WSRC-TR-95-0352

Evaluation of Coupons from Tank 50 (U)

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DOE Contract No. DE-AC09-89SR18035

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September, 1995

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WSRC-TR-95-0352

APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Keywords: Corrosion Monitoring
Pitting
Carbon Steel Waste Tank
Corrosion Rate

Retention: 20 years

EVALUATION OF COUPONS FROM TANK 50 (U)

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ISSUED: SEPTEMBER, 1995

D. Thomas Rudisill
Authorized Derivative Classifier

8/31/95
Date

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Westinghouse Savannah River Company
Prepared for the U. S. Department of Energy under Contract DE-AC09-89SR18035

DOCUMENT: WSRC-TR-95-0352

TITLE: EVALUATION OF COUPONS FROM TANK 50 (U)

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EVALUATION OF COUPONS FROM TANK 50 (U)

SUMMARY

The coupons from the corrosion coupon rig (CCR) were removed from tank 50 after a ten-month exposure. The evaluation consisted of microscopic examination, weight losses, and pit depth measurements. The coupons were exposed in both the liquid waste and the air space above the waste. The corrosion in the air space was characterized by variable-depth degradation under adherent corrosion products. Corrosion degradation was not significant for coupons in the waste. The coupon areas exposed at the air-waste interface had pits; the deepest measuring 6 mils. These results provide current information on actual corrosion in the waste tank. Continued use of the CCR on tank 50 is recommended (i) to monitor pitting rates, (ii) to verify the low corrosion degradation of the tanks, and (iii) to complete the CCR development for future implementation in tanks 43 and 48.

INTRODUCTION

Corrosion coupon rigs are used to monitor corrosion conditions of storage or process vessels. A CCR was fabricated for tank 50 as a preliminary trial for use in the tank farm. Tank 50 was chosen because of the low levels of contamination. The CCR was placed on tank 50 during May, 1994 and removed during March, 1995. The coupon rack floated sideways during the exposure [1]. The CCR was transported to SRTC for coupon removal and corrosion evaluation. This memo reports the findings of that investigation.

COUPON DESCRIPTION

The coupons that were placed on the rack were prepared with conditions that simulated the fabrication of Type III waste tanks and the cooling coils. The tank wall coupons were made of normalized ASTM A537, Class 1 plain carbon steel plate. The pipe coupons, representative of the cooling coils, were made of normalized A106, Grade B, schedule 40 plain carbon steel pipe. The documented welding procedures were followed to make the welded coupons.

The coupons were saw cut from either plate sections or pipes. The plate coupons were 8" by 1" by 0.125" and the pipe coupons were 8" by 0.75" by 0.154". Edges were rounded with a belt sander. The coupons were surface finished to 600 grit prior to stress relieving and numerically stamped. Holes were also drilled at each end of the coupon for attaching to the rack. Each coupon was photographed, weighed, and dimensionally measured.

The initial surfaces of the various coupons differed. The A537 plate coupons had a black-gray oxide which also covered the edges. Both welded and unwelded coupons had smooth surfaces. The A106 pipe coupons had rough pock-marked surfaces. The unwelded pipe coupons had a thick black oxide scale that appear sooty; these coupons were not stress relieved. The welded pipe coupons, however, had an oxide similar to the A537 coupons.

The weld bead could be clearly seen on the pipe coupons. The edges of the pipe coupons had a shiny metallic finish, resulting from the sanding operation.

COUPON EVALUATION

The coupon evaluation consisted primarily of visual examination and was performed at several stages. These stages were prior to removal from the floating rack, after removal, and after cleaning of corrosion products. The coupons were examined before and after cleaning with a stereomicroscope. Photographs were taken at each stage. Pit depth measurements were made using a digitized microscope. The coupons were cleaned according to ASTM G1-88, "Standard Practice for Preparing, Cleaning, and Evaluating Corrosion Test Specimens" [2]. The cleaning solution was a sodium hydroxide solution with granulated zinc. Coupon weights were measured after cleaning to calculate weight losses and average corrosion rates.

