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Review of Type I High Level Waste Tanks Ultrasonic Inspection Data (U)

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1 SUMMARY

A review of the data collected during ultrasonic inspection of the Type I high level waste tanks has been completed. The data was analyzed for relevance to the possibility of vapor space corrosion and liquid/air interface corrosion. The review of the Type I tank UT inspection data has confirmed that the vapor space general corrosion is not an unusually aggressive phenomena and correlates well with predicted corrosion rates for steel exposed to bulk solution. The corrosion rates are seen to decrease with time as expected. The review of the temperature data did not reveal any obvious correlations between high temperatures and the occurrences of leaks. The complex nature of temperature-humidity interaction, particularly with respect to vapor corrosion requires further understanding to infer any correlation. The review of the waste level data also did not reveal any obvious correlations.

2 INTRODUCTION

A technology development roadmap was developed to address the vapor corrosion and liquid/air interface (VSC/LAIC) phenomena. The roadmap incorporated expert panel recommendations from the Vapor Corrosion Workshop in March 2002 into a comprehensive program to investigate the potential for vapor space and liquid/air interfacial corrosion in the high level waste (HLW) tanks. As part of a zero-step implementation to the roadmap, a review of the historical ultrasonic inspection data for the Type I/II tanks was made with respect to vapor space corrosion and liquid/air interface corrosion. General corrosion rates were determined using the inspection data, and the data was correlated with operational parameters that impact variables key to corrosion processes. This report details the results of the review and the correlations.

3 BACKGROUND

The SRS has three types of high level waste tanks with secondary containment that are currently in service, Types I, II, and III. The Types I and II tanks were made of ASTM A285 steel during the 1950's and 1960's. Of the 16 Types I and II tanks, 11 have leaked waste into the annular space. The review of the inspection data focused on the Type I/II tanks, because they have developed leaksites.

3.1 Type I/II Tank Design and Fabrication

Type I tanks (shown in Figure 1) have a capacity of 750,000 gallons, are 75 feet in diameter, and 24 ½ feet high. The primary tanks are a closed cylindrical tank with flat top and bottom constructed from ½ in. thick steel plate. The top and bottom are joined to the cylindrical sidewall by curved knuckle plates. Type II tanks (shown in Figure 2) have a capacity of 1,030,000 gallons, are 85 feet in diameter, and 27 feet high. The primary container for Type II tanks consists of two concentric steel cylinders assembled with a flat bottom and flat top forming a doughnut. The top and bottom are joined to the outer cylinder by rings of curved knuckle plates. Neither Type I nor Type II waste tanks are stress relieved. Single-butt, full-penetration girth welds join each of the plates in both, Type I and Type II waste tanks. The tanks are constructed with a top weld to the top of the tank, middle welds between plates, and bottom welds to the bottom of the plate. A 5-foot high steel pan provides secondary containment for the tanks and a concrete vault encompassing the primary tank and the steel pan provides another barrier before waste can reach the ground.

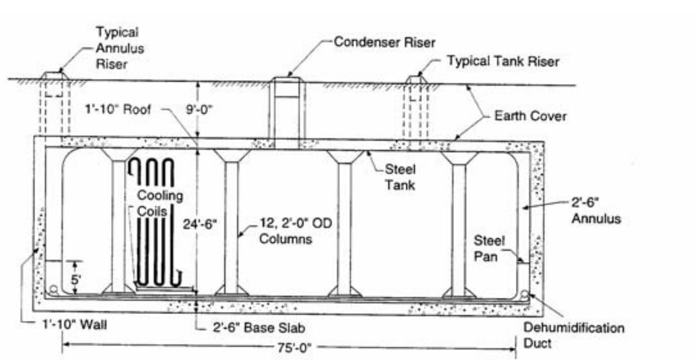


Figure 1: Type 1 High Level Waste Tank Schematic.

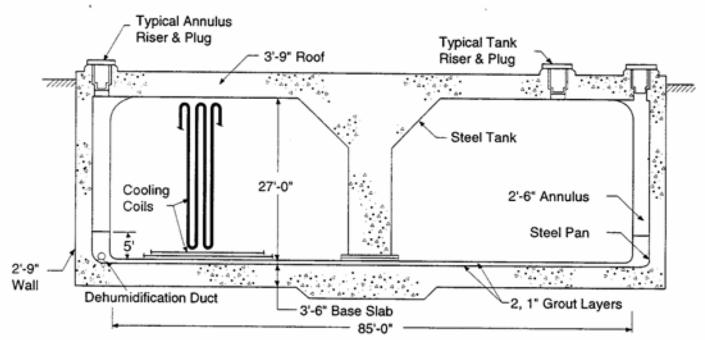


Figure 2: Type II High Level Waste Tank Schematic.

3.2 Degradation Mechanisms

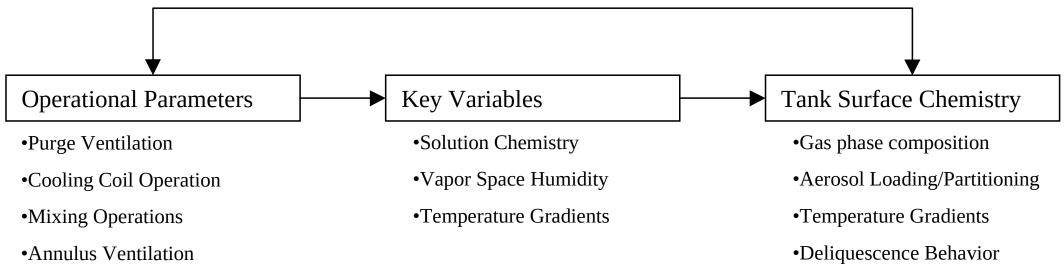
An assessment of the potential degradation mechanisms of Types I and II High-Level Waste (HLW) Tanks determined that pitting corrosion and stress corrosion cracking were the two most significant degradation mechanisms. Specifically, nitrate induced stress corrosion cracking and pitting were determined to be the principal degradation mechanism for the primary tank steel. Historically, cracks found in Type I and Type II waste tanks initiated by nitrate-induced stress corrosion cracking in the fabrication-induced residual stresses around welds. General corrosion of the waste tank steels may occur under certain chemistry conditions. Corrosion control measures are taken to prevent such degradation in the liquid space, but efficacy in the vapor space is unkown.

Several experiences have indicated the possibility of stress corrosion cracking or pitting within the vapor space. Tanks 5 and 6 developed leaks during refill after a long period of waste level stagnancy. These leaks were attributed to nitrate stress corrosion cracking, and hypothesized to be previously undiscovered leaksites, or through-wall crack growth in the vapor space. Additionally, Tank 15 appears to have stress corrosion crack growth within the vapor space.

An inspection program has been in place to provide accurate information on the condition of the tanks since the late 1960s. As part of this program, ultrasonic wall thickness measurements were made from 1971-1985 on most of the waste tanks. No detectable wall thinning was noted during these inspections. Additional ultrasonic examinations (utilizing P-Scan equipment) were performed on six Type III tanks in the late 1990's. No wall thinning or pitting due to in-service degradation was reported. The reportable levels were 15% of nominal for wall thinning and 35% of nominal for pitting. In 2000, ultrasonic examination of Tank 13, a Type II tank, was performed as part of the Tank Life Management Program. The wall thickness data from the ultrasonic measurements made during the 1970's and 1980's were reviewed in the context of vapor space corrosion and the results of that review follow.

4 TECHNICAL APPROACH

The vapor corrosion phenomenon is proposed to be dependent upon several key operational parameters. These include purge ventilation characteristics, cooling coil operation, slurry pump (or any mixing) operation, and annulus ventilation. Key variables include the solution chemistry, the humidity in the vapor space, and any temperature gradients that may exist. The influence of operational parameters on the key variables was established. The following schematic summarizes the parameters of interest.



The available data of the temperature, volume, chemistry profile and the UT data were compiled and analyzed. The results are presented in the following sections with summaries of their application to determine each tank's potential vulnerability to vapor space corrosion.

4.1 Review of Temperature Data

The temperature data was compiled from the initiation of service of the Type I tanks till 1992. The temperature data/graphs are presented in Appendix 1. The supernate temperature plays a key role in vapor corrosion. However, the salt and sludge temperature could also play a role by affecting the tank wall temperature, thereby influencing corrosion processes. The temperature potentially impacts vapor corrosion in several ways. At higher temperatures, the supernate may activate transport from the bulk solution into the vapor space.

The effect of temperature on the vapor corrosion rates would be complex in nature. An increase in temperature will tend to stimulate corrosive attack by increasing the rate of electrochemical reactions and diffusion processes. For a constant humidity, an increase in temperature would therefore lead to a higher corrosion rate. Raising the temperature will, however, generally lead to a decrease in relative humidity and more rapid evaporation of the surface electrolyte. By reducing the time of wetness in this manner, the overall corrosion rate would tend to diminish. The increase in relative humidity associated with a drop in temperature tends to have an overriding effect on corrosion rate. This implies that simple air conditioning, involving a decrease in temperature without additional dehumidification, will accelerate atmospheric corrosion damage.

The data were analyzed for extended periods of time in which the temperature remained high, or for excursions to high temperatures. Extended periods of high temperature service potentially keeps the corrosion process active at higher rates. Temperature excursions may initiate corrosion processes, that can then have a very slow growth rate during lower temperature service. A review of the data and discussion on the results is summarized in Table 1.

