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14-TF-0103

The Honorable Peter S. Winokur, Chairman
Defense Nuclear Facilities Safety Board
625 Indiana Avenue, NW, Suite 700
Washington, DC 20004

Mr. Chairman:

TRANSMITTAL OF DEFENSE NUCLEAR FACILITIES SAFETY BOARD RECOMMENDATION 2012-2 IMPLEMENTATION PLAN DELIVERABLE FOR ACTION 1-3

The attached report evaluates several types of non-destructive examination technologies currently in use in industry. The report also includes advantages and disadvantages of the technologies in view of the configuration of the ventilation ducts and lengths of duct runs in the various double-shell tank (DST) primary ventilation systems. The report presents conclusions as well as rough order of magnitude estimates of cost and duration to implement.

The U.S. Department of Energy, Office of River Protection has not completed its evaluation of the proposed inspection technologies applicable to the DST primary ventilation systems ductwork and has not made a decision on implementation at this time. We expect to complete the evaluation in early Fiscal Year 2015.

Kevin W. Smith
Manager

SEP 1 0 2014

Attachment

cc w/attach:
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ATTACHMENT

14-TF-0103

RPP-RPT-58120, Rev. 0: INSPECTING THE DST PRIMARY TANK VENTILATION SYSTEM

RPP-RPT-58120, Rev. 0

Inspecting the DST Primary Tank Ventilation System

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U.S. Department of Energy Contract DE-AC27-08RV14800

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Abstract: This report directly supports DNFSB 2012-2, Action 1-3, which is outlined within the Implementation Plan, Sub-Recommendation 1. Action 1-3 provides direction to prepare a feasiblity study for inspecting the DST primary tank ventilation system ductwork from the tank to the flow monitoring locations at each DST. WRPS has utilized Kurion Inc.'s expertise in remote robotic inspecting to determine what technologies are feasible for this application. WRPS reviewed the information presented by Kurion and recommends performing an initial visual inspection via boroscope.

RPP-RPT-58120
Revision 0

Inspecting the DST Primary Tank Ventilation System

Prepared by:

R.E. Mitchell
Washington River Protection Solutions, LLC

Date Published
August 2014

Washington River Protection Solutions LLC
Contractor for the U.S. Department of Energy
Contract No. DE-AC27-08RV14800

EXECUTIVE SUMMARY

In September 2012, Defense Nuclear Facilities Safety Board (DNFSB) issued DNFSB Recommendation 2012-2, *Hanford Tank Farms Flammable Gas Safety Strategy*, which included within it five recommendations (hereafter referred to as Sub-Recommendations) and associated actions. In general, DNFSB Recommendation 2012-2 identified the need to take action to reduce the potential risk posed by flammable gas events at the Hanford Tank Farms. The United States Department of Energy (DOE) responded to the DNFSB Recommendation 2012-2 with the *Implementation Plan for Defense Nuclear Facilities Safety Board Recommendation 2012-2, Hanford Tank Farms Flammable Gas Safety Strategy* (hereafter referred to as the *Implementation Plan*).

This report directly supports Action 1-3, which is outlined within the *Implementation Plan*, Sub-Recommendation 1. Action 1-3 provides direction to develop a feasibility study for inspecting the condition and integrity of double-shell tank (DST) primary tank ventilation ductwork between the tank and flow monitoring locations. This action is being worked in parallel with Action 1-2 and which is addressed in RPP-RPT-57356, *Streamlined Approach to Upgrading DST Primary Tank Ventilation.*

Washington River Protection Solutions, LLC (hereafter referred to as the Tank Operations Contractor [TOC]), was tasked with providing a feasibility study to inspect the DST primary tank ventilation system ductwork between the tank and the flow monitoring locations. The following technologies have been deemed feasible for inspecting the ductwork by Kurion Inc.

- Visual inspection via boroscope
- Ultrasonic testing (UT)
- Magnetic flux leakage (MFL) testing

Kurion's feasibility study is attached to this report for reference (see Attachment A).

TOC recommends performing an initial visual inspection of each DST primary tank ventilation system to obtain visual evidence of the integrity of the ductwork. The visual inspection would be performed via boroscope using existing technologies and instrument selection within those technologies will determine the amount of ductwork that is able to be inspected. Based upon the results of the visual inspections, TOC may perform UT in locations that warrant additional investigation. The acceptance criteria for selecting these UT locations and techniques will be determined at the time an inspection plan is written. Engineering judgment and/or statistical analysis may be utilized to ensure that these selected locations are representative of the entire system.

The scope to perform inspection of the DST primary tank ventilation system is not currently within the TOC contract. TOC would require contract direction prior to the initiation of this scope.