Prior To Removal

Since the coupon rack was lopsided during the exposure, two samples were completely immersed in the waste, one sample was exposed only to the air, and three samples were exposed to both the waste and the air. Table 1 gives the number, material, welding and exposure condition, and a description of the corrosion products for each coupon. Figure 1 is a photograph of the rack before the coupons were removed. The air-waste interface can be clearly seen in the photograph.

Before Cleaning

The corrosion degradation of the coupons, as described in Table 1, was directly affected by the exposure conditions and the material. Figures 2-5 are photographs of the corroded surfaces of each of the coupons. The sections of coupons (CW-1 and P-2) that were exposed to the air had greater degradation than those exposed to the waste. The air-exposed sections had tubercle corrosion in which corrosion products built up on the surface to form a tube or mound. Occluded cells form and maintain or increase the corrosive conditions. The waste-exposed sections (C-1, P-1, W-1, and W-2) had either pinpoints or spots of rust. The coupons that were exposed to the waste tended to have a brownish tint. The coupons with an air-waste interface (P-2, W-1, and W-2) had a white residue in this region. The oxide on A537, which was formed during the stress relieving operation, appeared to be more protective than the as-extruded surface on A106.

Weight Losses

Prior to cleaning the exposed coupons, unexposed coupons or blanks were cleaned to measure weight loss attributable to the cleaning solution. The weight loss was dependent on the type of coupon. The weight losses for the blanks were as follows: 0.1 g for the plate, 0.3 g for the welded pipe, and 1.1 g for the unwelded pipe. The absence of the heat formed oxide on the unwelded pipe probably allowed greater attack by the cleaning

solution. These weight losses were used to adjust the weight losses of the exposed coupons.

The weight losses and average corrosion rates were affected by both the exposure condition and the material as shown in Table 2. The corrosion rate in the vapor space was greater than that in the waste as seen by comparing the rates for CW-1 and P-2 with the other coupons. A537 had a significantly lower corrosion rate than A106. The overall averages for A537 and A106 were 0.075 and 0.25 mpy, respectively. The small values of the corrosion rates indicated that general corrosion was negligible during the ten-month exposure. This result supports the NDE findings that general corrosion in the waste tank is not a significant factor with respect to structural integrity.

After Cleaning

The surface and corrosion morphology were investigated after the corrosion products were removed by cleaning. Table 3 gives the number, material, welding and exposure condition, and a description of the surface morphology for each coupon. In general, irregular pit-like surfaces were observed on sections exposed to the air, while waste-exposed sections were slightly attacked at rust spots.

On the air-exposed sections for CW-1 and P-2, variable-depth corrosion was observed beneath the mounds of corrosion products. Variable-depth corrosion is characterized by broad, nonuniform holes in the material. The surface area of a hole may be about 0.05 in^2. The largest measured depths were 7.5 and 6 mils for CW-1 and P-2, respectively. The initial rough surface of CW-1 made the depth measurements for this coupon questionable. For P-2, the 6 mil depth was located in the interfacial region where most depths were in the range of 2-4 mils. Areas with adherent oxide layers did not corrode.

The waste-exposed coupons did not have significant corrosive attack. The pipe coupon, C-1, had a rough surface, but as explained above the rough surface was typical of the initial surface. For the plate coupon, the initial grinding marks and oxide were still observed. Slightly attacked areas were beneath the rust spots.

The interfacial regions on W-1 and W-2 were where pits were observed. The deepest pits that were measured were 2 and 3.7 mils, although most pits ranged between 1-2 mils. The waste-exposed sections of these coupons were slightly attacked showing a rough surface where rust spots were located.

