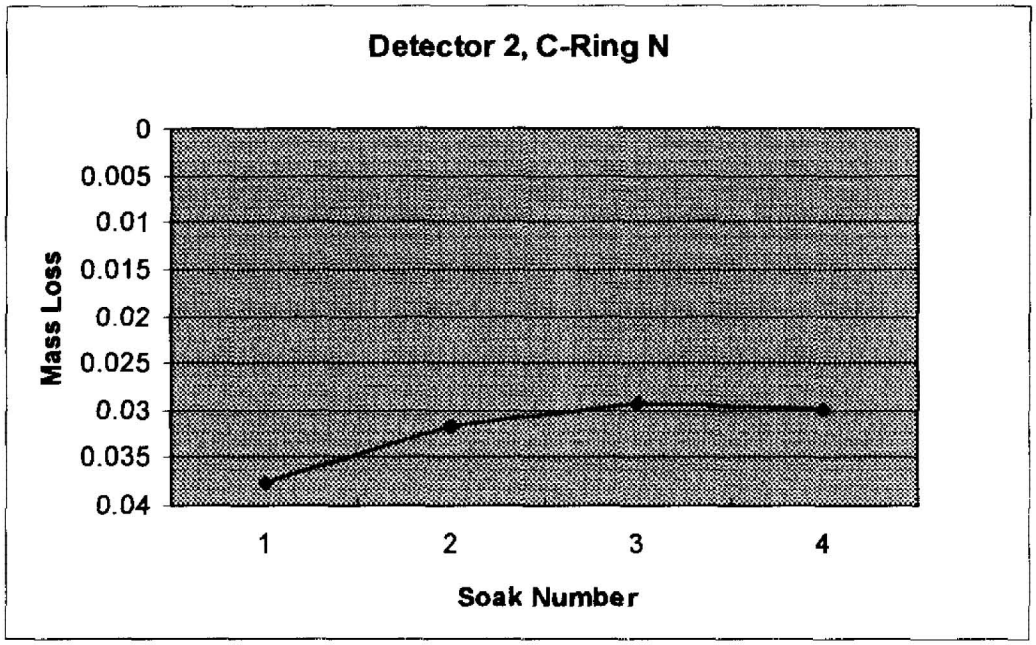



**Figure 13, Detector 2, Ring N**

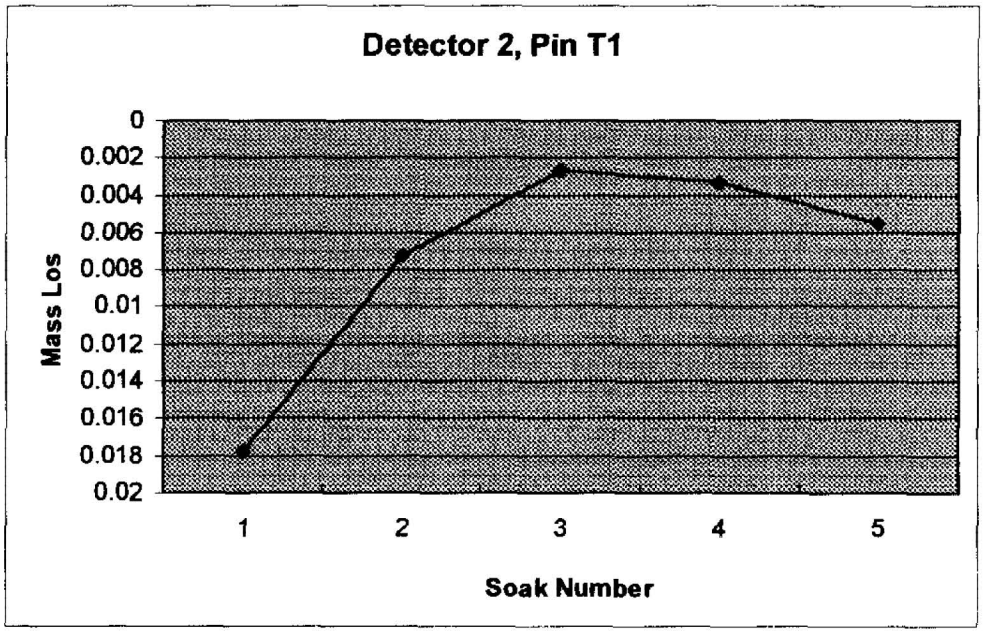



**Figure 14, Detector 2, Pin T1**

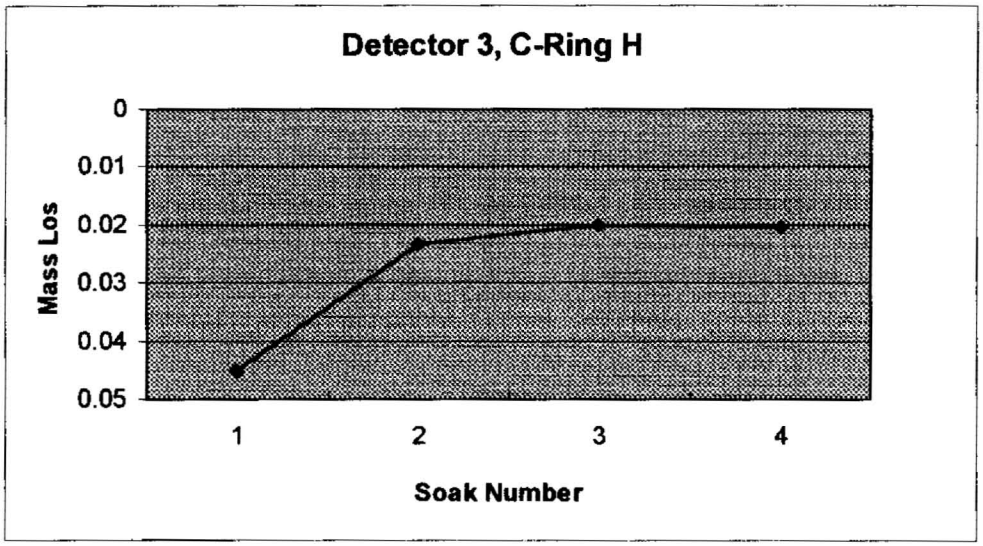



**Figure 15, Detector 3, Ring H**

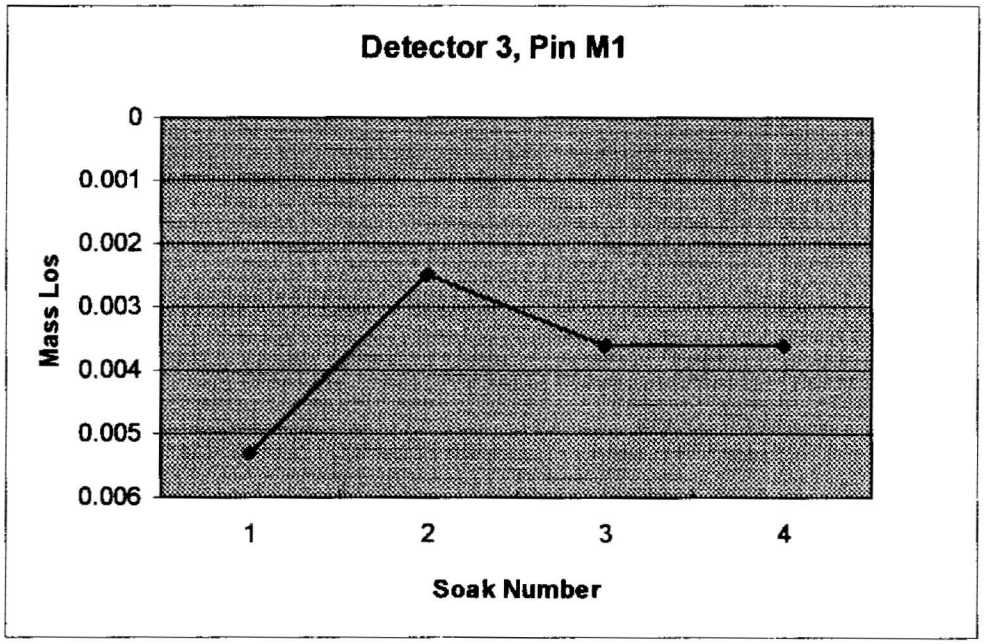



**Figure 16, Detector 3, Pin M1**

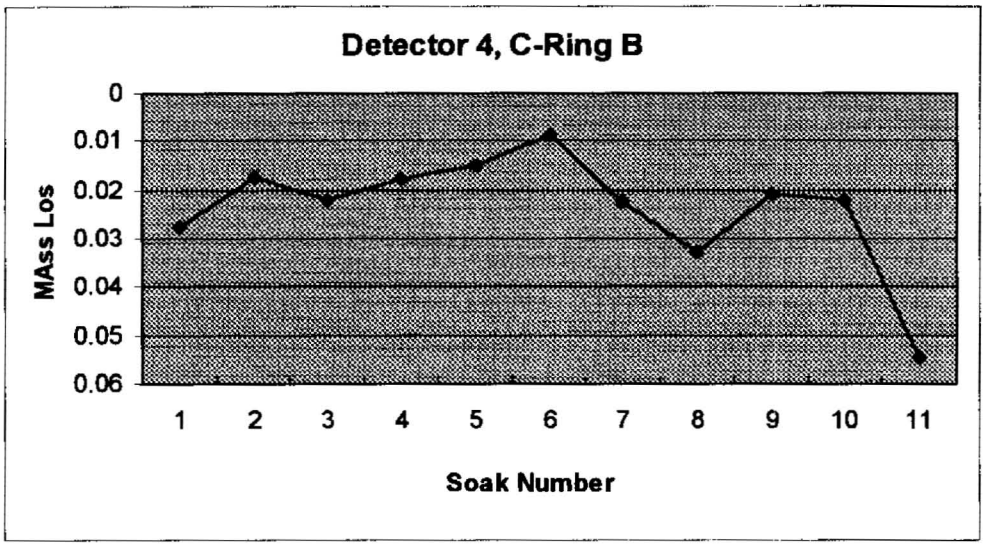



**Figure 17, Detector 4, Ring B**

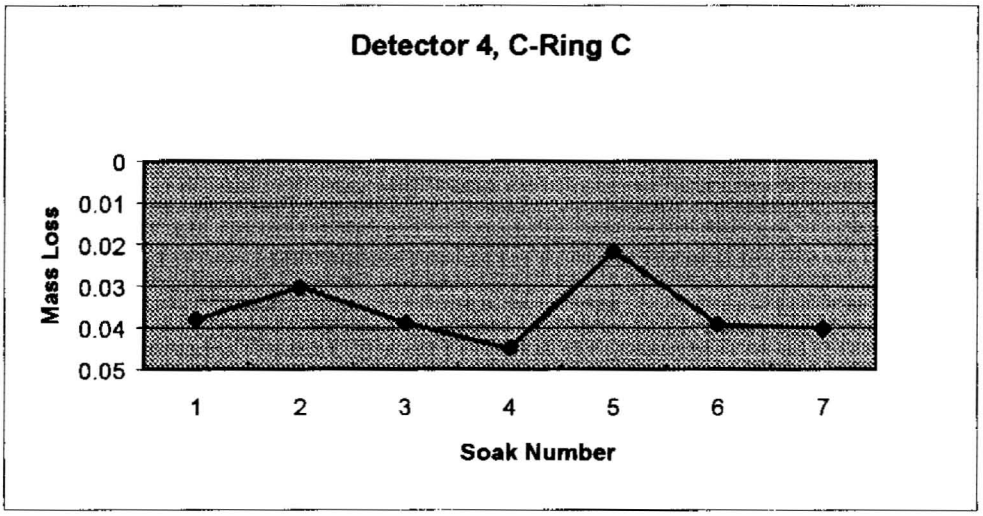



**Figure 18, Detector 4, Ring C**

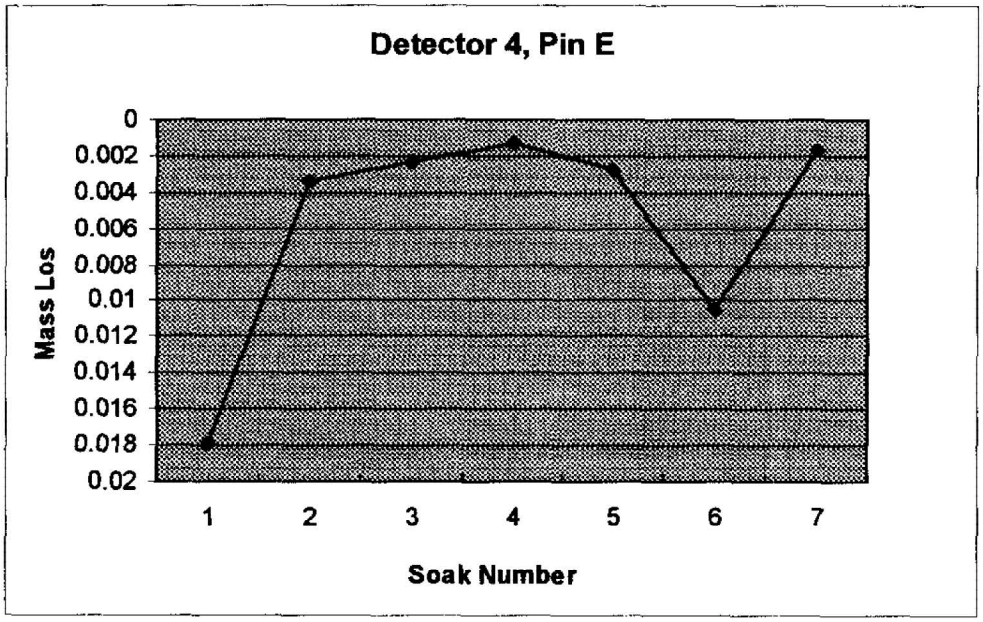



**Figure 19, Detector 4, Pin E**

## References

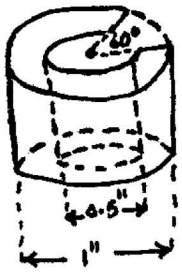
1. Edgemon, G. L., "**241-AN-107Corrosion Probe Electrode Weights**", HNF-SD-WM-TI-816, Rev. 0, August, 1997.

2. *"Standard Practice for Preparing, Cleaning, and Evaluating Corrosion Test Specimens"*, Designation: G-1 – 90 (Reapproved 1999), ASTM, 2000.