Table 1: Review of Temperature Data

Tank	Review of Temperature Data
1	Sludge temperature excursion (>200°C) after initial service
2	Low temperatures throughout
3	Low temperatures throughout
4	Sludge temperature excursion (>150°C) after initial service
5	Sludge temperature excursion (>100°C) after initial service
6	Sludge temperature excursion (>150°C) after initial

Tank	Review of Temperature Data
	service
7	Sludge temperature excursion (>150°C) after initial service
8	Low temperatures throughout
9	Low temperatures throughout
10	Supernate temperature excursion (>100°C)
11	Sludge remains >100°C
12	Oscillating sludge temperature around 100°C

Tanks 1, 4, 5, 6, 7, 11, and 12 have seen extended periods of high sludge temperature, while tanks 2, 3, 8, 9, and 10 have not. All the tanks have typically low (<60°C) supernate temperatures, except for Tank 10. The supernate temperature measurements indicate several excursions, but these have been attributed to measurement technique, as there is no corroboration with operational history for these temperature readings. The high sludge temperatures may lead to high tank wall temperatures creating a possibility for corrosion, but supernate temperatures remained low throughout. The vapor space temperatures will be lower than the supernate temperatures.

In terms of leakage, Tanks 1, 9-12 experienced leaks early into their service, while leaksites were found in tanks 5 and 6 during refill after a long period of stagnancy. In Tanks 5 and 6, previously unknown but probably pre-existing leaksites became evident by leakage into the annulus immediately after recent transfers of waste into those tanks. The recently observed Tank 5 and 6 leak sites were well above the pre-transfer waste level, suggesting stress corrosion crack growth in the vapor space.

The review of the temperature data did not reveal correlations between high temperatures and occurrences of leaks. The synergistic effects of these parameters potentially control the corrosion rates in the vapor space. It is difficult to understand the impact of temperature without further understanding the surface chemistry developed in the vapor space. The operation of the purge ventilation plays the key role in the temperature-humidity interaction, and the vapor space chemistry.

4.2 Review of Waste Level Data

The vapor corrosion and liquid/air interfacial corrosion phenomena are also dependent upon the waste levels. Long periods of time at a stagnant waste level may enhance interfacial corrosion, or allow for long-term transport to the vapor space and consequent corrosion. In addition, fast decanting of supernate may allow for salt to be deposited on the tank wall well above the post-decant waste level. An extended period of low stagnant waste level potentially enhances the possibility of vapor space corrosion. The volume data from the Type I tanks was analyzed for such occurrences. However, the data was readily available only until 1992. Since that time, the tanks may have operated differently. The data for the waste levels is included in Appendix 2. The summary of the review of the waste level data is presented in Table 2.

Table 2: Review of Waste Levels Data

Tank	Review of Waste Levels Data
1	Initially many fluctuations, followed by quick decant and long period of medium level, recent long period of stagnancy (minimal supernate)

Tank	Review of Waste Levels Data
2	Initially many fluctuations, followed by quick decant and long period of medium level, recent long period of stagnancy (minimal supernate)
3	Initially many fluctuations, followed by quick decant and long period of medium level, recent long period of stagnancy (minimal supernate)
4	Many fluctuations
5	Initially many fluctuations, followed by quick decant and long period of stagnancy at low level
6	Initially many fluctuations, followed by quick decant and long period of stagnancy at low level
7	Initially many fluctuations, followed by quick decant and long period of stagnancy at low level
8	Low fill throughout
9	Active for many years, followed by stagnancy
10	Active for many years, followed by stagnancy
11	Active for many years, followed by stagnancy
12	Active for many years, followed by stagnancy

The review of the waste levels did not reveal correlations with leaksite or with the inspection data. The Type I tanks were initially fresh waste receivers and were active in many cases. The continuous operation of the tanks and the filling/decanting cycles may have protected against localized vapor corrosion mechanisms.

4.3 Review of UT Data

An ultrasonic wall thickness (UT) measurement program was implemented for all HLW tanks in 1972, and was discontinued in 1985 since no evidence of general corrosion had been found. The UT spot thickness readings were designed to detect and measure wall loss from general corrosion. The spot thickness reading data were collected with a single element transducer and a multiple echo technique which provides a precise measurement of steel thickness while minimizing the error from any coating or changes in contact from pressure or surface debris. This program included all of the Type I and three of the four Type II HLW Tanks. Most tanks have more than one set of data.

The UT data measurement technique available for these tanks addresses only general corrosion concerns. The general corrosion mechanism is the controlling factor for maintaining structural integrity, even though localized corrosion mechanisms are hypothesized to be more active in the vapor space. The localized corrosion mechanisms, i.e. pitting and stress corrosion cracking, may compromise leak-integrity of the tanks, but will not impact the structural integrity or structural stability of the tanks. Thus, the review of the UT data lent insight to the impact of vapor space corrosion on the structural stability of the tanks, but does not address the localized corrosion mechanisms.

The data of the ultrasonic inspections from the Type II tanks was reviewed but will not be presented, as there was no data available for the top knuckle. Since the data was being analyzed in terms of vapor space corrosion, the unavailability of data at the top knuckle does not allow for analysis. Therefore, analysis was only done on Type I tank data.

The inspection data was analyzed in the following way for each inspection:

1. The maximum wall thickness at fabrication was conservatively estimated to be the nominal (0.5 in.) + the over-tolerance allowed (0.05 in.), which is 0.55 inches.

2. The data was averaged separately for the top knuckle, top plate, bottom plate, and the bottom knuckle. These averages were used for corrosion rate calculations.

3. The minimum wall thickness was conservatively estimated by subtracting the "uncertainty" determined from statistical analysis of UT data from other tanks.[1]

The calculation technique results in an inherent corrosion rate, that is used for comparison purposes for application to the vapor space corrosion phenomenon. The corrosion rates estimated by this procedure are conservative and exceed the maximum estimate of the corrosion rate based on laboratory studies by a factor of 3 to 5. This difference is due to the conservatism assumed in the estimate of the initial wall thickness and the conservatism in the assumption of negative error of ultrasonic thickness measurements. The data analysis technique is utilized here to compare the impact of vapor corrosion mechanism with that of the bulk solution corrosion mechanisms. The analysis of the data with respect to tank condition is reported in the results of the annual in-service inspection program.[2]

The data analysis does not take into consideration position-specific thickness measurements. The averaging was performed on measurements taken over the entire plate or knuckle to allow for a sufficient number of data points for thickness analysis. However, thickness measurements on the plates indicate a greater thickness towards the middle, and a lower thickness towards the welds. The averaging technique does not take this into account, and therefore cannot be considered as a means of determining localized thinning or corrosion.

5 UT DATA ANALYSIS

The corrosion rates for each inspection performed on each of the tanks are included in Appendix 3 in tabular and graphical form. The data was analyzed for possible correlations between the calculated corrosion rates for each of the following: (1) top knuckle, (2) top plate, (3) bottom plate, and (4) bottom knuckle as a function of inspection date. The corrosion rates were also analyzed for each of the risers and each of the inspections done.

5.1 Corrosion Rates Analyzed by Inspection Date

The general corrosion rates were analyzed as a function of inspection date. This data is a compilation of all the data collected from all the tanks, to provide the most data points. It was expected and confirmed that the general corrosion rates decrease with time. These data are shown in Table 3. It is important to note that much of the corrosion rate is due to the calculation techniques, and is meant for comparison purposes only.

Table 3: Corrosion Rate Data Sorted by Inspection Date

Year	Top Knuckle	Top Plate	Bottom Plate	Bottom Knuckle
1973	3.71	2.19	2.72	3.70
1974	4.42	3.42	3.83	3.68
1977	2.63	1.39	1.89	2.71
1978	2.62	2.28	1.33	3.22
1979	1.93	1.32	1.58	1.82
1981	2.37	1.51	1.75	2.35
1983	1.59	1.30	1.32	1.64
1985	1.93	1.18	1.35	1.88

A chart depicting the corrosion data as a function of the inspection date is shown in Figure 3.

