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7. Abstract On January 24, 1992, while transfer line SL-119 in 241-S Tank Farm was being pressure tested, water was observed flowing out of a Heat-Trace splice box. This study is to determine the cause of the failure.		
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S TANK FARM SL-119 SALTWELL PIPING FAILURE ANALYSIS

SEPTEMBER 1993

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System Structural Integrity Assessments

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WESTINGHOUSE HANFORD COMPANY
for the
U.S. Department of Energy
Richland Field Office (RL)

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Reviewer J. R. Divine, Phd. P.E.

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☒	☐	☐	Task objective clearly stated.
☐	☐	☒	The proper alloys are selected for testing.
☐	☐	☒	The stated task will accomplish the objective clearly.
☐	☐	☒	Corrosion tests modes being evaluated are appropriate.
☐	☐	☒	Test methods are satisfactory.
☐	☐	☒	Test temperature is appropriate.
☐	☐	☒	Test solutions are pertinent.
☐	☐	☒	Test matrix is acceptable.
☒	☐	☐	Test standards are sufficient.
☒	☐	☐	Test criteria are acceptable.
☒	☐	☐	Test criteria are sufficient.
☒	☐	☐	Test acceptance criteria are stated clearly.
☐	☐	☒	Test period is acceptable for scoping or screening test.
☒	☐	☐	Test specimens are acceptable and appropriate.
☒	☐	☐	Test specimen preparation is sufficient.
☐	☐	☒	The number of test specimens is sufficient.
☒	☐	☐	Test is sufficiently quantitative.
☒	☐	☐	The Quality Control level is sufficient.
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12 Oct 97

CONTENTS

1.0 INTRODUCTION	1
2.0 SUMMARY	1
3.0 BACKGROUND	2
3.1 DESIGN	2
3.2 HEAT TRACING	2
3.3 CATHODIC PROTECTION	3
3.4 PRESSURE TESTING	3
3.5 LEAK LOCATION	4
3.6 SOIL (EXTERNAL) ENVIRONMENT	4
3.7 MICROBIOLOGICAL INFLUENCED CORROSION	4
3.8 WASTE (INTERNAL) ENVIRONMENT	4
4.0 PAST PIPE FAILURES IN S TANK FARM	5
5.0 RESULTS OF THE FIELD INSPECTION	5
6.0 PACIFIC NORTHWEST LABORATORY ANALYSIS	7
7.0 CONCLUSIONS	8
8.0 RECOMMENDATIONS	9
9.0 REFERENCES	31

LIST OF FIGURES

1. View of the Hydrotest Leak Area Looking West.	10
2. Sketch of Hydrotest Leak Area	11
3. View of the Hydrotest Leak Area Looking North.	12
4. Close-Up View of Leak Area Looking West — Directly in Line with Piping	13
5. Looking East at the Leak Area	14
6. Clean Out Boxes 9 (SL-119) and 10 (SL-220) Located Just West of the Leak Area	15
7. Utility Station Cover Located About 3 m (10 ft) North of the Leak Area	16
8. The Interior (Cover Removed) of the Utility Station Shown in Figure 7	17
9. Heat Tracing Box J-A, at the Leak Site, Looking North	18
10. Looking Inside of Heat Tracing Box J-A	19
11. Cross Section of Buried Lines	20
12. Excavation of the Leak Area Looking South	21
13. Looking Down on the Piping After the Insulation has been Removed	22
14. A Piece of Polyurethane Foam After Removal.	23
15. A Piece of Bubble Wrap After Removal from Piping	24
16. Looking Down at the Top of the SL-119 Line After the Bubble Wrap Was Removed	25
17. A Close-Up of the SL-119 Line	26
18. Two Holes in the Top of the SL-119 Line	27

LIST OF FIGURES (cont.)

19. Views of the SL-119 Line (Top) and the SL-120 Line (Bottom)	28
20. View of the S Tank Farm Failure Excavation Showing the SL-119 Line (on the Left), the SL-120 Line, and Vertical Heat Tracing Conduits	29
21. The SL-120 Line on the Left and the SL-119 Line on the Right	30

LIST OF TERMS

ASTM	American Society for Testing and Materials
COB	clean out box
EMT	electric metallic tubing
MIC	microbiological influenced corrosion
NACE	National Association of Corrosion Engineers
NEMA	National Electrical Manufacturing Association
PNL	Pacific Northwest Laboratory
SN	Supernate Line
SL	Slurry Line
SRB	Sulfate-Reducing Bacteria

S TANK FARM SL-119 SALTWELL PIPING FAILURE ANALYSIS

1.0 INTRODUCTION

On January 24, 1992, while pressure testing saltwell line SL-119 in the 241-S Tank Farm, water was observed spraying out of heat trace enclosure. The SL-115, SL-116, SN-215, and SN-216 saltwell lines also recently failed pressure testing because of leaks.

This study documents the pertinent facts about the SL-119 line and discusses the cause of the failures.

2.0 SUMMARY

The inspection of the SL-119 failure revealed two through-the-wall holes in the top center of the pipeline. The inspection also strongly suggests that the heat tracing system is directly responsible for causing the SL-119 failure. Poor design of the heat tracing system allowed water to enter, condense, and collect in the electric metallic tubing (EMT) carbon steel conduits. Water flowed to the bottom of the elbow of the conduit and corroded out the elbow. The design also allowed drifting desert sand to enter into the conduit and fall to the bottom (elbow) of the conduit. The sand became wet and aided in the corrosion of the elbow of the conduit. After the EMT conduits corroded though, the water dripped from the corroded ends of the EMT conduits onto the top of the saltwell pipe, corroding the two holes into the top of the line.

If the heat tracing hot splice box had not allowed moisture to enter the EMT conduits, the saltwell piping would not have corroded and caused SL-119 to fail.

3.0 BACKGROUND

3.1 DESIGN

The S Tank Farm was built in 1943 (GE 1949) and saltwell piping was added in 1972, as part of the 242-S Evaporator Facility construction (Vitro 1972b). The Saltwell lines discussed in this report, SL-115, SL-116, SL-119, SN-215, and SN-216, were all installed under the 1972 project, HAP 655. The lines were all built to the Hanford piping code M-25 which allows a maximum operating temperature of 330°F and a maximum allowable operating pressure of 375 psig for slurry lines (SL) and 230 psig for supernate lines (SN). The pipe materials for these lines are schedule 40 carbon steel, American Society for Testing and Materials (ASTM) A53, type S, grade B or ASTM A-106, grade B6 (Vitro 1972b).

The SL-119 line runs the 70-m (200-ft) distance from the 241-S-A valve pit to the 241-S-103 tank. The 2 in.-diameter line is buried about 0.91 M (3 ft) below grade and slopes back to the tank.

It is also surrounded with polyurethane foam insulation and is located about 20.32 cm (8 in.) below 1.9-cm (3/4-in.) thick copper ammonia-arsenic treated plywood. The piping is also wrapped with plastic "bubble wrap" used to create voids around the piping to allow for its expansion and contraction caused by changing temperatures.