DISCUSSION

The corrosion processes that occurred in the waste tank were similar to those observed in the laboratory during partial-immersion coupon tests. These processes were variable-depth corrosion on air-exposed sections and minimal attack on waste-exposed sections. In the laboratory, rust spots were not typically observed on waste-exposed sections for properly

inhibited solutions. The rust spots on the coupons may have occurred after removal when residual rinse water remained on the surface.

The interfacial region has been the area of concern because hydroxide concentrations may be tenuous due to carbon dioxide absorption. The steel would be susceptible to pitting with insufficient inhibitors. The concentration ranges of the primary constituents in tank 50 during the ten-month exposure were 2.4-3.5 M for nitrate, 1.5-2.0 M for hydroxide, and 0.06-0.1 M for nitrite. Pitting may have occurred due to the low nitrite concentration.

The deepest measured pit on the coupons was 6 mils. If this rate is maintained a wall that is 0.5 inch thick would be penetrated in approximately 70 years. The constancy of this rate is an unknown. Pit growth may cease if the pit passivates or may continue depending on the waste conditions. Corrosion monitoring, therefore, would provide the information for assessing the corrosion state of the waste tanks.

The use of the CCR in tank 50 should be continued to complete the development of this corrosion monitoring tool for the waste tanks. Subsequent placement of a CCR into tanks 43 and 48 is recommended since the conditions in these tanks will be variable and possibly corrosive. Tank 48 is the processing tank for ITP and tank 43 is the recycle tank for DWPF, although in tank 43 various waste streams will be received. The CCR is a technique where the cumulative effect of these conditions could be detected and the corrosion mitigated.

CONCLUSION

The coupons from tank 50 have provided direct information on the actual corrosion occurring in a waste tank. This corrosion consisted of variable depth corrosion on air-exposed sections and pitting in interfacial regions. The pitting rate was not excessive, but should be monitored to verify that low rates are obtained and tank integrity is not compromised. The corrosion rate on air-exposed steel was greater than that measured in the waste, although the overall rates were low. These result are consistent with previous experimental finding and NDE measurements of the waste tanks. The development of the CCR should be completed on tank 50 so that waste tank conditions can be effectively monitored for corrosion. CCR placement into tanks 43 and 48 should follow since these tanks have variable conditions which may induce corrosion.

REFERENCES

1. D. K. Appel and J. I. Mickalonis, "Corrosion Coupon Rig Retrieval From Tank 50: Investigative Results And Recommendations," SRT-EES-950341, May, 25 1995.

2. ASTM G1-88, Standard Practice for Preparing, Cleaning, and Evaluating Corrosion Test Specimen, ASTM, Philadelphia, PA, 1995.

Table 1. The Exposure Condition and Corrosion For The Tank 50 Coupons Before Cleaning

Number	Material	Welding Condition	Exposure	Description
CW-1	A106	Welded	Air	tubercle corrosion on 40-50% of surface spotty rust on remaining surface welds unattacked
C-1	A106	Unwelded	Waste	thin rust layer over most of surface with black oxide scale edges shiny with pinpoints of rust
P-1	A537	Unwelded	Waste	pinpoint rust spots over entire surface reddish-brown coloring
P-2	A537	Unwelded	Air with Interface	tubercle corrosion on 20-25% of surface in both the interfacial and air-exposed sections pinpoint rust spots also present
W-1	A537	Welded	Waste & Interface	rust in spots on waste-exposed surface one corner of coupon was exposed in air and had a heavier rust layer
W-2	A537	Welded	Waste & Interface	few pinpoints of rust on waste-exposed surface one corner exposed to air and had tubercle corrosion