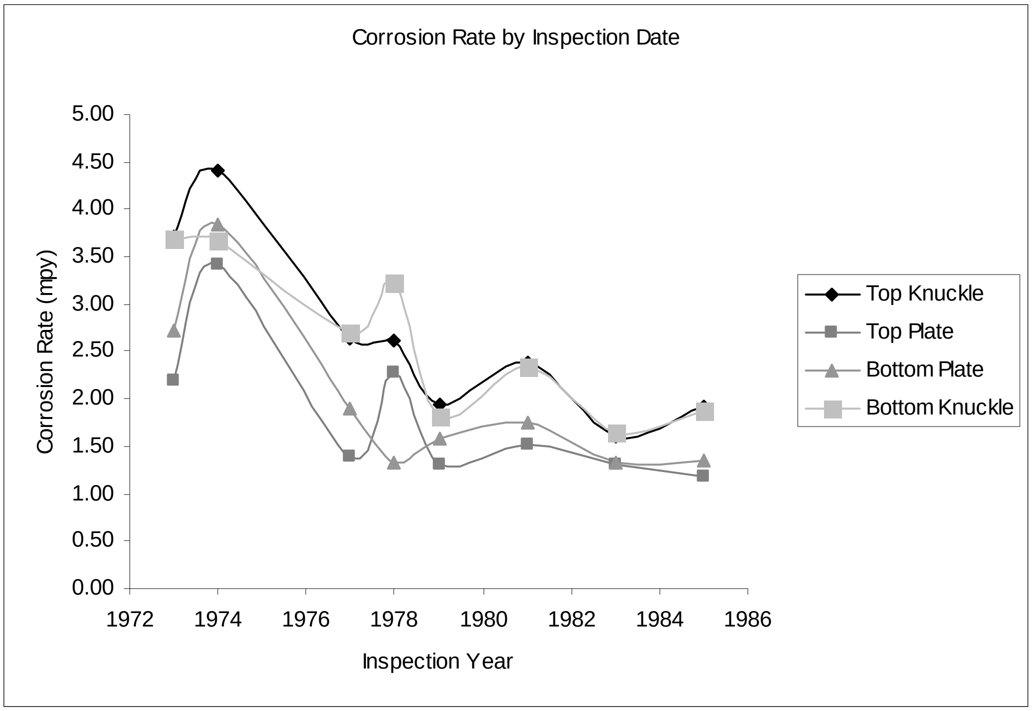


Figure 3: Corrosion Rate Data Sorted by Inspection Date for Type I Tanks

The corrosion rates are seen to decrease with each inspection from 1973 to 1981, and then become constant. The corrosion rates are between 1 and 2 mils/year as calculated from the most recent inspection (1985). The top knuckle and the bottom knuckle exhibit the higher corrosion rates which may be due to several reasons. The UT inspection technique was limited in data collection ability on the top knuckle and the bottom knuckle, and therefore collected data very near edges of the plate sections and near the welds. The edges of the plates are typically thinner due to the rolling process therefore the thickness indications are lower than expected. The corrosion rates calculated near the knuckles may be artificially lower than the plate general corrosion rates due to the fabrication process and the limited number of measurements. Alternatively, it may indicate that the general corrosion rate in the vapor space is higher than when exposed to bulk inhibited solution. The similarity between the corrosion rates at the top knuckle and the bottom knuckle indicate that the combination of the UT measurement technique and the inherent thinning at the edges is the controlling factor, rather than an active vapor space corrosion mechanism. Additionally, the general corrosion rates are well within expected corrosion rate.[3]

5.2 Corrosion Rates by Riser

The corrosion data were also analyzed by riser for the most recent inspections (i.e. 1985) in an effort to correlate possible effects of purge ventilation on the general corrosion rates. The Type I tanks have four risers, i.e. east, west, north, south.

Table 4: Corrosion Rate Data Sorted by Riser

Riser	Top Knuckle	Top Plate	Bottom Plate	Bottom Knuckle
East	2.07	1.24	1.36	1.98
West	1.75	1.20	1.34	1.72

Riser	Top Knuckle	Top Plate	Bottom Plate	Bottom Knuckle
North	1.91	1.12	1.08	1.69
South	1.99	1.06	1.58	2.18

The data is plotted in Figure 4. The corrosion rate for the top knuckle and bottom knuckle appears higher in the East and South Riser. The data for the top plate seems constant under each riser, with the corrosion rate on the bottom plate higher under the South Riser.

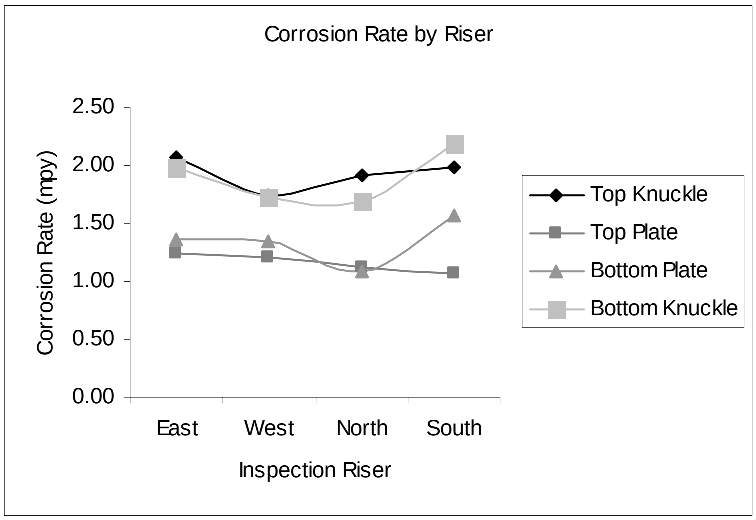


Figure 4: Corrosion Rates of Type I Tanks Sorted by Riser

Since the proposed vapor corrosion mechanism is hypothesized to be dependent upon the relative humidity within the tanks, and the relative humidity is controlled by the purge ventilation, the corrosion rate data was further broken down by location of purge ventilation ductwork relative to the risers inspected. The even numbered tanks have ventilation ducts situated in the southeast quadrant, while the odd numbered tanks have ventilation ducts situated in the southwest quadrant. If the vapor corrosion mechanism were unusually aggressive, the odd numbered tanks may exhibit higher general corrosion rates in the south and west riser, while the even numbered tanks may exhibit higher general corrosion rates in the south and east risers. The corrosion rate data sorted by riser and ventilation duct location (odd/even tanks) is shown in Table 5.

Table 5: Corrosion Rate Data Sorted by Riser & Ventilation Duct Location

Riser*	Top Knuckle	Top Plate	Bottom Plate	Bottom Knuckle
East (Even)	2.06	1.17	1.22	2.01
West (Even)	1.73	1.28	1.56	1.64
North (Even)	1.97	1.16	1.11	2.14
South (Even)	2.05	1.14	1.26	2.26
East (Odd)	2.05	1.06	1.45	1.81
West (Odd)	1.78	1.07	0.98	1.85
North (Odd)	1.85	1.16	1.27	N/A
South (Odd)	1.90	0.95	2.05	2.06

*Even Tanks: Ventilation ducts in southeast quadrant

*Odd Tanks: Ventilation duct in southwest quadrant

The corrosion rate data for the even tanks with the ventilation duct in the southwest quadrant is shown in Figure 5. The south quadrant has a slightly higher corrosion rate than the other quadrants at the top and bottom knuckle. The west quadrant indicates higher corrosion rates at the bottom plate and bottom knuckle.

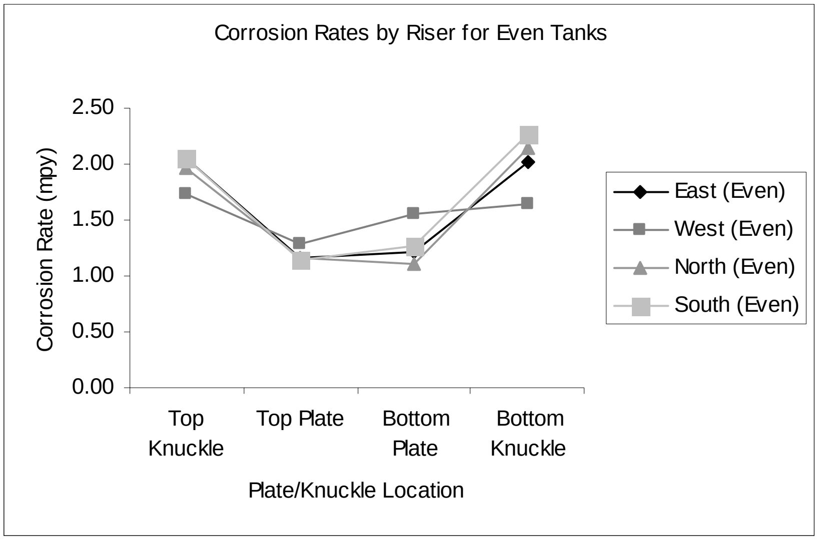


Figure 5: Corrosion Rates by Riser for Even Tanks

The corrosion rate data for the odd tanks with the ventilation duct in the southeast quadrant is shown in Figure 6. The south and east quadrants indicate higher corrosion rates at the bottom plate and bottom knuckle.

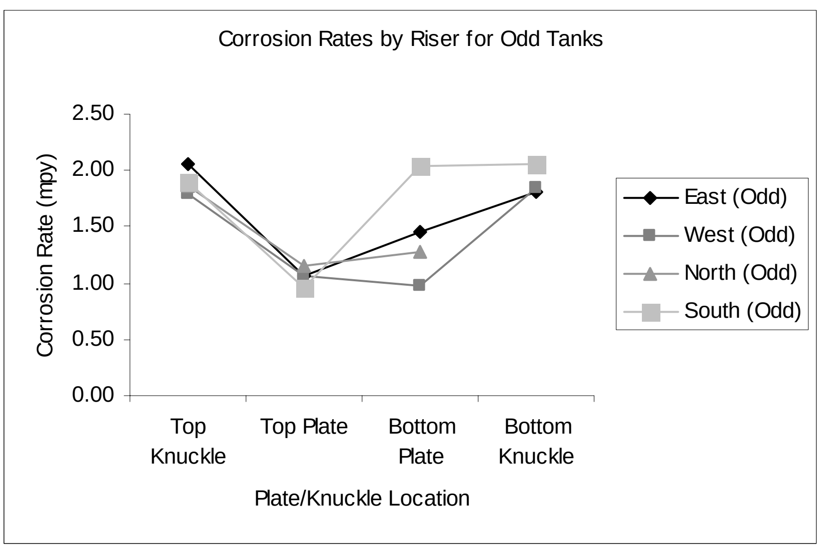


Figure 6: Corrosion Rates by Riser for Odd Tanks

There was no apparent effect of the purge ventilation on the general corrosion in the vapor space. The top plate/knuckle do not exhibit an unusually large corrosion rate when compared to the bottom plate/knuckle. This suggests that the purge ventilation may not induce the necessary airflow within the vapor space of the tank to affect the relative humidity and consequently corrosion processes. This may be particularly true when the vapor space within the space is small or the supernate level is high enough to maintain an inherent relative humidity close to 100%. The humidity factor becomes important at long periods of low-level waste stagnancy where the vapor space is relatively large.