3.2 HEAT TRACING

Heat tracing of the saltwell piping was provided to heat the waste in the piping, because the waste tends to solidify if it cools. Note 6 on HAP-655 drawing H-21-46187 (Vitro 1972e) shows the heat trace cables are in 1.27 cm (0.5 in.) EMT (carbon steel) conduit.

Drawing H-2-46159 (Vitro 1972a), shows the piping was electrically heat traced when it was built in 1972. According to the supplier, Thermon¹ Manufacturing Company, the S Tank Farm saltwell piping is the first electrical heat tracing installation at the Hanford Site (Thermon 1972). The heat tracing was used until 1980 when it was shut off. It had operated at a temperature of about 82 °C (180 °F). The high temperature limit was, and is, set at 121 °C (250 °F). Thus, the heat tracing operated hot much of the time. This explains the charred black appearance of the polyurethane insulation around the pipe and the poor condition of the bubble wrap.

Because of the relationship of the heat tracing hot splice box to the SL-119 pipe failure, some background on the heat trace splice box is presented here. The electrical heat

¹ Thermon is a registered trademark of Thermon Manufacturing Company.

trace plan, drawing H-2-46159 (Vitro 1972c), shows that the SL-119 line is heat traced and the heat trace box located at the leak site is identified as "J-A." J-A is described in the symbol list as "hot splice (pull point) wireway." Drawing H-2-46160 (Vitro 1972d), references detail 4 and "HC" which are described as heat trace cables. The detail shows the two hot section heater lengths running between the hot splice junction box and the process pipe. Detail 4 is included in Appendix C.

3.3 CATHODIC PROTECTION

Cathodic protection was provided on the piping to reduce external corrosion. Drawing H-2-1778 (GE 1951) shows that the piping in the S Tank Farm was cathodically protected in 1951. In 1977, a report (ARHCO 1977) on the S Tank Farm cathodic protection system found the system to be in poor condition and recommended the system be replaced. The cathodic protection system was turned off in the 200 West Area in October 1980 and abandoned in place (Carlos 1992).

The S Tank Farm saltwell piping was not included in the new cathodic protection upgrade, Project B234, designed in 1980, because the saltwell lines were to be temporary. They are still not cathodically protected.

3.4 PRESSURE TESTING

Pressure testing of the lines is performed to determine if the lines leak. Leaks were discovered during pressure testing of the lines. The document, OSD-T-151-00010, Rev C-3, *Operating Specification for Pressure Checking of All Direct Buried Transfer Lines and Cross-Site Lines* (WHC 1983), governs the test. The test variables for saltwell lines and specification limits are; minimum test pressure is 150 psig, the maximum test pressure is 225 psig, the testing time is 30 minutes. The acceptance criteria is 0% pressure drop in 30 minutes in piping without valves and less than 5% pressure drop in 30 minutes in piping with valves.

The following information is from the Occurrence Report (Garrett 1992):

On 1/24/92, at 0955 hours, while conducting a hydrostatic pressure test of underground waste transfer lines (SL-119) in the 241-S Tank Farm, water was heard draining into a 241-S valve pit. The pressure test was immediately stopped and contamination surveys in the area of the discharge indicated no discernable contamination levels above background.

On 1/24/92 at 1005 hours, personnel observed a small pool of water on the ground in the vicinity of the SL-119 transfer line. The water dissipated shortly after. Health

Physics personnel surveyed the area once the water had been absorbed and found no contamination levels above background level.

The SL-119 saltwell line was previously pressure tested when it was built in 1973. There are records of additional pressure tests on January 6, 1978; June 16, 1978; February 20, 1979; May 23, 1979; September 21, 1979; December 21, 1979; and May 9, 1980. It was also being pressure tested on January 24, 1992 when it failed. There is no documentation or suggestion that the SL-119 line was pressure tested or used between 1981 and 1992. Thus, the SL-119 lined failed after 1980. Copies of the pressure test data sheets are included in Appendix B.

3.5 LEAK LOCATION

The leak on the SL-119 line occurred directly under the J-A heat tracing hot splice box enclosure located at grade.

3.6 SOIL (EXTERNAL) ENVIRONMENT

The SL-119 line is coated with coal-tar epoxy, then wrapped in plastic bubble wrap, and then totally encased in polyurethane foam. The soil around the line is typical high resistivity gravel, 42,000 ohm-cm (Hanford Formation). The polyurethane foam is of continuous monocell, noninterconnecting structure. Thus, the carbon steel line is well isolated from the soil and soil corrosion. The vertical EMT conduits, running from the heat tracing hot splice box to the SL-119 line, are subject to soil corrosion between grade and the polyurethane foam.

3.7 MICROBIOLOGICAL INFLUENCED CORROSION

Historically, microbiological-influenced corrosion (MIC) has been found in soils on the Hanford Site. The documented account, by F. J. Mollerus (Carlos 1992), determined that MIC, caused by sulfate-reducing bacteria (SRB), attacked direct buried stainless steel piping before 1948. This MIC is prevented by cathodically protecting the lines.

MIC on the SL-119 line was not directly addressed by testing the soils around the SL-119 line for SRB. The corrosion on the line did not look like the MIC attack described by Mollerus and the WHC laboratory cannot test for SRB.

3.8 WASTE (INTERNAL) ENVIRONMENT

Starting in 1953 and ending in 1973, most of the tanks in the S Tank Farm received and stored Reduction Oxidation Plant waste. Most of the S Tank Farm tanks received waste

until 1979 and 1980 when they all became inactive. All of the S Tank Farm single-shell tanks are still sound, except the 241-S-104 tank (Anderson 1990). Jet pumped drainable interstitial/supernatant waste periodically flowed through the SL-119 saltwell line from the 241-S-103 tank until 1980. Some of the tanks were partially interim isolated in 1980 and 1984 (Hanlon 1992). Additional information is supplied in Appendix D.

4.0 PAST PIPE FAILURES IN S TANK FARM

The SL-176 slurry line, connecting the 241-S-152 diversion box with the 241-SY-B valve pit, failed on October 29, 1980. The failure analysis concluded, the pipe failed from an oxide inclusion in the pipe material, and not from external soil or internal liquid corrosion (Bendixsen 1980).

The SL-114 slurry line leaked on February 26, 1980. No failure analysis was performed and it was abandoned (Sexton 1980).

The SL-113, SL-114, and SL-126 lines leaked. An investigation was performed by Battelle Columbus Laboratories (Payer 1980). No details of the failures are in the report, but the failures were blamed on stray currents.

5.0 RESULTS OF THE FIELD INSPECTION

The SL-119 field inspection took place the weeks during October 1992. The berm was excavated down to the pipe and the inspection performed in accordance with the inspection plan. The results are as follows.