## Appendix A Calculation Sheets for Surface Area of C-Ring Plus Bolt and Pin

EXPOSED AREA OF C-RING:

To be conservative, assumed a 60° sector removed from right circular cylinder with dimensions 1" long × ½" I.D. × 1" O.D. to make a C-Ring coupon.




Total Surface Area (SA) = SA of Top + SA of Bottom + SA of inside of 0.5" dia cylinder + SA of outside of 1.0" cylinder + SA of exposed rectangular faces − ⅙ of cylinder SA cut out

$= \frac{5}{6}$ [Cylinder SA] + SA of exposed faces

$= 5/6 \left[2 \times \pi\left(1^2 - 0.5^2\right)/4 + \pi \times 0.5 \times 1 + \pi \times 1 \times 1\right]$ in²

$+ 2 \times 1 \times 1/4$ in²

$= 34.895$ cm²

EXPOSED AREA OF BOLT:

The exposed areas are ① Both sides of hexagonal head and ② Cylindrical bolt stem on inside of C-Ring.


① Hexagonal head SA $= 2 \times 6 \times \frac{1}{2} \times \frac{5}{16} \times \frac{5}{16} \times \sin 60° = 0.5074$ in² $= 3.2738$ cm²

Plus Rectangular sides SA $= 6 \times \frac{5}{16} \times 1/4 = 0.4688$ in² $= 3.0242$ cm²


② Bolt stem SA $= \pi \times 0.375" \times 0.5" = 0.5890$ in² $= 3.8003$ cm²

Therefore total SA $= 34.895 + 3.2738 + 3.0242 + 3.8003 \approx 45$ cm²

Exposed Area of Pin:

The exposed SA of Pin $= \pi \times \frac{1}{4}" \times 1" + \pi \times \left(\frac{1"}{8}\right)^2$

$= 0.8345$ in²

$\approx 5$ cm²

# Appendix B Laboratory Work Sheets

| Coupon Identification Detector ~~21~~ Pin: 4 | Weight Before placing in Soak Solution | Time in Soak Solution | Temperature of Solution | Weight after Solution Soak | Photograph Identification (Magnification and Distance) | Δ g* |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | |
| 1 | 4.9327 | 10 | 86°C | 4.9122 | 19-20-21 | 0.020 |
| 2 | 4.9122 | 10 | 86°C | 4.9022 | | 0.010 |
| 3 | 4.9022 | 10 | 89°C | 4.8755 | | 0.006 |
| 4 | 4.8955 | 10 | 90°C | 4.8885 | | 0.007 |
| 5 | | | | | #14 | |

| Coupon Identification Detector #1 C-Ring: X<br>1 | Weight Before placing in Soak Solution<br>2 | Time in Soak Solution<br>3 | Temperature of Solution<br>4 | Weight after Solution Soak<br>5 | Photograph Identification (Magnification and Distance)<br>6 | Δ gm |
|---|---|---|---|---|---|---|
| 1 | 74.3058 | 10 | 86 °C | 74.9995 | 19 + 20 | 2/8 22 |
| 2 | 74.9995 | 10 | 86 °C | 73.9388 | | → 0.306 |
| 3 | 73.9388 | 10 | 89 °C | 73.8705 | | → 0.060 |
| 4 | 73.8705 | 10 | 90 °C | 73.8254 | | → 0.06 |
| 5 | 73.8254 | | | | | → 0.045 |
| | | | | | #13 [redacted] | |
| | | | | | #15 } Both | X/4 |
| | | | | | #16 } | |