6 CONCLUSIONS

The review of the Type I tank UT inspection data has confirmed that the vapor space general corrosion is not an unusually aggressive phenomena and correlates well with predicted corrosion rates for steel exposed to bulk solution. The corrosion rates determined from the UT inspections are in line with predicted corrosion rates under exposure to bulk solution. Corrosion coupons immersed in the waste tanks for approximately 15 years showed little evidence of general corrosion.[4] The results also correlate well with laboratory tests in bulk simulant solution which estimated the corrosion rate at 1 mil/year.[5] The rates will be compared to rates determined in the current vapor space corrosion experimental program that is concurrently being performed.[6]

The corrosion rate calculation is ultra-conservative in several ways. The first is that all initial nominal thicknesses are assumed to be the maximum over-tolerance limits as allowed by code requirements for ASTM A285 plate steel. In addition, the UT thickness measurements were assumed to be maximum measurements and the uncertainty of 11 mils was assumed to be a negative error. These assumptions imply that after 25 years, an inherent corrosion rate of approximately 0.5mpy would be calculated due only to calculation technique. Additionally, the calculation technique allows for a decreasing corrosion rate.

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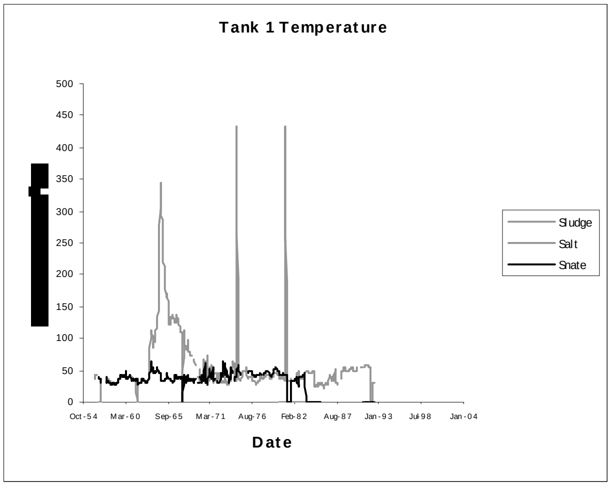
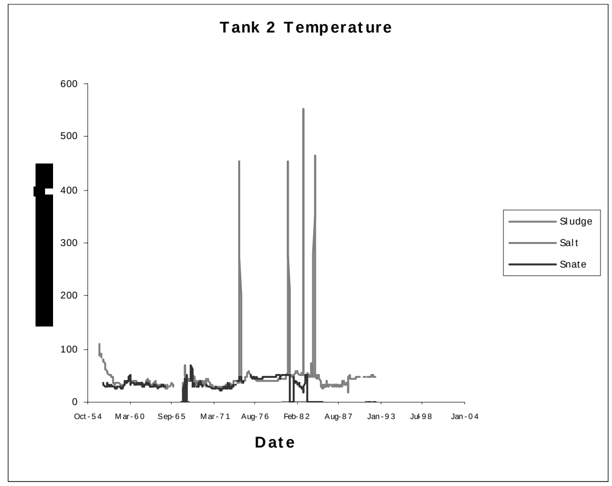
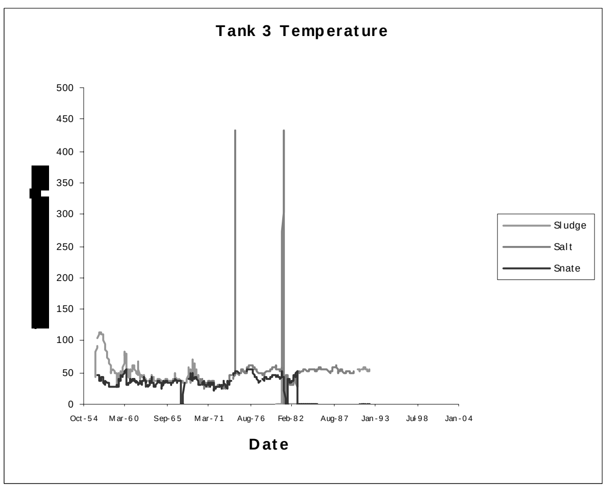
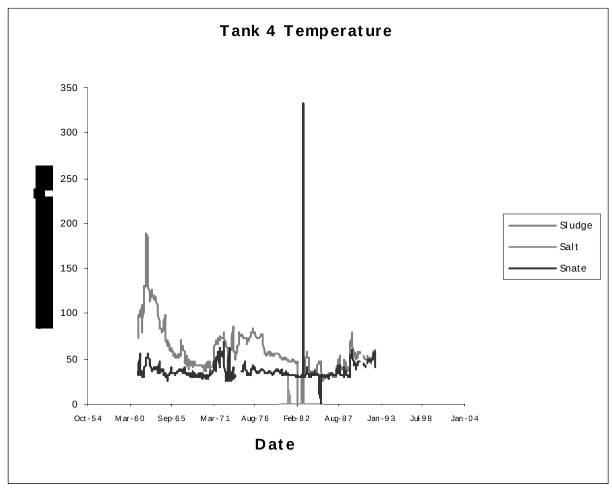
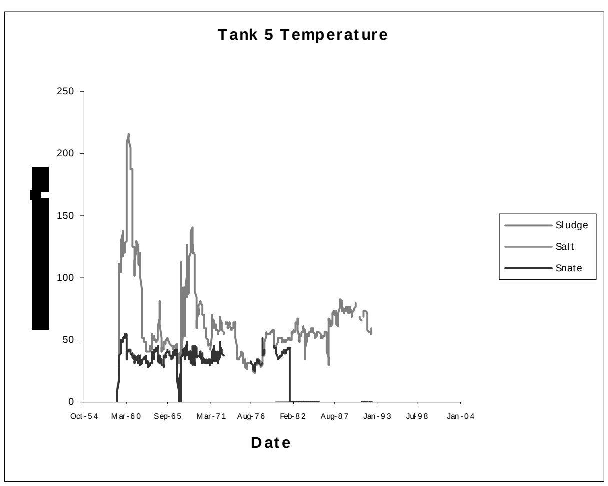
APPENDIX 1: TEMPERATURE DATA