A photograph was taken of the leak site before it was excavated and the operators who performed the hydrostatic test explained where the leaking water came from and where it went. The leaking water came out from under a 15 cm by 15 cm by 91 cm (6 in. by 6 in. by 36 in.) long National Electrical Manufacturing Association (NEMA) 3-R heat tracing hot splice box enclosure, identified on drawing H-2-46159 (Vitro 1972c) as J-A. Figure 1 shows the site before it was excavated. Figure 2 is a sketch of the picture in Figure 1, and shows the heat tracing hot splicing box, the leak location, and where the puddle formed. The leaking water ran down the berm in the south direction, turned north in the low area of the S Tank Farm, and formed a puddle. Based on this information the hole was excavated into the berm on top of line SL-119 and next to the heat tracing hot splice Box J-A. Figures 3, 4, and 5 also show the leak site before excavation.

Visual inspection of the clean out boxes (COB) 9 and 10 showed that they were both filled with sand to the top of the COB and thus gave no information of the underground piping. Figure 6 shows the interiors of COBs 9 and 10.

Figures 7 and 8 show the cover and the interior of the utility station located about 3 (10 ft) north of the leak site.

Figure 9 is a close-up of the heat tracing hot splice box J-A.

Figure 10 shows the inside of the heat tracing hot splice box J-A. Note the two electrical wires and conducts entering the bottoms of the splice box from each buried pipe. Note the ends of the EMT conduits in the enclosure are open to the atmosphere.

Figure 11 is a sketch of a cross section of buried lines showing the configuration of the underground piping. It is detail D-D on drawing H-2-46188. It also shows a typical cross section of a heat traced transfer line. It is detail H-H on drawing H-2-46160.

Figure 12 shows the excavation down to the top of the polyurethane foam insulation. Note the lack of any cracks or breaks in the surface of the insulation. It should also be noted that there was little radiation contamination at this location in the excavation. Note the insulation is intact.

Figure 13 shows a worker removing the polyurethane foam insulation. Note the insulation was chopped out with a tool that resembled an ice chopper. In the photograph the SL-119 line is the left horizontal pipe. The SL-120 line is the right horizontal pipe. At this level the SL-119 line had a surface radiation reading of 100 mR/h and the SL-120 line had a surface radiation reading of 300 mR/h. After the SL-120 line was exposed it was shielded with lead and not inspected.

Figure 14 shows a photograph of the insulation removed from the top of the pipe, which laid on the heat tracing. Note its charred appearance.

Figure 15 shows the bubble wrap that was removed from the pipe. Note that it is charred and has lost its integrity.

Figure 16 is a photograph of the SL-119 line, looking directly down, after the bubble wrap was removed. Note the bubble impressions left in the coating on the pipe. The heat tracing wires and heat tracing conduit are still in place on the line. Figure 17 is a close-up of the same area as Figure 16. The heat tracing wires were cut and spliced out of service by the electricians. The heat tracing conduit on the failed line was removed. Radiation levels were still low. Inspection of the pipe at this location by operations indicated no failure.

The excavation was dug a few feet north under the heat tracing hot splice box. The radiation level exceeded 25,000 counts/sec and indicated a leak site. The entire area under the heat tracing hot splice box was excavated. Exposure of the SL-119 lines showed two

2.54-cm (1-in.) holes, spaced about 2.54 cm (1 in.) apart, in the top of the SL-119 line directly under the heat tracing hot splice box, exactly where the two vertical electrical conduits run through the polyurethane foam insulation and between the heat tracing hot splice box and the SL-119 line. The bottom ends of the electrical conduits were completely corroded away. The heat tracing wires are intact and the heat tracing wire insulation was not degraded. Figure 18 shows the two holes in the SL-119 line.

Figure 19 shows the two holes in the SL-119 line, the corroded ends of the heat tracing conduits that once ran down to the SL-119 line, the heat tracing wires running out of the ends of the corroded heat tracing conduits, the SL-120 line and the two heat tracing conduits running down to the SL-120 line.

Figure 20 shows another view of the heat tracing conduits running down to the SL-120 line and all of the conduits running up to the heat tracing hot splice box J-A. Exposure of the SL-120 line shows the two vertical electrical conduits intact and no holes in the line under the heat tracing conduits.

Figure 21 shows another view of the excavation and the vertical heat tracing conduits running into the bottom of the heat tracing splice box J-A.

Ultrasonic wall measurements were not performed in the field because the surface of the pipe was not cleaned. Wall thickness, outer diameter, and interior measurements were performed by Pacific Northwest Laboratory (PNL) under laboratory conditions. At PNL the pipe was cleaned and then cut for photographic and metallurgical examination. The PNL report is in Appendix A.

Soil samples were taken in the S Tank Farm at the excavation location, about 27.94 cm (11 in.) deep.

6.0 PACIFIC NORTHWEST LABORATORY ANALYSIS

A 61-cm (24-in.) long section of SL-119, which included the failure, was sent to PNL for cleaning, measuring, visual inspecting, photographing, metallurgical examining, and documenting. PNL was directed to determine if the corrosion was general or local in nature, from the inside or outside of the pipe, and the condition of the uncorroded section. PNL's results are stated in Section 7.

7.0 CONCLUSIONS

The conclusions are based on both the PNL analysis and the field visual inspection.

The visual inspection was performed in the field under full respirator mask (limited visibility and high radiation and limited inspection time). The conclusions are as follows.

- Because the two corroded holes on top of the SL-119 line are directly under the two corroded ends of the vertical heat tracing conduits from heat tracing splice box J-A, it is concluded that the heat tracing conduits directly caused the local corrosion, the holes, in the SL-119 line. It is even more convincing when compared to the SL-120 line, 0.3 m (1 ft) away from the SL-119 line in similar environment, and from the same heat tracing splice box - J-A since its two vertical heat tracing conduits on the SL-120 line are not corroded and there are no holes under the heat tracing conduits on the top of the SL-120 line.
- It is postulated that water, probably from rain, snow, or condensate, ran down the two heat tracing conduits, most likely in the last 10 years when the heat tracing was electrically turned off. The water corroded through the heat tracing carbon steel conduits. After the water corroded through the conduits it dripped from the ends of the conduits on to the SL-119 carbon steel line and corroded the two holes in the top of it.
- Drifting desert sand also entered the NEMA 3-R enclosure heat tracing splice box and fell into the EMT conduit. It fell to the bottom of the vertical conduit. It absorbed the water and probably remained continuously wet. Thus, the bottom of the EMT conduit corroded the fastest.
- Physical measurements, by PNL, of the outer diameter, inner diameter and wall thickness on the corroded section of the SL-119 pipe shows most of the corrosion occurred on the outer side of the pipe. Visual inspection of the outer and inner surfaces of the SL-119 pipe shows little corrosion on the inner surface and pitting indentations on the outer surface.
- Hardness tests on the uncorroded sections of the SL-119 line, taken by PNL, indicates the strength of the uncorroded metal is similar to those in a section of new M-25 ASTM A53 pipe. Thus, the uncorroded section of the old pipe is as strong as the new pipe.
- Metallurgical examination of the microstructure, by PNL, of an uncorroded section of the SL-119 line shows it is similar to the microstructure in a section of new M-25 ASTM A53 pipe.