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ACRONYMS

ALARA	As low as reasonably achievable
DNFSB	Defense Nuclear Facilities Safety Board
DOE	U.S. Department of Energy
DSA	Documented Safety Analysis
DST	Double-shell tank
GS	General Service
MFL	Magnetic flux leakage
NDE	Non-destructive examination
ORP	DOE Office of River Protection
ROM	Rough order of magnitude
SAC	Specific Adminstrative Control
SS	Safety-Significant
TOC	Tank Operations Contractor
UT	Ultrasonic testing

1.0 BACKGROUND

The historical perspective on how the actions associated with upgrading the DST primary tank ventilation systems (including Action 1-3 which is the subject of this report) evolved, is as follows. In early 2010 as a part of a major upgrade to RPP-13033, *Tank Farms Documented Safety Analysis* (DSA), the steady-state flammable gas strategy for DSTs (which included safety-significant [SS] DST primary tank ventilation systems as a control) was re-evaluated. Based on a number of considerations, a Specific Administrative Control (SAC) requiring flammable gas monitoring and stipulating actions to be taken if the flammable gas concentration was found to be > 25% of the lower flammability limit replaced the SS DST primary tank ventilation systems as the preventive control for steady-state flammable gas hazards in DSTs. Given this reliance on the SAC, the DST primary tank ventilation systems were no longer classified as SS in the Tank Farms DSA (i.e., the systems became General Service [GS]).

In August 2010, the DNFSB questioned DOE on the adequacy of using the SAC for flammable gas monitoring as the primary control to prevent steady-state flammable gas hazards in DSTs. In March 2011, in an effort to elevate the safety importance of maintaining active primary ventilation at all times, the DOE Office of River Protection (ORP) directed the TOC to submit a safety basis amendment that designated the existing, GS DST primary tank ventilation systems as SS. TOC was also directed to perform a gap analysis to identify differences between the functional and performance requirements for the SS systems and the existing system designs. This gap analysis was to be used to identify planned improvements to the DST primary tank ventilation systems in the safety basis amendment.

In September of 2012, DNFSB Recommendation 2012-2, *Hanford Tank Farms Flammable Gas Safety Strategy*, was issued. Within this recommendation it was noted that, although DOE maintains a commitment to upgrading the DST ventilation systems, limited progress had been made. A number of recommendations were provided regarding near-term actions that should be taken to implement the DST primary tank ventilation system upgrades to SS.

DOE responded to DNFSB Recommendation 2012-2 with the *Implementation Plan,* which identifies the need to take action to reduce the risk posed by flammable gas events at the Hanford Tank Farms and includes five Sub-Recommendations and associated action items that address the DNFSB recommendations.

Action 1-3 is associated with DNFSB Sub-Recommendation 1 which reads: "Take near-term action to restore the classification of the DST ventilation systems to SS. In the process, determine the necessary attributes of an adequate active ventilation system that can deliver the required flow rates within the time-frame necessary to prevent and mitigate the site-specific flammable gas hazards at the Hanford Tank Farms." Action 1-3 specifically requests the development of a feasibility study for inspecting the condition and integrity of DST primary tank ventilation ductwork between the tank and flow monitoring locations.

2.0 PURPOSE

This document directly addresses Action 1-3 of the *Implementation Plan*, which is presenting the feasibility of inspecting the DST primary tank ventilation system ductwork between the tank and the flow monitoring locations via non-destructive examination (NDE).

The integrity of the DST primary tank ventilation system ductwork is a key element to ensure that the flammable gas hazard is mitigated sufficiently. Other Sub-Recommendations and actions related to the DST primary tank ventilation system are outside the scope of this report. Specifically, this report does not describe activities associated with Action 1-2, which is to develop a streamlined approach to upgrade the DST primary tank ventilation system to SS; nor does it describe Sub-Recommendation 2 (Actions 2-1 through 2-4), which focus on the installation of SS instrumentation for real-time monitoring of the ventilation exhaust flow from each DST.

Attachment A of this report contains a feasibility study authored by Kurion Inc., who was selected based upon past work experience and expertise in remote robotic inspections. KUR-1800-28-RPT-001, *DST Primary Tank Ventilation Ductwork Inspection Feasibility Study* concludes that three technologies are deemed feasible for this application. TOC has reviewed these conclusions and a recommended path forward is included this report.

The scope to perform inspection of the DST primary tank ventilation system is not currently within the TOC contract. TOC would require contract direction prior to the initiation of this scope.