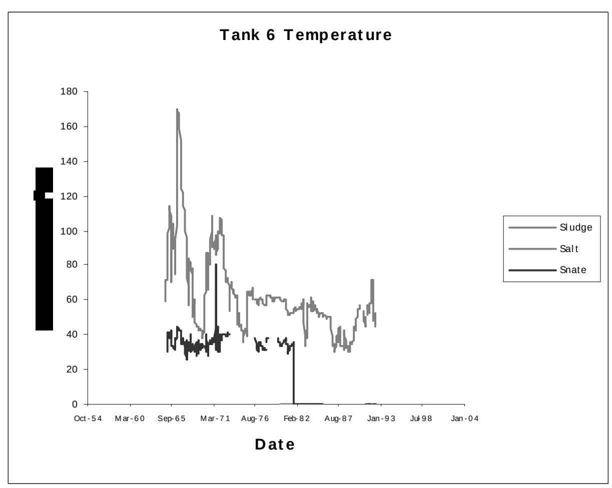


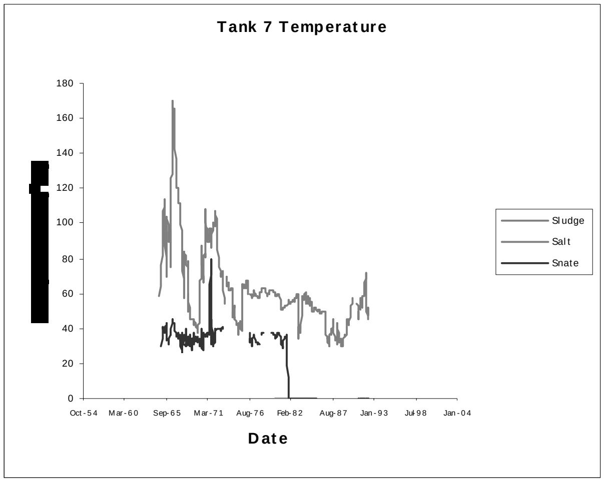








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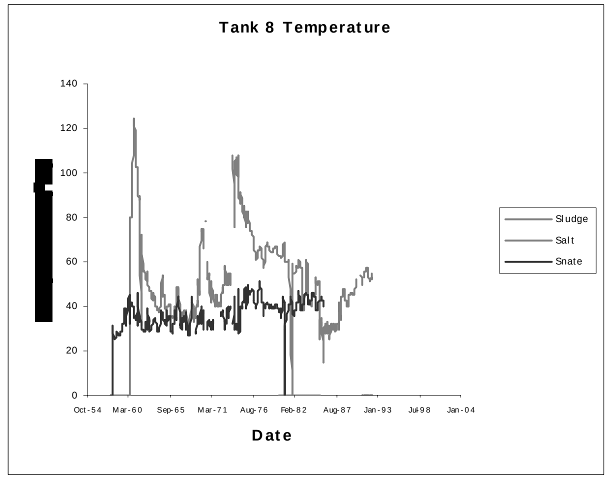
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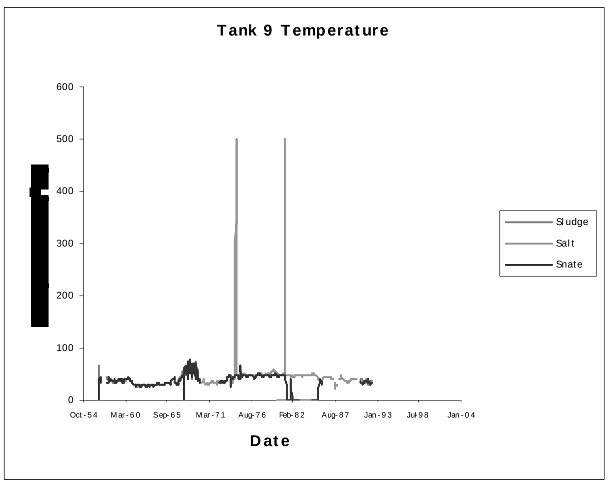
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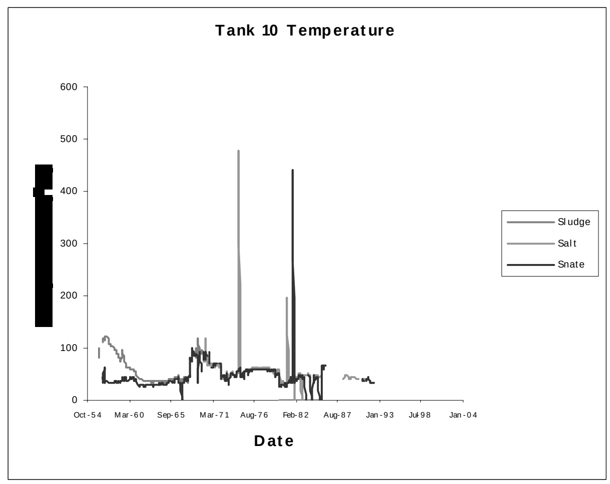
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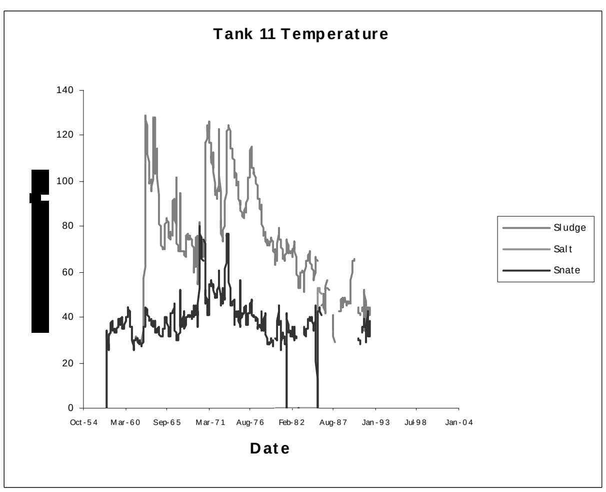
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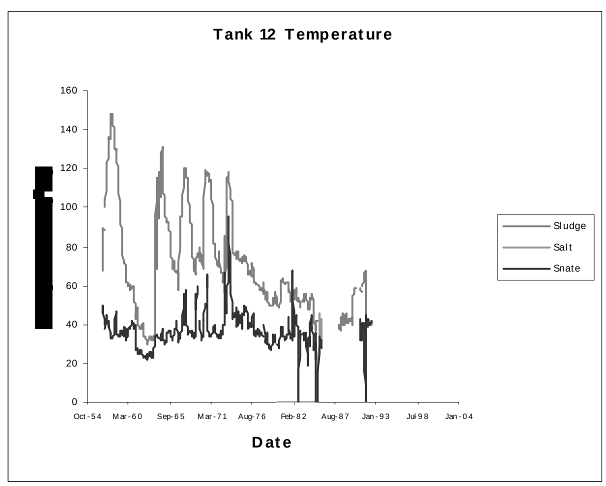
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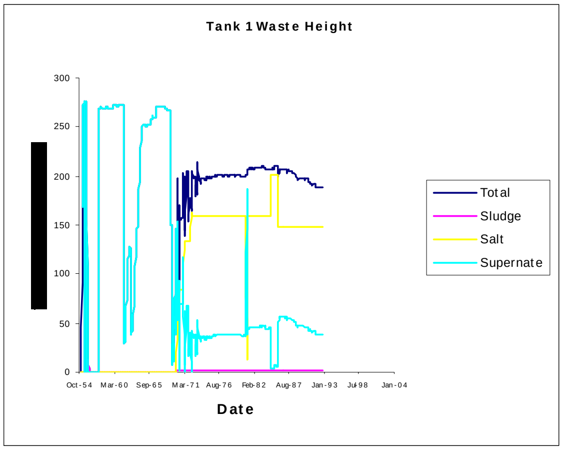
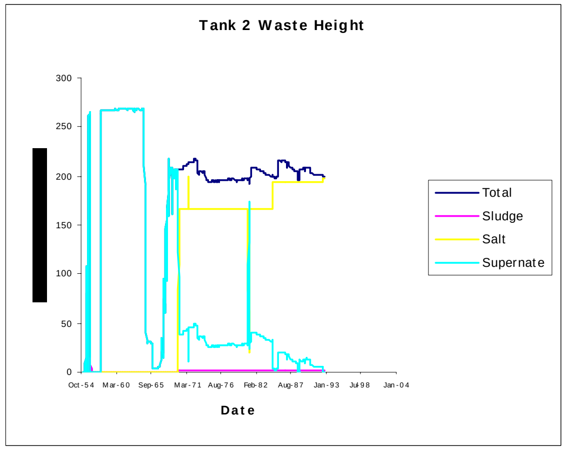
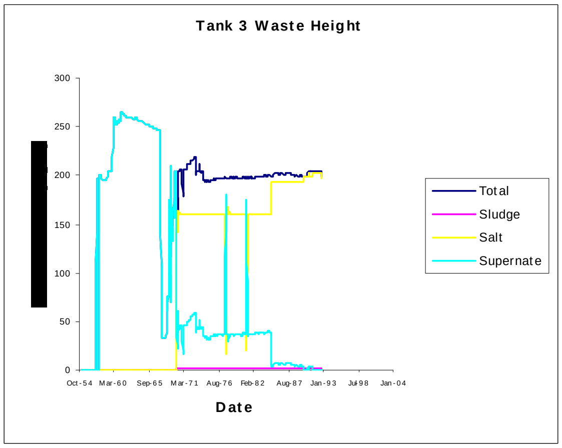
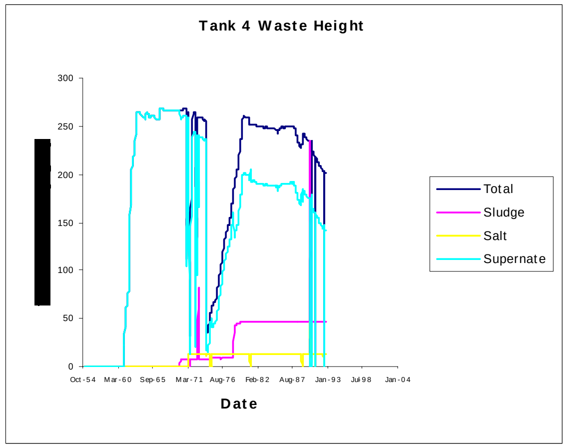
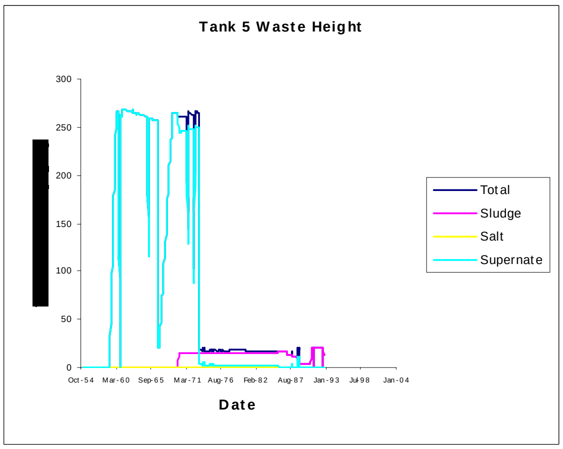
APPENDIX 2: WASTE LEVELS