- Corrosion products (rust), X-ray analyzed by PNL, found inside of the SL-119 line contained salts similar to those in the corrosion products found outside of the SL-119 line and are probably from the same source. Thus, the rust found inside the line was not caused by the waste.
- The failure of the SL-119 line is a result of local corrosion and is not general in nature. Thus, the SL-119 line can be repaired and reused. A new 61-cm (24-in.) length of 5-cm (2-in.) ASTM A53 schedule pipe can be welded into the space left in the SL-119 line where the failed 61-cm (24-in.) length was removed.

8.0 RECOMMENDATIONS

Electrical wiring enclosures should not be at grade level. The location of the of the heat trace hot splice boxes at grade allows the drifting sand to enter the boxes. Boxes, similar to the heat trace control enclosures, located 0.91 m (3 ft) higher, have much less sand in them.

NEMA 3-R enclosures specified for the heat trace hot splice box are unacceptable. IEEE Std 515 (IEEE 1989), the recommended national standard for electrical heat tracing now recommends NEMA 4 minimum enclosures.

EMT conduits, which run between the heat tracing enclosures and the buried transfer piping, must have closed (sealed) ends where they terminate in the heat trace enclosures.

The heat tracing on buried lines should be left on all the time. If the heat tracing had been left on, the heat generated would have evaporated the water and the corrosion might not have taken place.

Flushing and pressure testing of the lines should be performed with inhibited water only. Water for pressure testing and flushing should be inhibited per the Hanford Waste Tank Corrosion Specification (Kirch 1984).

Figure 1. View of the Hydrotest Leak Area Looking West.

Figure 2. Sketch of Hydrotest Leak Area.

Figure 3. View of the Hydrotest Leak Area Looking North.

Figure 4. Close-Up View of Leak Area Looking West —
Directly in Line with Piping.

Figure 5. Looking East at the Leak Area.

Figure 6. Clean Out Boxes 9 (SL-119) and 10 (SL-220)
Located Just West of the Leak Area.

Figure 7. Utility Station Cover Located About
3 m (10 ft) North of the Leak Area.

Figure 8. The Interior (Cover Removed) of the
Utility Station Shown in Figure 7.

Figure 9. Heat Tracing Box J-A, at the Leak Site, Looking North.
(The leak came out from underneath the
heat tracing splice box.)

Figure 10. Looking Inside of Heat Tracing Box J-A.

Figure 11. Cross Section of Buried Lines.

Section D-D
(H-2-46188)

Section H-H
(H-2-46160)

Figure 12. Excavation of the Leak Area Looking South.

Figure 13. Looking Down on the Piping After the
Insulation has been Removed.

Figure 14. A Piece of Polyurethane Foam After Removal.
(Note the charred appearance where it laid
on the heat traced piping.)

Figure 15. A Piece of Bubble Wrap After Removal from Piping.

Figure 16. Looking Down at the Top of the SL-119 Line After
the Bubble Wrap Was Removed.

Figure 17. A Close-Up of the SL-119 Line
(same Area as Figure 16.)

Figure 18. Two Holes in the Top of the SL-119 Line.

Figure 19. Views of the SL-119 Line (Top) and the SL-120 Line (Bottom).

Figure 20. View of the S Tank Farm Failure Excavation Showing the SL-119 Line (on the Left), the SL-120 Line, and Vertical Heat Tracing Conduits.

Figure 21. The SL-120 Line on the Left and the SL-119 Line
on the Right. (Note the heat tracing wires
look in good condition.)

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APPENDIX A
PACIFIC NORTHWEST LABORATORY'S
SL-119 REPORT

Report on the Investigation of Corroded Pipe SL119-A

J. L. Brimhall and S. G. Pitman
Pacific Northwest Laboratory

I. Introduction

A steel pipe, buried for about 19 years and unused for an unknown number of years, leaked severely when repressurized. A badly corroded region of pipe was discovered and a section about 2 feet long was removed. As the pipe had been used for a radioactive waste line, the cut pipe was sent to the hot cell facilities in the radio-metallurgical laboratory for examination. After an initial photographic examination, tests were performed to determine the type and manner of corrosion and to determine the quality of the underlying, uncorroded metal. These included measurements of the pipe dimensions, metallographic examination, hardness measurements of remaining metal, and SEM examination of the corrosion products. Metallographic and hardness evaluation of new pipe of the same type was also done.

II. Test Results

For purposes of future discussion, a schematic of the pipe sections is shown in Figure 1. This illustrates the regions of the pipe from which the various tests or test specimens were taken.

a) Macro Observations

Initial observations revealed severe corrosion in the center region of the cut-out sections, Figure 2. The pipe was completely corroded through at two places leaving two large holes. As a result of the handling, with the accompanying crumbling, the holes are not particularly obvious in Figure 2. The severity of corrosion, as evidenced by surface appearance, diminished near the cut ends. The cut ends of the pipe are shown in Figures 3 and 4 with the west cut end showing a less corroded condition. For comparison, the opposite (corroded) ends

Figure 1. Sketch of PNL Pipe Identification Scheme Illustrating Regions from Which Measurements were Taken

SL119 - B (TOP EAST)

SL119 - A (TOP WEST)

3 2 1

Figure 2. As-Received Sections of Corroded Pipe

A-4

SL119 - A (TOP WEST)

Figure 3. West Cut End Section of Corroded pipe

SL119 - B (TOP EAST)

Figure 4. East Cut End Section of Corroded Pipe

SL119 - A (TOP WEST)

Figure 5. Opposite End (Corroded End) of West Pipe Section

SL119 - B (TOP EAST)

Figure 6. Opposite End (Corroded End) of East Pipe Section

of the pipe sections are shown in Figures 5 and 6.

b) Dimensional Measurements

Measurements of the inner and outer diameter and wall thickness were taken along the length of the better of the cut sections (west cut end). Three measurements of the outer and inner diameter were taken around the circumference. Measurements were taken along the length of the pipe every inch. (Refer to Figure 1 for the location of these measurements.) The results are shown in Figure 7 which shows the average diameter as a function of the distance along the length of pipe as measured from the cut end.

Figure 7. Variation in Outer and Inner Diameter of Corroded Pipe as a Function of the Distance from the West Cut End.

The data show that the inner diameter remains relatively constant whereas the outer diameter is gradually decreasing. For comparison purposes, Schedule 40 pipe is given in the ASTM standards as 2.375 OD and 2.067 ID and these values

are shown as the dotted line in Figure 7. According to Figure 7, the measured ID is close to this value but the OD is considerably less.

Independent measurements of the wall thickness were taken at positions of 1 inch and 5 inches from the west cut end section of the pipe. The values given in Table I show a significant decrease in wall thickness as the distance from the good cut end increases. Because of the more severe corrosion of the east section, wall thickness measurements were only taken near the cut end. These are also shown in the table and indicate that the wall thickness at this point was about the same as the worst of the west section. The minimum wall thickness specified in the standards is also given. At the west cut end, the wall thickness exceeds this specification for most of the circumference, whereas 5 inches in from the cut end, the wall thickness does not meet the specification at any place.