Table 2. Weight Losses And Average Corrosion Rates For Tank 50 Coupons

Number	Weight (g) Initial	Weight (g) Final	Weight Loss (g)	Adjst.[1] Loss (g)	Surface Area (in^2)	Corrosion[2] Rate (mpy)
CW-1 (A106)	133.58	132.76	0.82	0.52	15.69	0.31
C-1 (A106)	143.92	142.33	1.59	0.31	15.44	0.19
P-1 (A537)	121.14	121.00	0.14	0.04	17.38	0.02
P-2 (A537)	119.68	119.30	0.38	0.28	17.38	0.15
W-1 (A537)	85.62	85.40	0.22	0.15	16.64	0.08
W-2 (A537)	105.52	105.32	0.20	0.10	17.05	0.05

1. Weights were adjusted for cleaning solution attack.

2. Corrosion rates (CR) were calculated from the adjusted losses (AL) and surface areas (SA) with the following equation:

$$CR\ (mpy) = \{[AL(g)/128.64(g/in^3)]/[SA]0.83(yr)\}1000(mil/in)$$

Table 3. The Exposure Condition and Corrosion For The Tank 50 Coupons After Cleaning

Number	Material	Welding Condition	Exposure	Description
CW-1	A106	Welded	Air	irregular surface under tubercles rough surface under rust spots
C-1	A106	Unwelded	Waste	rough surface under oxide scale and pinpoint rust on edges
P-1	A537	Unwelded	Waste	rough surface under rust spots
P-2	A537	Unwelded	Air with Interface	irregular surface under tubercles several areas with pits
W-1	A537	Welded	Waste & Interface	waste-exposed surface smooth, did not have significant attack interfacial area had rough surface with several pits
W-2	A537	Welded	Waste & Interface	rough surface under rust spots interfacial area had rough surface with several pits

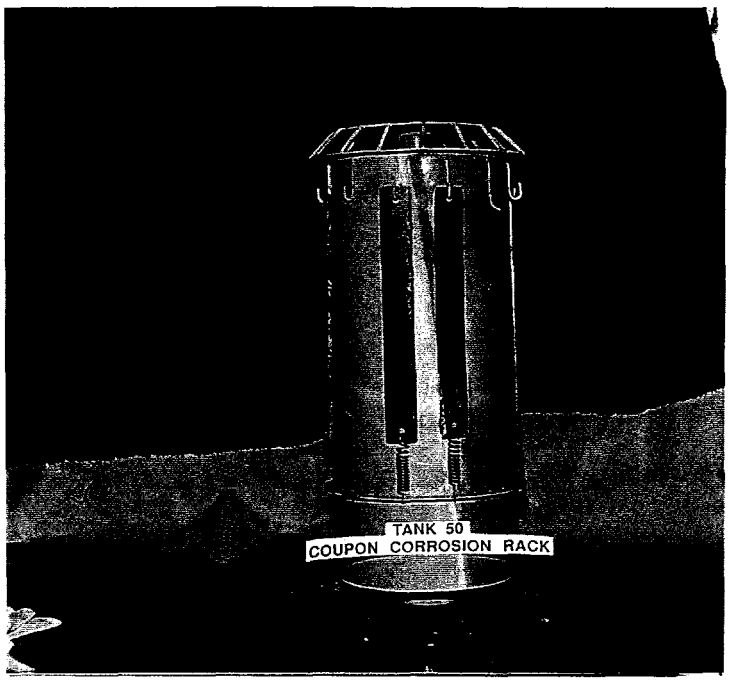


Figure 1. Floating rack of the Coupon Corrosion Rig from tank 50. The two coupons along the interface are P-2 (left) and W-1 (right).