3.0 CONCLUSIONS

The DST primary tank ventilation system ductwork configurations are installed in 241-AN, 241-AP, 241-AW, 241-AY/AZ, and 241-SY DST tank farms. The feasibility of inspecting the ductwork is bounded from the tank to the flow monitoring locations at each DST. The integrity of the ductwork between the tank and the flow monitoring location ensures accuracy in the flow monitoring measurements. These ventilation systems have been categorized into configuration types by Kurion. Table 1 below contains these ventilation systems by tank farm with their corresponding configuration type. It also contains the grade of the ductwork, location of the currently installed flow monitoring locations (ports), and the size of the flow ports.

Table 1 - DST Primary Tank Ventilation Type

Tank Farm	Configuration	Duct Location	Port Location & Size
AN, AP & AW	Type 1	Below-grade	Ventilation pits – ¾"
AY & AZ	Type 2	Below-grade	Ventilation building – ¾"
SY	Type 3	Above-grade	Above each tank (just downstream of tank riser) – ¾"

Kurion performed an extensive market research that ultimately ended with the following potential options for consideration in the feasibility study.

- Ground penetrating radar
- Gas pressure decay testing
- Tracer gas testing
- Visual inspection (boroscopes)
- Ultrasonic testing (UT)
- Magnetic flux leakage (MFL) testing

Based on Kurion's past experience and expertise, the technologies that were deemed feasible for this application were visual inspection via boroscope, UT, and MFL testing. Table 2 utilizes information from Table 2 in Kurion's feasibility study (see Attachment A). This table provides conclusions on each technology including rough order of magnitude (ROM) cost, ROM schedule, advantages and disadvantages such as radiological concerns (As-low-as-reasonably-achievable [ALARA]) and modifications required to the existing system.

The ROM costs and schedules associated with inspecting the DST primary tank ventilation system are based upon the items listed below.

- Project Management activities, which consist of the Project Manager, Project Engineer, and Project Controls personnel.

- Engineering activities, which consist of any necessary design, engineering change notices for additional port installation, specifications, and any required analysis.

- Procurement of the equipment needed for additional port installation, testing, and the inspection.

- Field work activities, which consist of planning and facility modifications.

The DST primary tank ventilation systems contain high-levels of radiological contamination. TOC will ensure that the appropriate safety and radiological controls are in-place for any work activity that is undergone in the field. TOC remains committed to facility work safety during all work activities.

Table 2 – Feasible Inspection Technologies

Technology	ROM Cost	ROM Schedule	Advantages	Disadvantages
Large Borescope	$2.4 million	14 months	• Provides visual evidence of ductwork integrity • Low risk associated with obtaining test data • Commercially available technology • Lowest cost of the technologies deemed feasible	• Modification to ductwork required (i.e., 2.5-inch ports) • ALARA concerns • Borescope may not be able to access or view all ductwork within its theoretical reach • May not maneuver multiple pipe bends (testing required) • Debris on lens could obstruct view • May require entering the limiting condition for operation
Crawler UT	$2.7 million	17 months	• Provide physical evidence of ductwork integrity	• Modification to ductwork required (i.e., 6-inch ports) • ALARA concerns • May require extensive testing to interpret corrosion results accurately • Butterfly valves could restrict range • May not maneuver multiple pipe bends (testing required) • May need gel or other liquid to accommodate sufficient contact with UT probe and duct • May require entering the limiting condition for operation
MFL	$2.9 million	19 months	• Provide physical evidence of ductwork integrity	• Modification to ductwork required (i.e., 12-inch ports) • ALARA concerns • Bends in duct could limit usefulness of MFL technology • Butterfly valves will restrict range • May require entering the limiting condition for operation

Notes:
1. Small boroscope through existing penetrations and spot UT are not included in this table and considered bounded from a cost and schedule standpoint by large boroscope and crawler UT respectively.
2. The ROM estimates assume that any duct modifications can be performed in close proximity to the existing flow test ports and no excavation is required.

4.0 RECOMMENDATION

TOC has reviewed Kurion's conclusions on the feasible technologies for inspecting the DST primary tank ventilation system ductwork. Operational input along with both Kurion's conclusions and the amount of unknowns associated with the DST primary tank ventilation system ductwork allow for TOC to make the following recommendation.

TOC should perform a visual inspection via boroscope to obtain substantial visual evidence of the DST primary tank ventilation system ductwork integrity. TOC expects this to cost approximately $2.4 million and take 14 months to complete. Based upon the results that were gained in the visual inspection, TOC would focus on locations that showed visual evidence of degradation. The degraded locations would then have UT performed to obtain additional ductwork integrity information. If no degradation was evident, TOC would utilize engineering judgment to determine whether additional inspection methods shall be used. Any locations that are determined to have jeopardized integrity will be further evaluated for additional action. Figure 1 below contains a flow diagram of the process from a high-level.