| Coupon Identification Detector #2 Pin: ~~#3~~ T1<br>1 | Weight Before placing in Soak Solution<br>2 | Time in Soak Solution<br>3 | Temperature of Solution<br>4 | Weight after Solution Soak<br>5 | Photograph Identification (Magnification and Distance)<br>6 | |
|---|---|---|---|---|---|---|
| 1 | 5.1767 | 10 | 88 C | 5.1590 | #5 2nd 10H | 0.0171 |
| 2 | 5.1590 | 10 | 86C | 5.1517 | | 0.0073 |
| 3 | 5.1517 | 10 | 88C | 5.1490 | | 0.0027 |
| 4 | 5.1490 | 10 | 87C | 5.1457 | | 0.0033 |
| 5 | 5.1457 | 10 | 89C | 5.1402 | 17 + 18 | 0.0053 |

| Coupon Identification Detector #2 C-Ring: N<br>1 | Weight Before placing in Soak Solution<br>2 | Time in Soak Solution<br>3 | Temperature of Solution<br>4 | Weight after Solution Soak<br>5 | Photograph Identification (Magnification and Distance)<br>6 | |
|---|---|---|---|---|---|---|
| 1 | 74.2255 | 10 | 88 C | 74.1889 | Photo 3, 4 | 0.0375 |
| 2 | 74.1880 | 10 | 86 C | 74.1563 | 2nd roll | 0.0317 |
| 3 | 74.1563 | 10 | 88 C | 74.1271 | | 0.0292 |
| 4 | 74.1271 | 10 | 87 C | 74.0972 | Photo roll 3. | 0.0299 |
| 5 | 74.0972 | 10 | 89 C | 74.0554 | 17 + 18 | 0.0418 |

Δ 0.0323

| Coupon Identification Detector 2 C-Ring: R<br>1 | Weight Before placing in Soak Solution<br>2 | Time in Soak Solution<br>3 | Temperature of Solution<br>4 | Weight after Solution Soak<br>5 | Photograph Identification (Magnification and Distance)<br>6 | Δ |
|---|---|---|---|---|---|---|
| Orig Wgt | 72.9451 | 10 | 86 C | 72.9166 | #22/23 | 0.0285 |
| 0 72.9774 | 72.9166 | 10 | 92 °C | 72.8825 | | 0.0341 |
| #3 | 72.8825 | 10 | 85 C | 72.8562 | | 0.0263 |
| #4 | 72.8562 | 10 | 83C | 72.8185 | | 0.0377 |
| #5 | 72.8185 | 10 | 87C | 72.7753 | | 0.0432 |
| #6 | 72.7753 | 10 | 87 °C | 72.7325 | | 0.0428 |
| #7 | 72.7325 | | | | | |

Check Weights

1g = 1.0000 g
5g = 5.0001 g
10g = 10.0002 g
50g = 50.0003 g
100g = 100.0005g

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| Coupon Identification Detector 3 C-Ring: H<br>1 | Weight Before placing in Soak Solution<br>2 | Time in Soak Solution<br>3 | Temperature of Solution<br>4 | Weight after Solution Soak<br>5 | Photograph Identification (Magnification and Distance)<br>6 | Δ |
|---|---|---|---|---|---|---|
| 1 | 71.9047 | 10 | 88 °C | 71.8596 | 8" 19,20 | 0.0451 |
| 2 | 71.8596 | 10 | 88 °C | 71.8361 | | 0.0235 |
| 3 | 71.8361 | 10 | 83 C | 71.8159 | | 0.020 |
| 4 | 71.8159 | 10 | ~~88~~ C | 71.7954 | # 24 | 0.020 |
| 5 | 71.7954 | 16 | | | | |