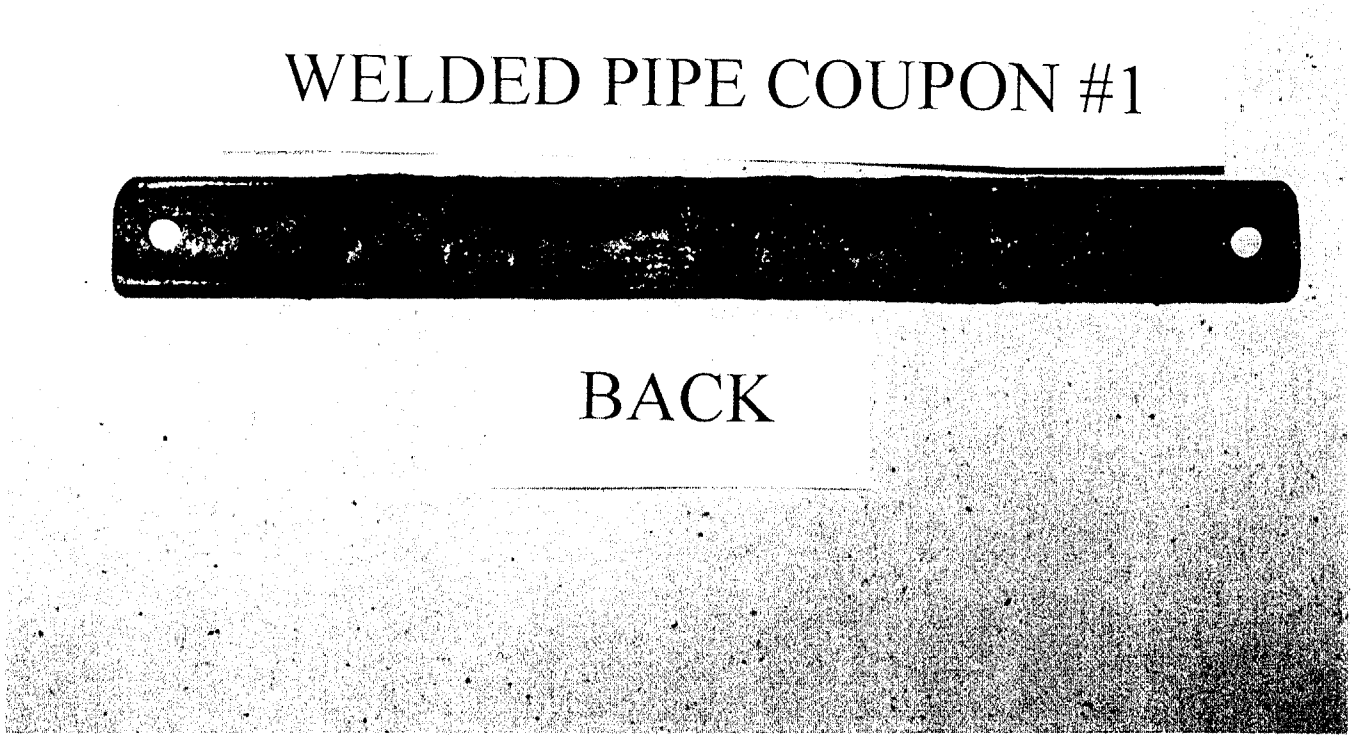


Figure 2. Back view of the corroded welded pipe coupon (CW-1) which was exposed to the air.