TABLE I. Wall Thickness Measurements on Corroded Pipe

Position on Circumference	Wall Thickness at West Cut End (in.)		Wall Thickness East Cut End (in.)	Standard Minimum Wall Thickness (in.)
	@ 1 in.	@ 5 in.	@ 1 in.	
0°	.116	.100	.095	0.135
60°	.130	.095	.105	0.135
120°	.148	.107	.130	0.135
180°	.142	.097	.100	0.135
240°	.138	.084	.087	0.135
300°	.130	.095	.087	0.135

c) Metallographic Examination

Four pieces taken at 90° intervals around the circumference were extracted from the best portion of pipe and metallographically polished for microstructural and

Figure 8. Polished cross-section of pipe wall showing corrosion layer on outer and inner surface. Two separate regions around circumference shown. 37X

Pipe Wall
Outer Surface

1117-0

Pipe Wall
Inner Surface

1117-0

Figure 9. High magnification of corrosion layers on the outer and inner surface of corroded pipe. 175X

hardness determination. Typical as-polished cross sections are shown in Figures 8 and 9. It was apparent that corrosion was more severe at the exterior or outer diameter of the pipe than at the inner surface. However, there was still some corrosion on the inner surface. The remaining metal appears to be very sound with no evidence of cracking or other manifestation of interior corrosion.

The polished samples were subsequently etched to reveal the grain structure. The etched microstructure consists of ferrite and pearlite grains, typical of a plain carbon steel, Figure 10. There is no evidence of corrosion penetrating along grain boundaries, Figure 10a. This microstructure can be compared with that taken from a new piece of pipe of the same type A53 steel as shown in Figure 11. There is no significant difference between the microstructures. The grain size of the new steel appears to be slightly larger than that of the corroded pipe. These observations indicate that the unoxidized portion of the pipe should still have the structural properties of a new steel.

e) Hardness

Microhardness measurements were made on the metallographic specimens extracted from the good west cut end. The values given in Table II represent an average of five readings taken on each extracted specimen. The hardness values have been converted to ultimate strength values using the conversion table in the ASM Metals Handbook. Also shown in Table II are the hardness values taken on sections extracted from a new piece of pipe, ASTM type A53, which is the same steel type as the corroded pipe. The ultimate tensile strength of the new pipe deduced from the hardness values is very close to the measured values of 73600 and 74900 psi quoted in the specification sheet. The strength for the corroded pipe appears to be somewhat greater than the new pipe but still within 10%. These observations are consistent with the metallographic analysis which showed very little difference between the corroded and virgin pipe. The small differences observed can be attributed to changes in processing technology over the last 20 years as well as different suppliers.

(a)

(b)

Figure 10. Etched microstructure of corroded pipe. a) At outer surface showing no penetration of corrosion layer into base metal. b) Microstructure at the center of the pipe wall. 200X

Figure 11. Microstructure of New Type A53 Steel Pipe. 200X

Table II. Hardness Values for Corroded and New Steel Pipe

Specimens Extracted from West Cut End of Corroded Pipe		
<u>Section #</u>	<u>Avg VHN</u>	<u>Approx UTS (psi)</u>
1	164	82000
2	168	83000
3	155	77000
4	159	80000
Specimens Extracted from New Pipe, ASTM A53 Steel		
1	155	76000
2	154	73000
3	146	70000
4	145	69500

d) X-ray analysis in the SEM

The polished but unetched samples were also analyzed for chemical composition in the SEM. The corrosion product at the outer surface showed only iron and oxygen peaks. Based on the relative ratios of the iron and oxygen x-ray peaks, the phases were Fe_2O_3 and Fe_3O_4 . The two oxides are revealed as light and dark grey areas in the SEM photograph in Figure 12. The same oxides were observed at the inner surface. However, there were small amounts of other elements present at the inner surface. Trace amounts of aluminum, calcium, chlorine, magnesium, chromium and phosphorous were observed in the x-ray spectra, although not all areas showed all of these elements. In most cases, the amount of the element did not exceed 1%. These elements could be residue from the waste stream. The origin of the iron oxide on the inner surface therefore could arise from water that migrated along the surface after the pipe had corroded through or from water in the waste stream.

Figure 12. SEM micrograph of corrosion layer on outer surface. Both Fe_2O_3 and Fe_3O_4 were identified in the layer.

III. Discussion and Conclusions

Although the photographs show severely corroded pipe, the corrosion was in fact quite localized and the pipe is basically sound beyond this localized region. Based on the observations, corrosion started on the outer surface of the pipe, presumably as a result of water leaking through the insulation, and spread along the surface of the pipe from the initial point of contact. Although corrosion was severe enough at the initiation point to completely perforate the pipe, the severity of corrosion diminished with distance from the initiation region. The interior corrosion could have resulted from water migrating along the inner surface after the pipe had corroded completely through. Waste liquid that was originally transported in the pipe however could also have caused corrosion on the inner surface. This latter speculation is supported by the fact that there appeared to be no variation in corrosion along the pipe length at the inner diameter compared to the outer diameter. The interface between the oxide corrosion layer and base metal was very distinct and there was no evidence of corrosion into the base metal along grain boundaries. The evidence indicates that the underlying base metal is still sound and should retain its original qualities. This is supported by the comparison of the hardness measurements and metallographic comparison of the corroded pipe and a new piece of pipe of the same type. The following conclusions can be made based on these observations:

- The corrosion was localized and the remaining pipe will have adequate strength as long as the residual wall thickness is within specifications.
- The variation in corrosion was not measurable at the east cut end but the outer diameter of the pipe is a reliable indication of the remaining wall thickness. When the outer diameter approaches the original specifications, there is assurance that the pipe is in good condition and the wall thickness is within specifications

APPENDIX B

**HISTORICAL SL-119 LINE
PRESSURE TEST DATASHEETS**

Done
6-16-79

DATA SHEET
PRESSURE CHECK OF SUPERNATANT
TRANSFER LINE

2-23-79
WHC-SD-WM-ANAL-014
Rev. 0

Transfer Line No. SL-119

Low elevation nozzle B

Box/Pit ~~SE-75~~ 103 S Pit

High elevation nozzle L-7

Box/Pit SA PIT

Preliminary checks completed per instructions A.3. []

Heat trace power off: Date 2-8-79 Time _____

Specified check pressure 200-220 psig.

Pumps locked and tagged out Date 2-15-79 Time _____ Pump B PB-2

Pressure check gage serial no. I-192

calibration date 1-18-79

range 0 to 300 psi

Rupture disc.
Pressure relief valve serial no. 54944

calibration date _____

psi setting 250

Supervisor's signature J E Perham Date 2-20-79

<u>Time</u>	<u>Pressure (psig)</u>	<u>Date</u>	<u>Time</u>	<u>Pressure</u>	<u>Date</u>
<u>1430</u>	<u>205</u>	<u>2-21-79</u>	_____	_____	_____
<u>1440</u>	<u>205</u>	<u>2-21-79</u>	_____	_____	_____
<i>REARM</i> <u>1448</u>	<u>212</u>	<u>2-21-79</u>	_____	_____	_____
<u>1458</u>	<u>209</u>	<u>2-21-79</u>	_____	_____	_____
<u>1518</u>	<u>205</u>	<u>2-21-79</u>	_____	_____	_____

Heat trace power on Date 2-21-79 Time 1530 Initials JEP

Note: Do not use sanitary water for pressure testing. Fire hydrants with "S" supply sanitary water.