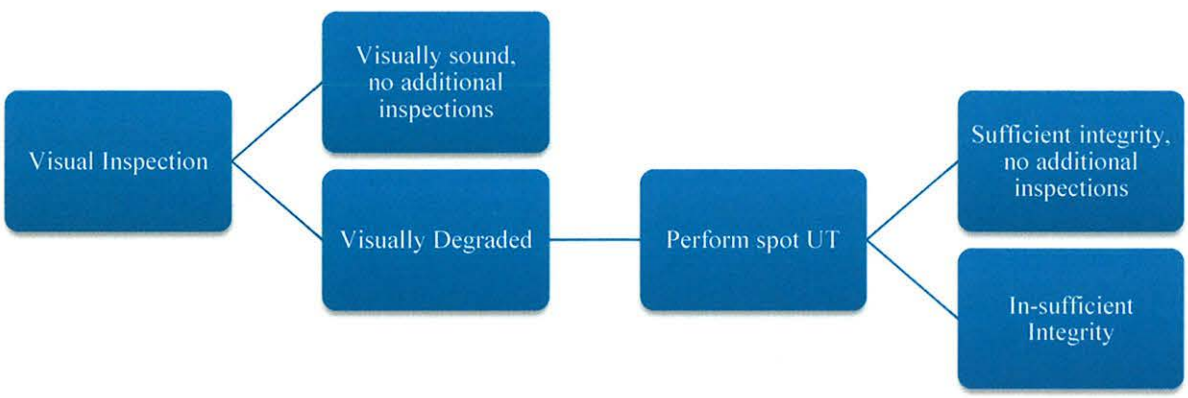

Figure 1 – Recommended High-Level Inspection Plan

5.0 RISKS

The risks listed below in Table 3 are associated with pursuance of the above recommended inspections. The risks are written specifically to address the impact and probability of executing field inspections.

Table 3 – Potential Risks

ID	Risk	Impact	Probability	Mitigation
1	Visual inspection finds degraded ductwork that renders no additional technology feasible for deployment.	Low	Medium	If possible, deploy the boroscope technology that provides the maximum inspection footprint.
2	Lack of trained WRPS personnel to operate inspection equipment.	Low	High	Train operators on use of equipment prior to mock-up. Alternatively, utilize a Subcontractor to perform inspections.
3	Changes in DOE and/or TOC procedures, standards, and codes impact project cost and schedule.	Medium	Medium	Ensure that DOE is engaged and fully aware of project status.

6.0 REFERENCES

DNFSB Recommendation 2012-2, *Hanford Tank Farms Flammable Gas Safety Strategy*, dated September 28, 2012.

DOE Response to Recommendation 2012-2, dated January 7, 2013.

DOE Implementation Plan for Defense Nuclear Facilities Safety Board Recommendation 2012-2, *Hanford Tank Farms Flammable Gas Safety Strategy*, dated June 6, 2013.

RPP-13033, *Tank Farms Documented Safety Analysis*, Revision 5-G, Washington River Protection Solutions, LLC, Richland, WA.

KUR-1800-28-RPT-001, *DST Primary Tank Ventilation Ductwork Inspection Feasibility Study*, Revision 0, Kurion Inc., Richland, WA.

ATTACHMENT A

KUR-1800-28-RPT-001

DST Primary Tank Ventilation Ductwork Inspection Feasibility Study

KUR-1800-28-RPT-001

DST Primary Tank Ventilation Ductwork Inspection

Feasibility Study

Revision: **0**

Issue Date: **11 Aug 2014**

Prepared for:

washington river protection solutions

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Carol Farwick 8/11/2014

Carol Farwick, Project Manager Date

Status: ☐ In-Process ☒ Final

Contains assumptions and/or inputs which require verification: ☐ Yes ☒ No

Report History

Revision #	Reason for Revision	Approvals/Date
0	Final release with client comments incorporated	Originator: Geoff Barnes [signature] 8/6/14 Checker: James Kriskovich [signature] 8/6/14 PM: Carol Farwick [signature] 8/6/2014 Other:
		Originator: Checker: PM: Other:
		Originator: Checker: PM: Other:
		Originator: Checker: PM: Other:
		Originator: Checker: PM: Other:

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Terms

Acronym	*Definition*
DOE-ORP	U.S. Department of Energy, Office of River Protection
DNFSB	Defense Nuclear Facilities Safety Board
DST	Double-Shell Tank
ECN	Engineering Change Notice
FS	Feasibility Study
GPR	Ground Penetrating Radar
IS	Intrinsically Safe
MFL	Magnetic Flux Leakage
NDE	Non-Destructive Examination
ROV	Remotely Operated Vehicle
UT	Ultrasonic
WRPS	Washington River Protection Solutions

1.0 Introduction

This feasibility study presents concepts for inspecting portions of the Double Shell Tank (DST) primary tank ventilation ductwork within the five DST tank farms at the 200 area of the Hanford Site. This feasibility study is prepared in accordance with the Department of Energy, Office of River Protection's (DOE-ORP) Implementation plan for Defense Nuclear Facilities Safety Board (DNFSB) Recommendation 2012-2 to "develop a feasibility study for inspecting the condition and integrity of DST primary tank ventilation ductwork between the tank and flow monitoring locations."

2.0 Scope

This feasibility study evaluates non-destructive methods to inspect the below-grade and above-grade DST primary tank ventilation ductwork within the five DST tank farms. The inspection is bounded from each DST to its respective flow monitoring locations. The DST primary tank ventilation ductwork pertaining to this study is located in the AN, AP, AW, AY/AZ and SY Tank Farms. The flow monitoring locations will be assumed to be consistent with the location of existing flow test ports. The flow test port locations are indicated below:

- AN, AP and AW Farms: The flow test port locations are within the ventilation pits
- AY/AZ Farm: The flow test port locations are within the recirculation buildings
- SY Farm: Locations of the test ports in the above-ground ducting in SY Farm are found in Engineering Change Notice ECN-12-000466

3.0 Purpose

The purpose of this report is to present concepts for non-destructive examination (NDE) equipment that could be used to inspect DST primary tank ventilation ductwork for the tank farms. This report supports Sub-Recommendation #1, Action 1-3 of DNFSB Recommendation 2012-2 (which requires "a feasibility study for inspecting the condition and integrity of DST primary tank ventilation ductwork between the tank and flow monitoring locations").

4.0 Current Ventilation Duct Configurations

This Feasibility Study was conducted by first reviewing drawings and other technical documents related to the DST primary tank ventilation ductwork and ancillary equipment. This review was performed to determine configurations and to locate potential inspection ports for insertion of NDE inspection equipment. The main objective of the review was to locate the flow test port locations for the ducts and to determine the sizes of ports available at the flow test port locations. In all cases, the ports available at the flow test port locations are small and will limit NDE equipment. Because of limited port size at the flow test port locations, optional larger ports were also investigated within the ductwork that could accommodate larger NDE equipment.

A review of drawings and other technical documents including ECNs and specifications made it clear that there are three different primary ventilation duct arrangements for the five DST Farms. For the purposes of this study, the three ventilation duct arrangements (Type 1, 2, and 3) will be discussed separately. The drawings reviewed for this study are summarized in Appendix A.

4.1 Type 1 Ventilation Ducts

The AN, AP, and AW DST primary ventilation ductwork all consist of Type 1 configurations. The ductwork to be inspected for Type 1 ducts are all below-grade and access into the ducts is limited to small ports within ventilation/instrumentation pits. Type 1 ductwork is thin-walled Schedule 10 carbon steel pipe. In all cases for Type 1 ducts, new flow sample ports have been added in recent years. These new ports consist of two 0.75-inch penetrations installed directly into the duct for periodic flow measurement purposes. A 1.5-inch plug seals the flow test ports when not in use. A typical design of a new flow test port installation is shown in excerpts from ECN-12-000465 (Figure B-1 in Appendix B). A model of a typical Type 1 ventilation duct is shown in Figure 1. Figure 2 shows photographs of a typical flow test port for the ductwork.