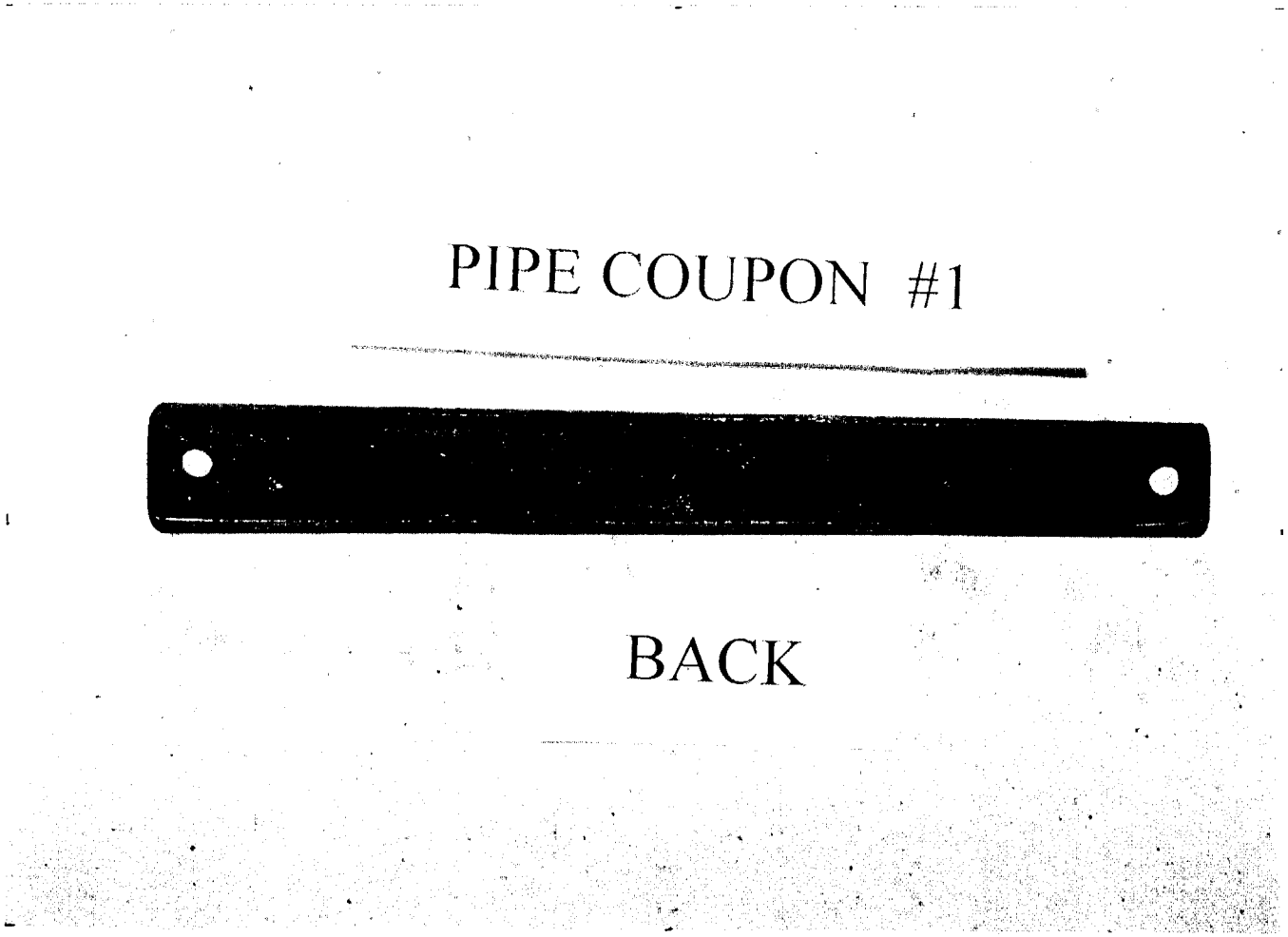
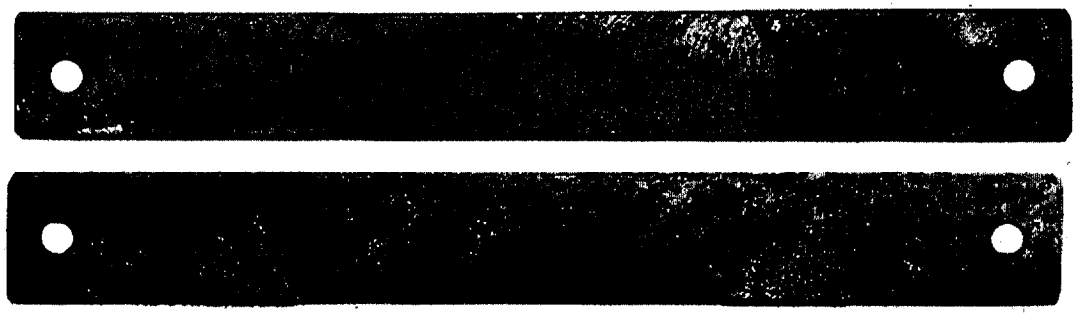


Figure 3. Back view of the corroded pipe coupon (C-1) which was exposed to the waste.