Transfer line approved for use J E Perham
Y Supervisor

Pressure test failed. Required
notifications made.

Supervisor

Sign one *Report*
Feb
2-29-79
osm

B-2

DATE ISSUED	REVIEW BY	SUPERSEDES DATE ISSUED	PAGE	SOP NO
<u>JAN 5 1979</u>	<u>1-5-84</u>	<u>2-7-77</u>	<u>11</u> of <u>11</u>	<u>300.16</u>

DATA SHEET
PRESSURE CHECK OF SUPERNATANT
TRANSFER LINE

Rev. 0

Transfer Line No. SL #119

Low elevation nozzle 2

Box/Pit 403 S

High elevation nozzle L-7

Box/Pit SA

Preliminary checks completed per instructions A.3. [☒]

Heat trace power off: Date 5-19-79 Time 11:00

Specified check pressure 200-220 psig.

Pumps locked and tagged out Date 5-21-79 Time 0830 Pump 1035

Pressure check gage serial no. ~~5-9-79~~

calibration date 5-9-79

range 0-300

Pressure relief valve serial no. RUPTURE DISK TYPE ZAP

calibration date N/A

psi setting 250

Supervisor's signature [Signature]

Date 5-23-79

Time	Pressure (psig)	Date	Time	Pressure	Date
1420	211#	5/22/79	1506	212#	5/22/79
1432	183#	5/22/79	1516	198#	5/22/79
1438	210#	"	1026	210#	5/23/79
1445	194#	"	1036	209#	5/23/79
1452	208#	"	1036	205#	5/23/79
1502	195#	"			

Heat trace power on Date _____ Time _____ Initials _____

Note: Do not use sanitary water for pressure testing. Fire hydrants with "S" supply sanitary water.

Transfer line approved for use

Supervisor

5/23/79

Pressure test failed. Required notifications made.

Sign one

Supervisor

Other data was obtained by George Henmore - OC Rep. [Signature]

B-3

DATE ISSUED	REVIEW BY	SUPERSEDES DATE ISSUED	PAGE	TOP NO
JAN 5 1979	1-5-84	2-7-77	11 of 11	IO-140-170

DATA SHEET
PRESSURE CHECK OF SUPERNATANT
TRANSFER LINE

9-25-79

Transfer Line No. SL 119

Low elevation nozzle 5

Box/Pit 1-2-5

High elevation nozzle 2-7

Box/Pit 1-11-5

Preliminary checks completed per instructions A.3. []

Heat trace power off: Date 9-21-79 Time

Specified check pressure psig.

Pumps locked and tagged out Date 9-21-79 Time Pump

Pressure check gage serial no. 6-300

calibration date 1-21-80

range 0-300

Pressure relief valve serial no. 5235

calibration date

psi setting

Supervisor's signature [Signature] Date 9-21-79

Time	Pressure (psig)	Date	Time	Pressure	Date
	<u>211</u>	<u>9-21-79</u>		<u>211</u>	<u>9-21-79</u>
<u>1034</u>	<u>206</u>	<u>9-21-79</u>		<u>206</u>	<u>9-21-79</u>
<u>1114</u>	<u>202</u>	<u>9-21-79</u>		<u>202</u>	<u>9-21-79</u>

Heat trace power on Date 9-21-79 Time 1337 Initials [Signature]

Note: Do not use sanitary water for pressure testing. Fire hydrants with "S" supply sanitary water.

Transfer line approved for use [Signature]
Supervisor

Sign one

Pressure test failed. Required notifications made.

Supervisor

DATA SHEET
PRESSURE CHECK OF SUPERNATANT
TRANSFER LINE

WHC-SD-WM-ANAL-014
Rev. 0

1-1-80
JCM

Transfer Line No. SL-119

Low elevation nozzle B

Box/Pit 103-S

High elevation nozzle L-7

Box/Pit SA-PIT

Preliminary checks completed per instructions A.3. [☒]

Heat trace power off: Date 12-14-79 Time 0900

Specified check pressure 200-220 psig.

Pumps locked and tagged out Date 11-21-79 Time 0930 Pump 103-S

Pressure check gage serial no. PG-73

107-S
106-S

calibration date 1-1-80

range 0-300

Pressure relief valve serial no. 1-32-AP

calibration date NA

psi setting 240

Supervisor's signature R. S. Rodriguez Date 12-21-79

<u>Time</u>	<u>Pressure (psig)</u>	<u>Date</u>	<u>Time</u>	<u>Pressure</u>	<u>Date</u>
<u>208</u>	<u>1056</u>	<u>12-21-79</u>	<u>1326</u>	<u>211</u>	<u>12-21-79</u>
<u>203</u>	<u>1106</u>	<u>12-21-79</u>			
<u>1306</u>	<u>213</u>	<u>12-21-79</u>			
<u>1316</u>	<u>212</u>	<u>12-21-79</u>			

Heat trace power on Date _____ Time _____ Initials _____

Note: Do not use sanitary water for pressure testing. Fire hydrants with "S" supply sanitary water.

Transfer line approved for use R. S. Rodriguez
Supervisor

Pressure test failed. Required
notifications made.

Sign one

Supervisor

B-5

<u>Release Date</u>	<u>Date Expires</u>	<u>Procedure No.</u>	<u>Revision</u>	
Jan 5, 1979	Jan. 5, 1984	TO-140-170	A-1	11 - 11

DATA SHEET
PRESSURE CHECK OF SUPERNATANT
TRANSFER LINE

WHC-SD-WM-ANAL-014
Rev. 0

Good until 8/9/80 ocm

Transfer Line No. ~~SL-119~~ SL-119

Low elevation nozzle B

Box/Pit 103-S SL-119

High elevation nozzle L-7

Box/Pit SA

Preliminary checks completed per instructions A.3. [☒]

Heat trace power off: Date N/A Time N/A

Specified check pressure 550-570 psig.

Pumps locked and tagged out Date N/A Time N/A Pump N/A

Pressure check gage serial no. N/A

calibration date 11/80 due date

range 0-1000

Pressure relief valve serial no. FH

calibration date 5/5/80

psi setting 680

Supervisor's signature [Signature] Date 5/9/80

Time	Pressure (psig)	Date	Time	Pressure	Date
<u>14:07</u>	<u>558</u>	<u>5-9-80</u>	_____	_____	_____
<u>14:37</u>	<u>545</u>	<u>5-9-80</u>	_____	_____	_____
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____

*417
555
558*

Heat trace power on Date N/A Time N/A Initials [Signature]

Note: Do not use sanitary water for pressure testing. Fire hydrants with "S" supply sanitary water.

Transfer line approved for use [Signature] 5/9/80
Supervisor

Pressure test failed. Required notifications made.