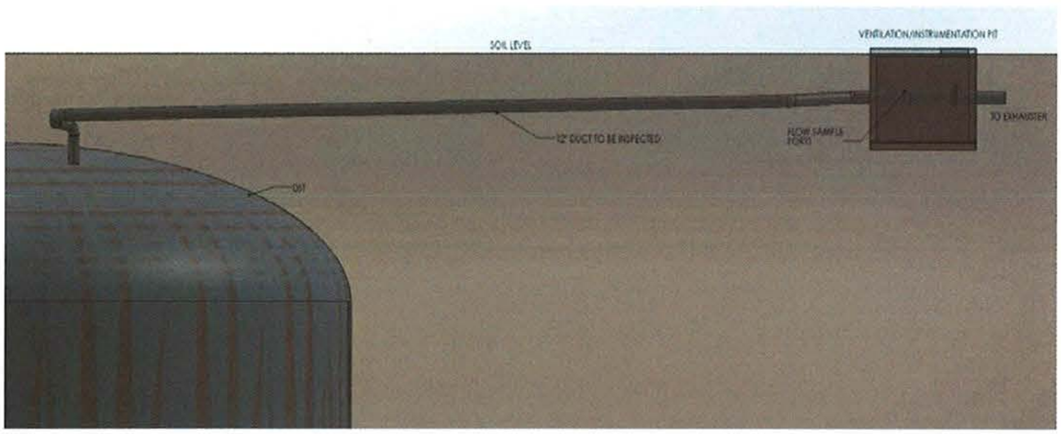

Figure 1: Typical Type 1 Ventilation Ductwork

Figure 2: Typical Flow Test Port

Besides the new flow test ports recently installed in the ventilation ducts for Type 1 configurations, older ports may be available at the flow test port locations. These older ports are slightly larger (2-inch) than the newer flow test ports and were most likely installed during construction several years ago. In many cases, these older ports exhibit significant corrosion and should not be considered safe access areas for inspections (see Figure 3). For the purposes of this study, it is assumed that none of the older ports are useable for inspection purposes.

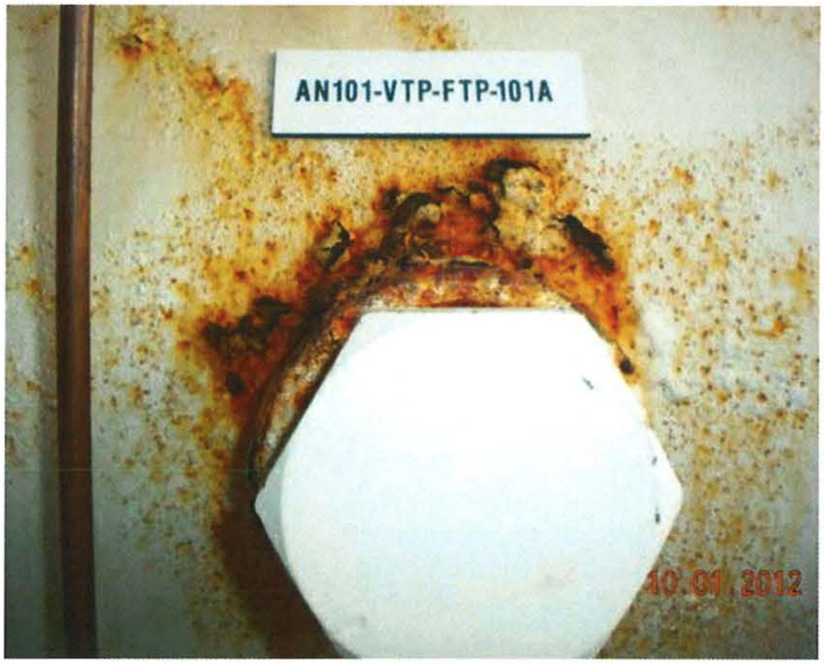

Figure 3: Port AN101-VTP-FTP-101A

Due to the small 0.75-inch ports available at the flow test locations, access for NDE equipment will be very limited. To improve access for NDE equipment, larger (6 inch and above) ports are required. Drawings were reviewed to determine if large ports are available in the ductwork close to the flow test port locations. It was determined that there are no large ports available close to the flow test ports for all Type 1 ductwork. The closest larger ports that may be available are located at the demisters for all three farms. These larger ports are a considerable distance away from the ventilation ducts to be inspected and all have butterfly valves that would obstruct NDE equipment.

Figure B-2 is a typical P&ID showing these potential large ports for inspection equipment insertion along with the locations of the flow test port locations and the locations of butterfly valves in the ductwork.

In order to perform effective quantitative NDE inspections on Type 1 ductwork (see Section 5.0), new duct penetrations (6 inch or larger) will need to be installed at the flow test port locations in the ventilation pits upstream of the butterfly valves.

4.2 Type 2 Ventilation Ducts

The AY/AZ DSTs all consist of Type 2 configurations. For the Type 2 primary ventilation ducts, the flow test ports are located in the recirculation buildings inside the DST Farms. The ducts to be inspected for Type 2 ducts are mostly below grade except within the recirculation buildings. Type 2 ductwork is made from stainless steel pipe. Figure B-3 shows a typical P&ID for a Type 2 configuration. In Figure B-3, the ducts to be inspected are shown in red. As shown in the figure, numerous butterfly valves are located between the flow test ports and the DST's.

Like the Type 1 configurations, the flow test ports for the Type 2 configurations consist of two 0.75-inch ports with a 1.5-inch plug to seal the port when not in use. Figure 4 shows the flow test ports in the AZ-102 duct.