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Distilled H2O changed once a detector

| Coupon Identification Detector 3 Pin: M1 | Weight Before placing in Soak Solution | Time in Soak Solution | Temperature of Solution | Weight after Solution Soak | Photograph Identification (Magnification and Distance) | Δ |
|---|---|---|---|---|---|---|
| 1 | 5.2402 | 10 | 88 °C | 5.2349 | #18 ~8" | 0.005 |
| 2 | 5.2349 | 10 | 88 °C | 5.2324 | | 0.0025 |
| 3 | 5.2324 | 10 | 83 C | 5.2288 | | 0.0036 |
| 4 | 5.2288 | 10 | (~88 C) | 5.2252 | #24 | 0.0038 |
| 5 | | 10 | | | #1 on 2nd roll | |
| | | | | | Photo of bunker on bag | 1 roll |
| 1 | 2 | 3 | 4 | 5 | 6 | |

| Coupon Identification Detector #4 Pin: E<br>1 | Weight Before placing in Soak Solution<br>2 | Time in Soak Solution<br>3 | Temperature of Solution<br>4 | Weight after Solution Soak<br>5 | Photograph Identification (Magnification and Distance)<br>6 | Δ |
|---|---|---|---|---|---|---|
| 1ST SOAK | 5.3121 | 10 | 87 °C | 5.2942 | #15 | 0.0179 |
| 2ND SOAK | 5.2942 | 10 | 86 °C | 5.2908 | | 0.0034 |
| 3RD Soak | 5.2908 | 10 | 86 °C | 5.2885 | | 0.0023 |
| 4TH SOAK | 5.2885 | 10 | 84 °C | 5.2872 | | 0.0013 |
| 5TH SOAK | 5.2872 | 10 | 88 °C | 5.2844 | | 0.002 |
| 6TH Soak | 5.2844 | 10 | 89 °C | 5.2739 | | 0.010 |
| 7TH Soak | 5.2739 | 10 | 90 °C | 5.2722 | #17 | 0.001 |
| | | | | | | ~8' |

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visual: no stress cracks

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**APPENDIX D (Data Sheets)**

| Coupon Identification Detector # 4 C-Ring: B<br>1 | Weight Before placing in Soak Solution<br>2 | Time in Soak Solution<br>3 | Temperature of Solution<br>4 | Weight after Solution Soak<br>5 | Photograph Identification (Magnification and Distance)<br>6 | Δ |
|---|---|---|---|---|---|---|
| 1 | 72.6363 | 10 | 89°C | 72.6085 | photo # #9 ≈ 1ft | 0.0278 |
| 2 | 72.6085 | 10 | 88°C | 72.5910 | | 0.0175 |
| 3 | 72.5910 | 10 | 89 °C | 72.5688 | | 0.0222 |
| 4 | 72.5688 | 10 | 85°C | 72.5512 | | 0.0176 |
| 5 | 72.5512 | 10 | 81°C | 72.5361 | | 0.0151 |
| 6 | 72.5361 | 10 | 83°C | 72.5275 | | 0.0086 |
| 7 | 72.5275 | 10 | 81°C | 72.5049 | | 0.0226 |
| 8 | 72.5049 | 10 | 84 C | 72.4723 | | 0.0326 |
| 9 | 72.4723 | 10 | 84 C | 72.4515 | | 0.0208 |
| 10 | 72.4515 | 10 | 85 C | 72.4294 | #10 ≈ 1ft | 0.0221 |
| 11 | 72.4294 | 10 | 90°C | 72.3749 | 11 & 12 | 0.0545 |

0.88M

check wgh 1g = 0.9999g
50g = 50.0003g
100g = 100.0006g
} 9-7-01 DR

| Coupon Identification Detector #4 C-Ring: C<br>1 | Weight Before placing in Soak Solution<br>2 | Time in Soak Solution<br>3 | Temperature of Solution<br>4 | Weight after Solution Soak<br>5 | Photograph Identification (Magnification and Distanee)<br>6 | Δ |
|---|---|---|---|---|---|---|
| 1ST SOAK | 73.4756 | 10 | 83°C | 73.4375 | #13 & 14 | 0.0381 |
| 2ND SOAK | 73.4375 | 10 | 87°C | 73.4072 | | 0.0303 |
| 3rd SOAK | 73.4072 | 10 | 87°C | 73.3683 | | 0.0389 |
| 4th SOAK | 73.3683 | 10 | 84°C | 73.3233 | | 0.0450 |
| 5th SOAK | 73.3233 | 10 | 83°C | 73.3018 | | 0.0215 |
| 6TH Soak | 73.3018 | 10 | 88°C | 73.2626 | | 0.0392 |
| 7TH Soak | 73.2626 | 10 | 87°C | 73.2224 | | ~~0.0403~~ |
| 8TH | 73.2224 | 10 | 82°C | 73.1965 | #16 ~8" | 0.0402 |
| | | | | | | 0.0259 |

note got some shavings out of both heads