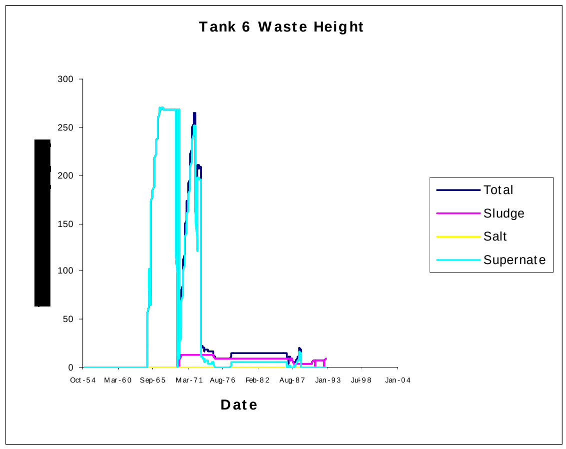


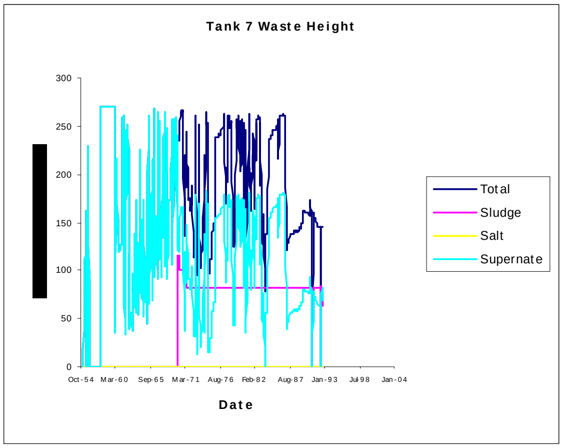


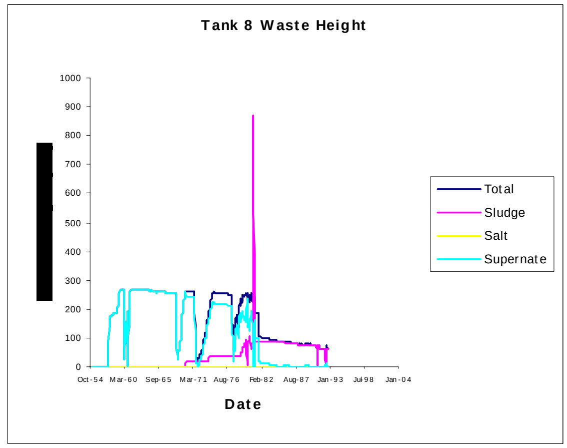









Tank 7 Waste Height
[redacted]
0
50
100
150
200
250
300
Oct-54 Mar-60 Sep-65 Mar-71 Aug-76 Feb-82 Aug-87 Jan-93 Jul-98 Jan-04
Date
Total
Sludge
Salt
Supernate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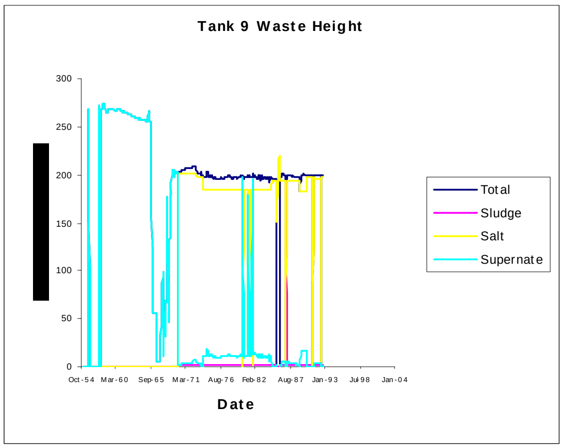
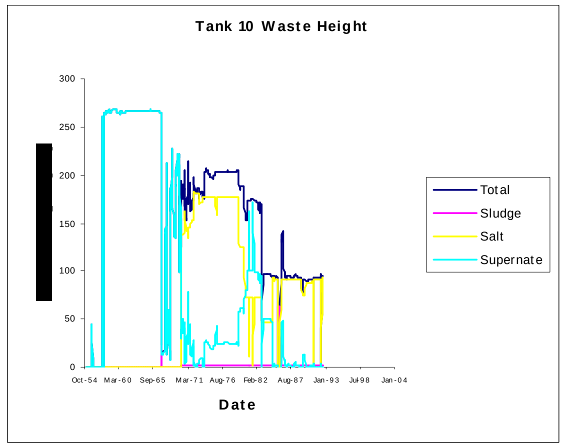
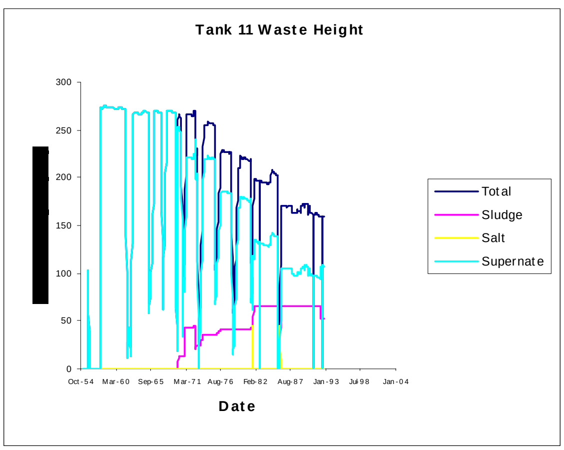
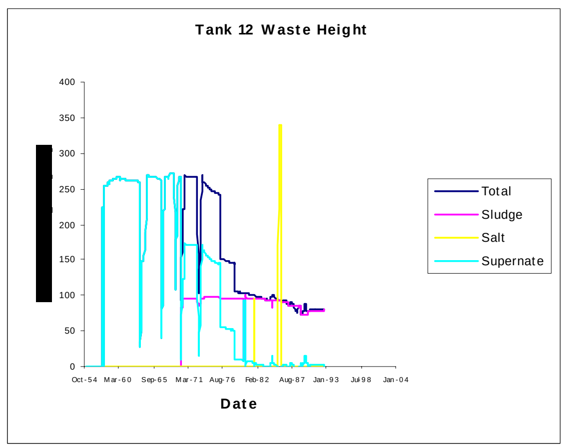
[redacted]
0
100
200
300
400
500
600
700
800
900
1000
Oct-54 Mar-60 Sep-65 Mar-71 Aug-76 Feb-82 Aug-87 Jan-93 Jul-98 Jan-04
Date
Total
Sludge
Salt
Supernate


Tank 9 Waste Height
[redacted]
0
50
100
150
200
250
300
Oct-54 Mar-60 Sep-65 Mar-71 Aug-76 Feb-82 Aug-87 Jan-93 Jul-98 Jan-04
Date
Total
Sludge
Salt
Supernate


Tank 10 Waste Height
[redacted]
0
50
100
150
200
250
300
Oct-54 Mar-60 Sep-65 Mar-71 Aug-76 Feb-82 Aug-87 Jan-93 Jul-98 Jan-04
Date
Total
Sludge
Salt
Supernate


Tank 11 Waste Height
[redacted]
0
50
100
150
200
250
300
Oct-54 Mar-60 Sep-65 Mar-71 Aug-76 Feb-82 Aug-87 Jan-93 Jul-98 Jan-04
Date
Total
Sludge
Salt
Supernate

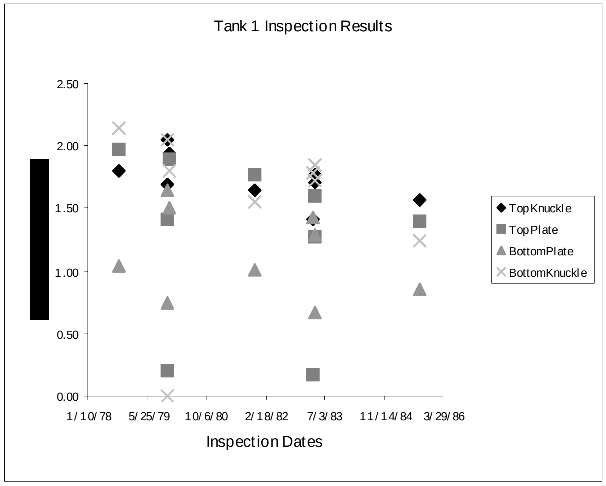

Tank 12 Waste Height
[redacted]
0
50
100
150
200
250
300
350
400
Oct-54 Mar-60 Sep-65 Mar-71 Aug-76 Feb-82 Aug-87 Jan-93 Jul-98 Jan-04
Date
Total
Sludge
Salt
Supernate

APPENDIX 3: UT INSPECTION DATA – CORROSION RATE (MPY)

Tank	Riser	Inspection Dates	Top Knuckle	Top Plate	Bottom Plate	Bottom Knuckle
1	*East*	11/20/79	2.05	1.41	0.75	2.04
	East	4/18/83	1.76	1.27	0.66	1.72
	West	9/22/78	1.81	1.97	1.04	2.14
	West	11/19/81	1.65	1.77	1.01	1.56
	West	9/11/85	1.56	1.39	0.86	1.25
	North	11/26/79	1.94	1.89	1.51	1.80
	North	4/5/83	1.70	1.60	1.29	1.85
	South	11/20/79	1.70	0.21	1.65	N/A
	South	4/3/83	1.41	0.17	1.42	1.79
2	*East*	5/16/73	3.51	1.80	1.46	2.98
	East	10/31/77	2.50	1.13	0.83	2.39
	East	11/19/81	2.19	1.08	0.98	1.88
	East	4/17/85	1.88	0.89	0.90	1.47
	West	5/15/73	2.88	2.20	2.65	2.35
	West	11/16/77	1.67	1.68	2.03	2.77
	West	11/18/81	2.08	1.53	1.79	1.94
	West	4/18/85	1.83	1.53	1.66	1.70
	South	5/15/73	3.14	1.71	1.97	3.66
	South	10/31/77	2.48	1.18	1.12	2.77
	South	11/17/81	2.01	0.85	0.86	1.96
	South	4/17/85	1.71	0.80	0.90	1.68
3	*East*	7/3/73	3.81	1.43	2.98	3.68
	East	11/9/77	2.86	0.93	1.72	2.30
	East	11/17/81	2.23	0.76	1.30	1.66
	East	4/24/85	1.92	1.00	1.50	1.42
	West	7/9/73	3.23	2.48	2.99	2.64
	West	11/10/77	2.89	1.01	2.21	2.74
	West	11/16/81	2.31	0.85	1.92	2.04
	West	7/24/85	1.81	1.06	1.22	1.66
	South	7/13/73	3.36	2.09	3.25	2.60
	South	11/9/77	2.73	1.51	2.66	3.56
	South	11/16/81	2.14	1.24	2.14	2.40
	South	4/21/85	1.70	1.12	1.88	1.92
	North	7/19/73	3.73	2.42	4.01	3.39
	North	11/9/77	2.61	1.60	2.92	2.68
4	*East*	7/5/73	4.46	2.67	4.32	3.99
	East	11/1/77	2.86	1.45	2.63	2.77
	East	6/19/81	2.52	1.46	2.21	2.31
	East	5/6/85	2.10	1.11	1.86	2.08
	West	9/19/73	4.63	3.20	2.27	4.52
	West	11/6/77	3.13	2.14	1.29	3.50
	West	7/27/81	2.47	1.78	1.33	2.38
	West	6/17/85	1.99	1.32	1.05	1.95
	South	9/10/73	5.29	3.41	2.59	5.15
	South	8/5/81	2.65	1.50	1.00	3.05