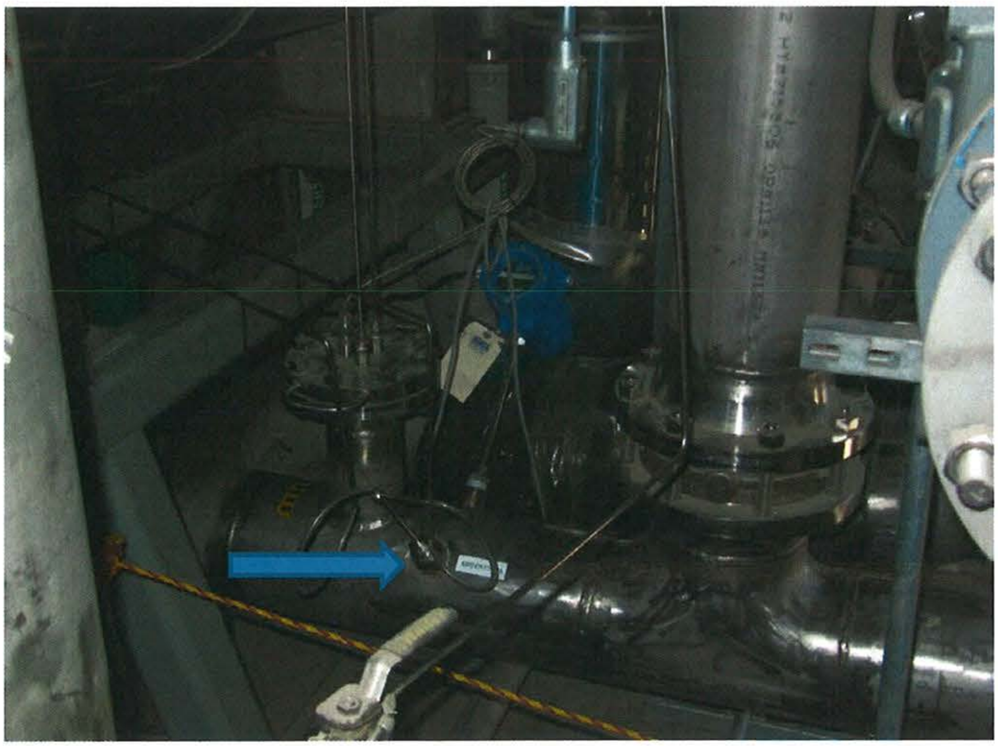

Figure 4: AZ-102 Flow Test Ports

Due to the small 0.75-inch ports available at the flow test locations, available NDE equipment will be limited to visual (borescope) or spot ultrasonic techniques like the Type 1 ducts. To accommodate larger pipe inspection equipment, the AY/AZ DST drawings were reviewed to determine if larger (6-inch and above) ports are available and unobstructed from valves. It was determined that within the recirculation buildings for the AY/AZ farms, 8-inch ports are available (see Figure B-3) for inspection purposes. In order to use these 8-inch ports for insertion of NDE equipment, the butterfly valves would need to be temporarily removed. If these ports are not available, larger ports would need to be installed in the ductwork to accommodate larger NDE equipment.

4.3 Type 3 Ventilation Ducts

The three SY DSTs have Type 3 primary ventilation ductwork. Type 3 primary ventilation ductwork is all above ground except at tank dome penetrations. The flow test ports for Type 3 ductwork, like Type 1 ductwork, are limited to small ports installed in recent years (ECN-12-000466). These flow test ports are very similar to the Type 1 and Type 2 flow sample ports in that they consist of two 0.75-inch ports installed directly into the ducts. Figure 5 is a photo of typical flow test ports installed in the SY farm ductwork.

Figure 5: SY Farm Primary Ventilation Duct Flow Test Ports

There are also butterfly valves installed in the duct between the flow test ports and the tank dome penetrations which will obstruct large inspection equipment entirely and make passage difficult for smaller equipment inserted into the ducts. However, unlike Type 1 and Type 2 ductwork, Type 3 ductwork is mostly above grade, so the duct could be inspected from the outside using standard NDE equipment (e.g. ultrasonic). Like Type 1 and 2 configurations, alternate ports were investigated for insertion of larger inspection equipment. For the SY Farm ductwork, there is a large port at the exhauster (see Figure B-4). This potential access point is the connection for the portable exhauster, but there are multiple butterfly valves installed between the portable exhauster port and the tanks, making internal duct inspections problematic.

Because of obstruction within the ductwork and most of the ductwork being above grade, inspecting the ductwork from the outside is the preferred method for inspection of Type 3 ductwork.