Which is P1 ?

Figure 4. Back view of the corroded plate coupons; P-1 was exposed to the waste and P-2 was exposed to the air.

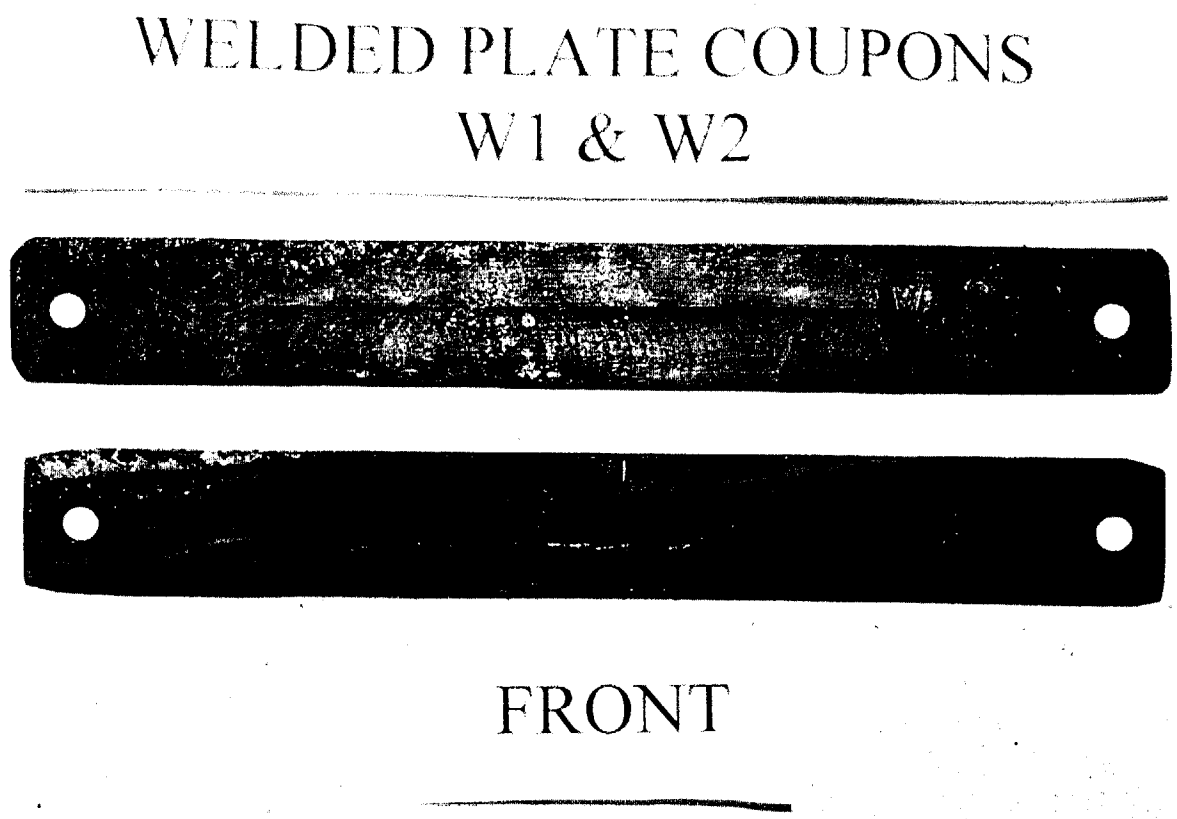


Figure 5. Front view of the corroded welded plate coupons (W-1 and W-2) which were exposed mostly to the waste.