Tank	Riser	Inspection Dates	Top Knuckle	Top Plate	Bottom Plate	Bottom Knuckle
	South	6/14/85	1.79	1.44	0.80	2.54
	North	9/17/73	3.97	3.20	1.62	4.95
	North	11/1/77	2.07	2.18	0.94	3.03
	North	7/28/81	2.03	1.84	0.92	2.78
	North	6/26/85	1.66	1.47	0.69	2.18
5	*East*	5/9/73	3.47	2.27	2.26	3.56
	East	11/15/77	2.84	1.63	1.97	3.00
	East	5/9/81	2.40	1.40	1.80	2.64
	East	6/25/85	2.19	1.12	1.40	2.19
	West	3/21/73	3.43	1.34	1.91	4.78
	West	11/8/77	2.00	1.07	1.55	2.94
	West	6/9/81	2.36	0.97	1.18	3.14
	West	6/11/85	1.97	0.76	0.86	2.64
	South	5/9/73	4.29	1.78	4.15	4.43
	South	5/1/77	3.17	1.37	3.12	3.15
	South	6/4/81	2.49	0.95	2.62	2.61
	South	6/21/85	2.10	0.78	2.21	2.20
	North	4/4/73	4.11	2.67	3.37	4.97
	North	11/8/77	N/A	2.02	2.69	3.52
	North	6/17/81	2.47	1.51	1.94	2.69
6	*East*	1/16/74	6.14	3.77	3.15	6.20
	East	7/12/78	3.43	2.58	1.61	4.31
	East	6/18/81	3.50	2.20	1.35	3.41
	East	4/17/85	2.86	1.80	1.07	2.70
	West	2/22/74	5.50	4.35	5.42	3.12
	West	6/17/81	3.17	2.40	3.12	3.12
	West	4/16/85	2.56	1.83	2.45	2.37
	South	11/9/79	3.47	1.57	2.73	0.00
	South	6/19/81	3.13	1.48	2.57	3.17
	South	4/17/85	2.66	1.18	2.08	2.57
	North	11/1/77	4.12	1.14	2.12	0.00
	North	6/18/81	2.99	1.04	1.91	3.35
	North	4/10/85	2.54	0.82	1.47	2.61
7	*West*	2/13/74	4.18	4.39	5.50	5.38
	West	11/13/79	2.20	2.03	1.94	2.67
	West	7/9/83	2.38	2.17	1.49	0.00
	South	8/5/81	5.05	3.82	3.28	5.83
	South	2/12/74	1.85	1.16	1.27	0.00
	North	8/4/81	2.45	1.51	1.62	2.04
	North	7/10/85	1.85	1.16	1.27	0.00
8	*East*	11/1/77	2.39	1.43	1.69	2.45
	East	7/29/81	1.33	0.93	1.08	2.09
	East	3/27/85	1.39	0.87	1.04	1.81
	West	8/16/73	3.53	1.84	2.97	2.59
	West	11/3/77	2.63	1.20	2.22	3.18
	West	7/30/81	2.14	0.99	1.90	1.42
	West	3/20/85	1.07	0.73	1.48	0.76

Tank	Riser	Inspection Dates	Top Knuckle	Top Plate	Bottom Plate	Bottom Knuckle
	South	8/21/73	3.26	2.03	2.69	4.26
	South	11/7/77	2.42	1.35	1.95	2.96
	South	3/20/81	1.92	1.18	1.69	1.70
	South	3/25/81	1.63	0.97	1.37	1.26
	North	8/20/73	4.24	2.01	2.52	3.94
	North	11/3/77	3.11	1.19	1.67	2.53
	North	7/30/81	2.35	1.06	1.42	2.23
	North	3/25/85	1.87	1.00	1.22	1.79
9	*West*	11/21/79	0.00	1.25	1.19	1.97
	West	4/18/83	1.74	1.21	1.14	1.88
10	*East*	11/16/79	1.91	0.78	1.69	2.07
	East	4/7/83	1.62	0.84	1.46	1.93
	West	11/19/79	2.09	0.82	1.09	2.01
	West	4/7/83	1.85	0.79	1.10	1.97
	North	11/19/79	2.06	1.89	1.71	1.97
	North	4/13/83	1.89	1.66	1.16	1.63
11	*East*	2/2/73	3.26	2.50	3.39	3.38
	East	8/5/81	2.00	1.89	1.87	0.00
	South	3/20/73	3.12	1.68	1.75	2.63
	South	12/2/77	2.30	1.49	1.86	2.62
	South	8/5/81	2.03	1.25	1.56	2.20
12	*East*	12/3/81	2.42	2.22	2.42	2.24
	East	5/25/83	0.00	2.03	2.18	2.04
	East	4/17/85	2.16	1.88	1.72	2.18
	East	8/19/81	2.28	2.13	2.29	2.13
	West	1/29/73	3.26	1.29	2.01	3.23
	West	8/10/81	1.47	1.14	1.31	1.69
	West	11/20/81	2.41	2.36	2.58	2.27
	West	4/3/85	1.19	0.99	1.18	1.42
	West	11/29/77	2.48	1.38	1.65	2.38
	South	8/13/81	2.10	1.74	1.27	2.42
	North	12/5/77	2.04	0.55	0.85	2.31
	North	4/2/85	1.79	1.36	1.08	1.99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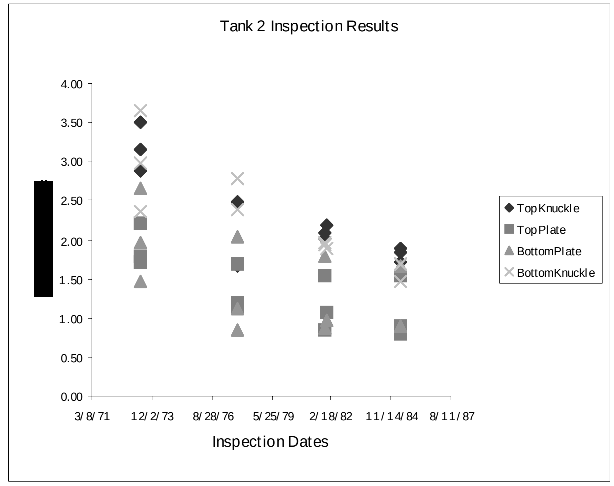
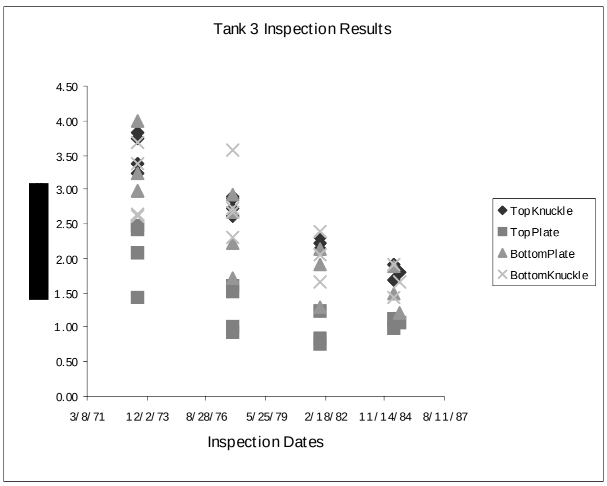
2.50
2.00
1.50
1.00
0.50
0.00
1/10/78
5/25/79
10/6/80
2/18/82
7/3/83
11/14/84
3/29/86
Inspection Dates
TopKnuckle
TopPlate
BottomPlate
BottomKnuckle