Sign one

Supervisor

DATA SHEET
PRESSURE CHECK OF ST W TRANSFER LINE

Transfer Line No. # 119

Low elevation nozzle B NOZZLE

Box/Pit 103 S Pump Pit

High elevation nozzle L-7

Box/Pit SF VALVE PIT

Preliminary checks completed per instructions A.3. [✓]
Heat trace power off: Date 9/8/78 Time 1430
Specified check pressure 200-220 psig.

Pumps locked and tagged out Date N/A Time _____ Pump _____

Pressure check gage serial no. NONE
calibration date 7-17-78
range 0-300

Pressure relief valve serial no. 5000
calibration date NONE
psi setting 150

Supervisor's signature Frank Green Date 9/24/78

Time	Pressure (psig)	Date	Time	Pressure	Date
	<u>201</u>	<u>9-29-78</u>			

Heat trace power on Date _____ Time _____ Initials _____

Note: Do not use sanitary water for pressure testing. Fire hydrants with "S" supply sanitary water.

Transfer line approved for use _____
Supervisor

Pressure test failed. Required _____ Sign one
notifications made. Supervisor

B-7

DATE ISSUED	REVIEW BY	SUPERSEDES DATE ISSUED	PAGE	POP NO
2-7-77	2-1-79	9-21-76	11 of 11	300.16

DATA SHEET
PRESSURE CHECK OF SUPERNATANT
TRANSFER LINE

pen

Transfer Line No. SL -119

Low elevation nozzle B-N02

Box/Pit 103-S Pump PLT

High elevation nozzle L-7

Box/Pit 241-A-VALVE PIT

Preliminary checks completed per instructions A.3. []

Heat trace power off: Date 6-12-78 Time 0900

Specified check pressure 200-320 psig.

Pumps locked and tagged out Date 6-15-78 Time 0900 Pump 103-S

Pressure check gage serial no. N/A

calibration date 5-8-78

range 0-600

Rupture disc
Pressure relief valve serial no. 52359

calibration date N/A

psi setting 250

Supervisor's signature J E Perham Date 6-16-78

Time	Pressure (psig)	Date	Time	Pressure	Date
<u>1041</u>	<u>208</u>	<u>6-16</u>	_____	_____	_____
<u>1051</u>	<u>195</u>	<u>6-16</u>	_____	_____	_____
<u>1052</u>	<u>220</u>	<u>6-16</u>	_____	_____	_____
<u>1102</u>	<u>218</u>	<u>6-16</u>	_____	_____	_____
<u>1125</u>	<u>215</u>	<u>6-16</u>	_____	_____	_____

Heat trace power on Date 6-16-78 Time 1130 Initials JEP

Note: Do not use sanitary water for pressure testing. Fire hydrants with "S" supply sanitary water.

Transfer line approved for use J E Perham
Supervisor

Pressure test failed. Required notifications made.

Sign one

Supervisor

B-8

ISSUED	REVIEW BY	SUPERSEDES DATE ISSUED	PAGE	SOP NO
<u>7-77</u>	<u>2-1-79</u>	<u>9-21-76</u>	<u>11</u>	<u>309-10</u>

Monthly

DATA SHEET
PRESSURE CHECK OF SUPERNATANT
TRANSFER LINE

WHC-SD-WM-ANAL-014
Rev. 0

1-11-78

Transfer Line No. 54-119

Low elevation nozzle "B"

Box/Pit 103-S

High elevation nozzle 4-7

Box/Pit 5-A Tube Pit

Preliminary checks completed per instructions A.3. []

Heat trace power off: Date _____ Time _____

Specified check pressure 200 psig.

Pumps locked and tagged out Date 1-6-78 Time 0900 Pump 103-S

Pressure check gage serial no. NONE

calibration date 8-15-77

range 0-300

Pressure relief valve serial no. 52359

calibration date _____

psi setting 250

Supervisor's signature J. B. Skinner Date 1-6-78

<u>Time</u>	<u>Pressure (psig)</u>	<u>Date</u>	<u>Time</u>	<u>Pressure</u>	<u>Date</u>
<u>1307</u>	<u>200</u>	<u>1-6-78</u>	_____	_____	_____
<u>1322</u>	<u>197</u>	<u>"</u>	_____	_____	_____
<u>1337</u>	<u>199.5</u>	<u>"</u>	_____	_____	_____
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____

Heat trace power on Date 1-6-78 Time 1310 Initials JS

Note: Do not use sanitary water for pressure testing. Fire hydrants with "S" supply sanitary water.

Transfer line approved for use J. B. Skinner
Supervisor

Pressure test failed. Required
notifications made.

Sign one

Supervisor

B-9

<u>DATE ISSUED</u>	<u>REVIEW BY</u>	<u>SUPERSEDES DATE ISSUED</u>	<u>PAGE</u>	<u>SOP NO</u>
<u>2-7-77</u>	<u>2-1-79</u>	<u>9-21-76</u>	<u>11</u> of <u>11</u>	<u>300.16</u>

APPENDIX C
INFORMATION AND DATA

PIPING INSPECTION FORM

Date: Oct. 5, 1992

Report Number: _____

Number and Name of Line: SL-119 Slurry line, Drawing No. H-2-46188

Location of Pipe: S Tank Farm, Direction of Pipe: East-West

Depth of Pipe: 4 feet, Fluid: Slurry Waste, Flow Direction: West

Pipe Code: M25, Size of Pipe: 2 inch, Pipe Schedule: 40

Pipe Material: carbon steel see M25 data sheet, Encasement: none

Wall Thickness-nominal: 0.154 inches, from Piping Handbook

Type of Joint: Welded: yes, Flanges: _____, Bell and Spigot: _____

Coating Type: AWWA spec. coal-tar enamel, Wrap type: bubble wrap

Coating Thickness: AWWA spec. Coating Condition: charred

Cathodic Protection: yes, in the past, not presently
type: impressed current, old system turned off in 1980

Soil type: Hanford gravel

Soil Resistivity: 44,000 ohm-cm @ 2.5 ft deep, from Ebasco Report

Corrosion conditions:

Pitting: _____

Thinning: _____

Holes: 2 holes in top of pipe

Cracks: _____

Rust: _____

Date of Construction: 1972, Pipe age: 19 years

Supports Conditions:

Heat Traced: yes X, no _____

Insulation: yes X, no _____, poly-urethane form, looked OK

Photographs: yes X, no _____

Inspectors: name and signature William Carlos, date: Oct 10, 1992

A

PIPE CODE M-25

WHC-SD-WM-ANAL-014
Rev. 0

Service: Max. Operating Pressure: Max. Operating Temp.:

*Slurry (insulated)	375 psig	330 F
*Supernatant (insulated)	230 psig	330 F
Drains (insulated).	120 psig	330 F

Size	1" thru 6"	8" thru 12"
Pipe	Carbon steel, ASTM A53, Type S, Grade B	
Wall Thickness	Schedule 40	Schedule 20 (0.250" wall)
Fittings	Wrought carbon steel, butt welding, per ANSI B16.9, ASTM A234, Gr. WPB. Schedule to match pipe.	
Flanges	None	
Valves	As indicated on piping drawings.	