Tank 2 Inspection Results
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
3/8/71
12/2/73
8/28/76
5/25/79
2/18/82
11/14/84
8/11/87
Inspection Dates
TopKnuckle
TopPlate
BottomPlate
BottomKnuckle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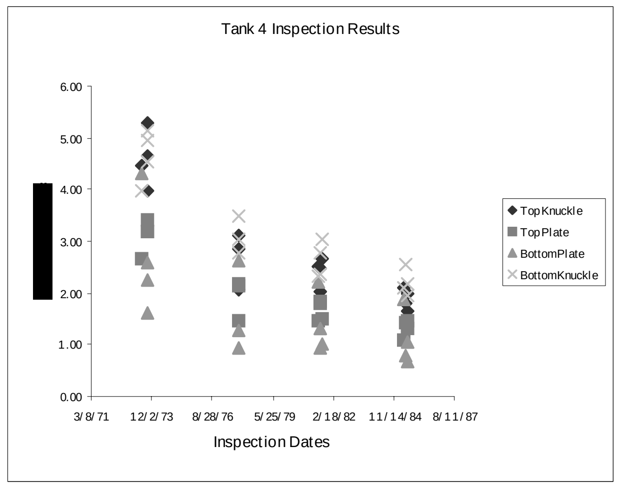
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
3/8/71
12/2/73
8/28/76
5/25/79
2/18/82
11/14/84
8/11/87
Inspection Dates
TopKnuckle
TopPlate
BottomPlate
BottomKnuckle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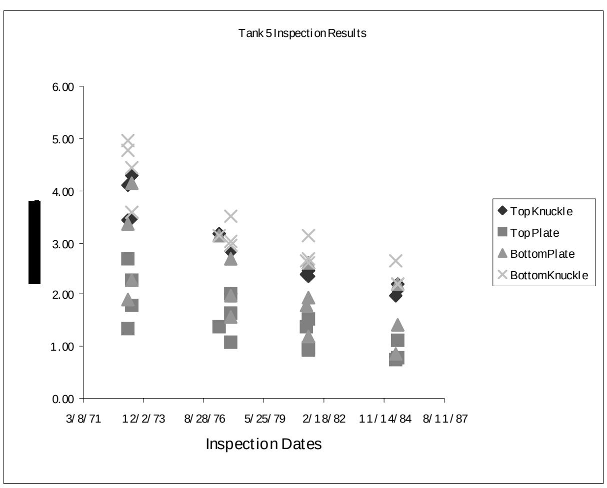
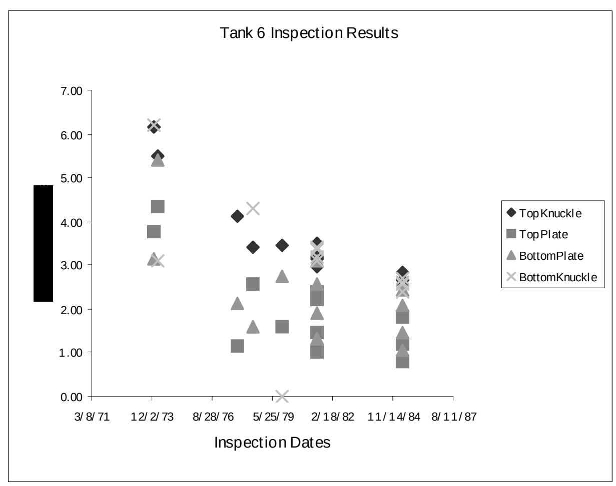
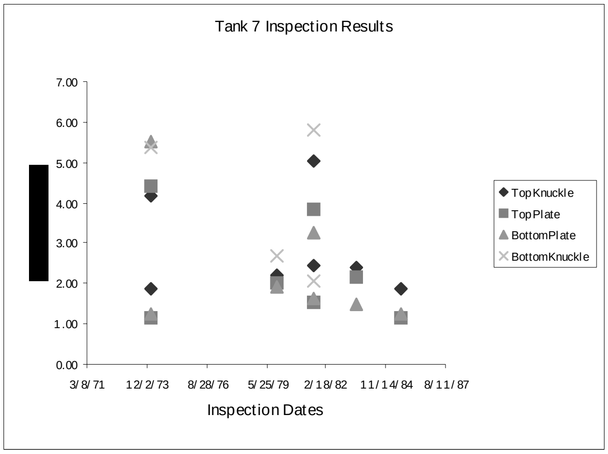
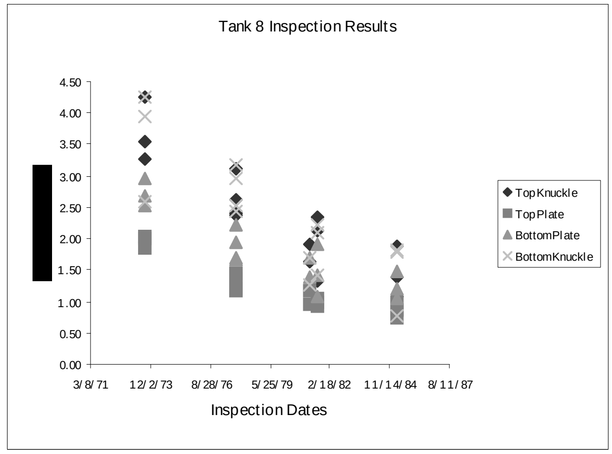
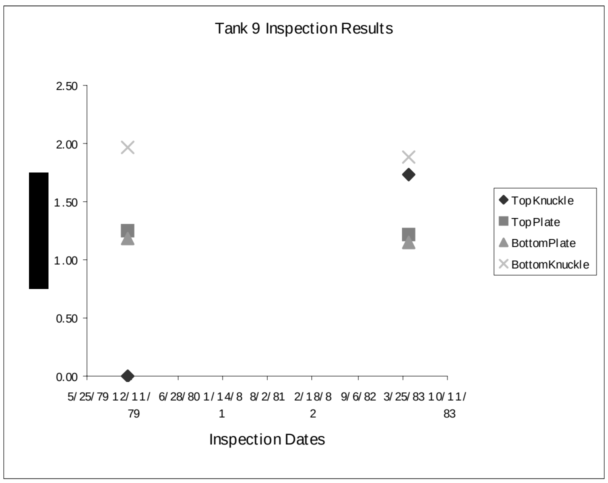
6.00
5.00
4.00
3.00
2.00
1.00
0.00
3/8/71
12/2/73
8/28/76
5/25/79
2/18/82
11/14/84
8/11/87
Inspection Dates
TopKnuckle
TopPlate
BottomPlate
BottomKnuckle

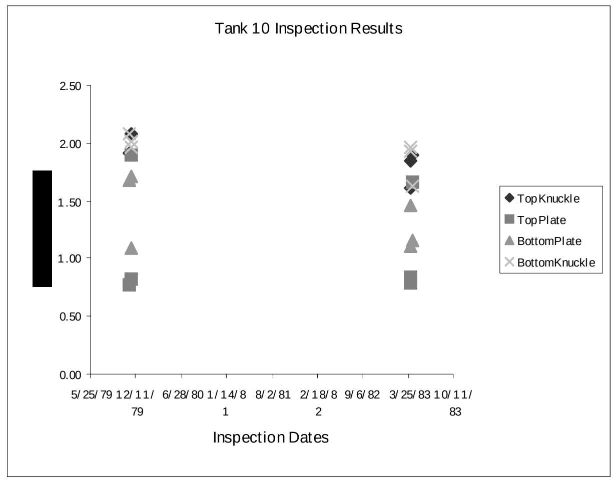

Tank 5 Inspection Results
6.00
5.00
4.00
3.00
2.00
1.00
0.00
3/8/71
12/2/73
8/28/76
5/25/79
2/18/82
11/14/84
8/11/87
Inspection Dates
TopKnuckle
TopPlate
BottomPlate
BottomKnuckle

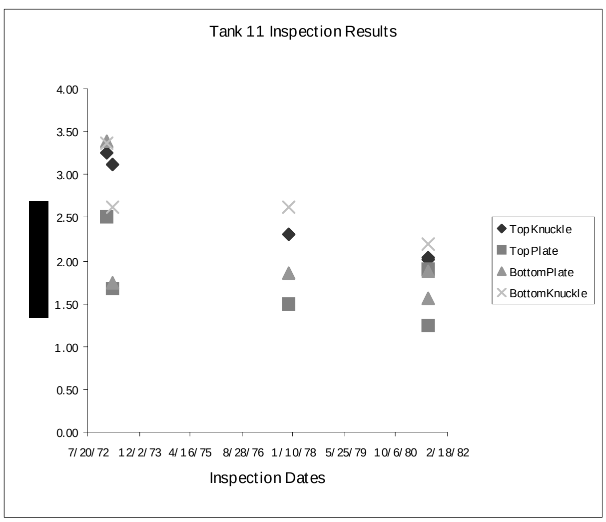

Tank 6 Inspection Results
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
3/8/71
12/2/73
8/28/76
5/25/79
2/18/82
11/14/84
8/11/87
Inspection Dates
TopKnuckle
TopPlate
BottomPlate
BottomKnuckle

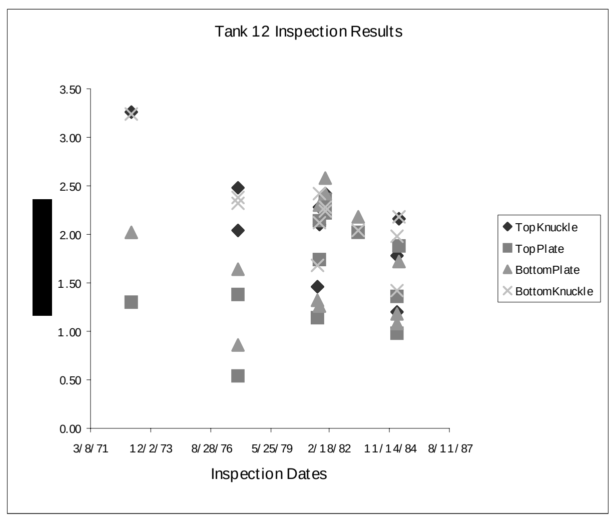

Tank 7 Inspection Results
[redacted]
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
3/8/71
12/2/73
8/28/76
5/25/79
2/18/82
11/14/84
8/11/87
Inspection Dates
TopKnuckle
TopPlate
BottomPlate
BottomKnuckle


Tank 8 Inspection Results
[redacted]
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
3/8/71
12/2/73
8/28/76
5/25/79
2/18/82
11/14/84
8/11/87
Inspection Dates
TopKnuckle
TopPlate
BottomPlate
BottomKnuckle


Tank 9 Inspection Results
[redacted]
0.00
0.50
1.00
1.50
2.00
2.50
5/25/79
12/11/79
6/28/80
1/14/81
8/2/81
2/18/82
9/6/82
3/25/83
10/11/83
Inspection Dates
TopKnuckle
TopPlate
BottomPlate
BottomKnuckle


Tank 10 Inspection Results
[redacted]
0.00
0.50
1.00
1.50
2.00
2.50
5/25/79
12/11/79
6/28/80
1/14/81
8/2/81
2/18/82
9/6/82
3/25/83
10/11/83
Inspection Dates
TopKnuckle
TopPlate
BottomPlate
BottomKnuckle


Tank 11 Inspection Results
[redacted]
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
7/20/72
12/2/73
4/16/75
8/28/76
1/10/78
5/25/79
10/6/80
2/18/82
Inspection Dates
TopKnuckle
TopPlate
BottomPlate
BottomKnuckle


Tank 12 Inspection Results
[redacted]
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
3/8/71
12/2/73
8/28/76
5/25/79
2/18/82
11/14/84
8/11/87
Inspection Dates
TopKnuckle
TopPlate
BottomPlate
BottomKnuckle