* Full traceability required for installation of these lines.

Figure C-4. Heat Trace Detail 4.

APPENDIX D

**SL-119 SALTWELL LINE AND
TANK S-103 WASTE COMPOSITIONS**

GLOSSARY/DEFINITIONS

Condensate	The product of a physical reaction involving a reduction from a vapor to a liquid, i.e., steam to water.
Drainable Interstitial Liquid (DIL)	Interstitial liquid that is not held in place by capillary forces, and will therefore migrate or move by gravity.
Double-Shell Slurry Feed (DSSF)	Waste concentrated just before reaching the sodium aluminate saturation boundary in the evaporator without exceeding receiver tank composition limits. This form is not as concentrated as double-shell slurry.
Interstitial	Being within or between.
M	Molarity.
mil	.001 inch.
MPY	Mils per year.
Supernate	The liquid above the solids in a waste storage tank.

S-103 TANK WASTE

The interstitial liquid (waste) that was pumped through the SL-119 line came from the S-103 Tank. Thus, the S-103 Tank waste will be defined and evaluated for corrosion. The *Tank Farm Surveillance and Waste Status Report for May 1993*¹ states the wastes in the S-103 Tank are double-shell slurry feed (DSSF). The waste in the S-103 Tank was sampled and analyzed on December 6, 1974 and the analysis is summarized in Table D-1, below.

Table D-1. Tank 103 S
Waste*.

Component	Quantity
Hydroxide	1.18 M
Nitrate	1.43 M
Nitrite	0.58 M
Sulfate	0.012 M
Carbonate	0.067 M
Phosphate	0.034 M
Fluoride	0.004 M
SpG	1.24

*December 6, 1974.

The above waste data was inputted into the Divine corrosion model, in the DSS mode and the corrosion results are presented below.

¹Hanlon, B. M., 1993, *Tank Farm Surveillance and Waste Status Report for May 1993*, WHC-EP-0182-62, Westinghouse Hanford Company, Richland, Washington.

Table D-2. Alloy 516 Corrosion
Results from 1974 data.*

Chemical Contents	M
Hydroxide	1.1800
Aluminate	.0000
Nitrate	1.4300
Nitrite	.5800
Complexant	.0000
Fluoride	.0000
Carbonate	.0670
Phosphate	.0340
Sulfate	.0120
Citrate	.0000

*With exposure time
(8,760 hours) and temperature
(180 °C).

Table D-3. Analysis of December 6, 1974 Sample.

Predicted penetration	1.11 MPY
Standard deviation of the predicted penetration	.22 MPY
Standard deviation of the predicted value of the experimental error standard deviation	95%
Under these conditions, there is a 90% probability that the average penetration is less than	1.39 MPY
And that 90% of the actual penetration values are less than	1.76 MPY
Under these conditions, there is a 95% probability that the average penetration is less than	1.47 MPY
And that 90% of the actual penetration values are less than	1.87 MPY
Under these conditions, there is a 99% probability that the average penetration is less than	1.62 MPY
And that 90% of the actual penetration values are less than	2.08 MPY

MPY = mils per year.

The *Tank Waste Technical Option Report*, Appendix D², gives the waste composition in S-103 Tank. It is summarized below in Table D-4. This data was inputted into the Divine corrosion model, DSS mode and the corrosion results are presented below.

Table D-4. Normalized Chemical Data for S-103 Tank Waste.²

Chemical	Grams	M
Nitrate	2,580,000,000	5.31
Nitrite	.108	0
Hydroxide	2,650,000	0.02
Chloride	.00134	0
Phosphate	2,400,000	0.003
Sulfate	1,750	.00
Carbonate	.0926	0

Table D-5. Alloy 516 Corrosion Results from 1993 data.*

Chemical Contents	M
Hydroxide	.5000
Aluminate	.0000
Nitrate	5.3100
Nitrite	.2000
Complexant	.0000
Fluoride	.0000
Carbonate	.2000
Phosphate	.0000
Sulfate	.0500
Citrate	.0000

*With exposure time (8,760 hours) and temperature (180 °C).

²Boomer, K. D., 1993, *Tank Waste Technical Option Report*, Appendix D, "Tank Waste Radionuclide and Chemical Compositions," WHC-EP-0616, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Table D-6. Analysis of 1993 Data.

Predicted penetration	.44 MPY
Standard deviation of the predicted penetration	.27 MPY
Standard deviation of the predicted value of the experimental error standard deviation	161 %
Under these conditions, there is a 90% probability that the average penetration is less than	.78 MPY
And that 90% of the actual penetration values are less than	1.10 MPY
Under these conditions, there is a 95% probability that the average penetration is less than	.88 MPY
And that 90% of the actual penetration values are less than	1.23 MPY
Under these conditions, there is a 99% probability that the average penetration is less than	1.06 MPY
And that 90% of the actual penetration values are less than	1.52 MPY

MPY = mils per year.

Based on the calculated results, the corrosion rates are at a maximum 2.08 MPY with a 99% probability. Because of the short pumping duration as the above corrosion rate, little corrosion is expected in the SL-119 line as a result of the waste.³

A comparison of the SL-119 pipe material and the S-Tank Farm 103 Tank material follows.

Table D-7. A Comparison of Carbon Steel Compositions.

Material		Carbon %	Manganese %	Phos %	Sulfur %
103-S Tank	ASTM A7-39	0.30 max	1.00 max	0.10 max	0.05 max
SL-119 Pipe	ASTM-A53 Type S Grade B	0.30	1.20	0.05	0.06

³Divine, J. R., K. H. Pool, D. B. Mackey, 1985, *Prediction Equations for Corrosion Rates of A-537 and A-516 Steels in Double-Shell Slurry Future PUREX and Hanford Facility Wastes*, PNL-5488, Pacific Northwest Laboratory, Richland, Washington.

The interior of the saltwell piping was exposed to other environments (e.g., pressure testing described in Section 3.4 and flushing of the line with water after a waste transfer). Recent CTTV inspections of similar lines in the S Tank Farm confirm that water can remain in the lines for long periods after pressure testing or flushing (Walter 1993). The lines do not completely drain. Water remaining from these operations may be the worse-case corrosive event of the line during its service life.

Because the 103-S Tank has held waste for 50 yr, has not leaked, and is sound¹, this strongly suggests the waste stored in the tank is compatible with its carbon steel.

All of the waste that flowed through the SL-119 line came from the S Tank Farm 103-S Tank.

Based on a comparison of their chemical composition the 103-S Tank carbon steel and the SL-119 pipe carbon steel are almost identical.

Because of this similarity the waste that flows through the SL-119 from the 103-S Tank is compatible with the SL 119 line. Thus, the SL-119 line is expected to have little corrosion from contact with the waste. Visual inspection of the internal systems of the SL-119 pipe by the author and ID measurement by Pacific Northwest Laboratory confirm this conclusion.

DATE

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END