5.0 Technologies

Kurion conducted a market survey to identify the current technologies available to conduct NDE of piping and/or ducts. Pipe inspection is a very mature industry focused on Oil and Gas, Waste Water, and Industrial Process Piping. These industries use a variety of technologies and systems to test the integrity of piping. The technologies identified in the market survey included:

- Ground Penetrating Radar (GPR)
- Gas pressure decay
- Tracer Gas Tests
- Visual (Borescope)
- Ultrasonic (UT)
- Magnetic Flux Leakage (MFL)

A number of technologies were considered infeasible based on the duct configuration, quality of information obtainable, or complexity.

Ground Penetrating Radar (GPR) was considered infeasible due to the gross nature of the data. Although GPR could identify gross discontinuities in the ductwork (i.e., large holes or dents in the duct), the duct integrity is not expected to be grossly compromised. A gas pressure decay test was also considered, but the duct runs which require inspections cannot be isolated from the system (due to the open end at the tank inlet) and the ventilation system would have to be shut down to conduct a pressure test. A pressure test could also cause catastrophic failure of the duct if the integrity is jeopardized from corrosion as expected. Tracer gas tests would again require isolation of the ductwork and shut down of the ventilation system to introduce a tracer gas. Finally, crawlers with only visual inspection equipment were considered, but the function, design, and implementation was considered commensurate with the ultrasonic crawler considered in Section 5.3. Note that the ultrasonic crawler would include visual inspection and UT technologies, making a visual-only crawler redundant.

Based on industry practice and known constraints posed by the tank farm systems, three technology families are considered feasible for NDE of the ductwork:

- Visual Inspection
- UT Inspection
- MFL Inspection

Visual inspection consists of a camera and lighting. The camera is installed on borescopes, crawlers, or poles that can be deployed into pipes. This can provide information about the condition of the pipes, but it is restricted to qualitative (subjective) data. Examples are shown in Figure 6.

Figure 6: Typical Visual Inspection (ROV – Left, Borescope – Right)

Ultrasonic detectors use high-energy sound waves to measure wall thicknesses. This is an established method for pipe inspection. Ultrasonic detectors may take discrete measurements (spot) or complete measurement using multiple probes. The ultrasonic probes are quite small but in most cases require good contact with the surface and may not read well through corrosion products. They are ideal for external measurements of pipes with internal corrosion but not as common for internal measurements. Typical ultrasonic detectors are shown in Figure 7.

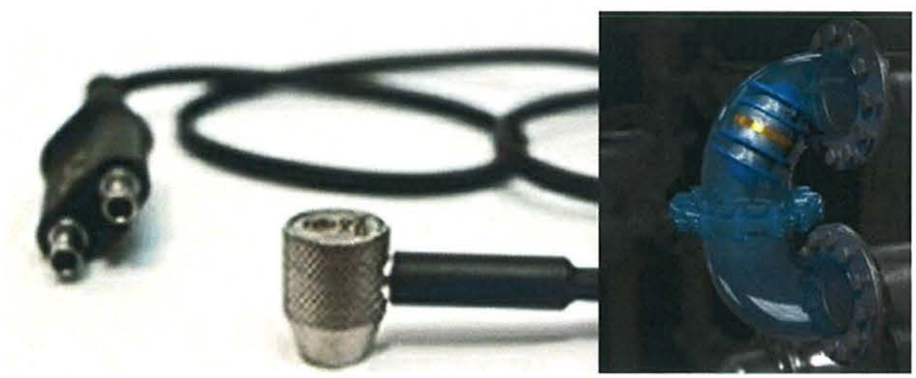

Figure 7: Typical Ultrasonic Pipe Probes (Probe – Left, Ultrasonic Pipe Pig – Right)

One of the most widely used technologies for larger diameter pipe inspection is Magnetic Flux Leakage. This technology uses a near full diameter pipe "pig" that creates a magnetic field whose behavior can measure the metal thickness around it. One variety is depicted in Figure 8.

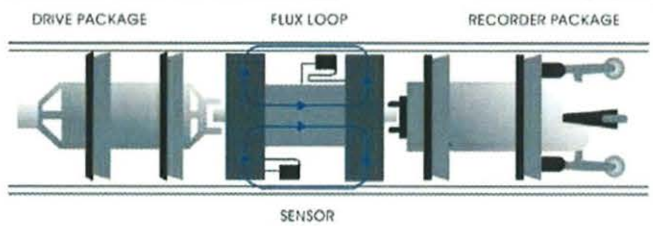

Figure 8: Typical Magnetic Flux Leakage Pipe Pig

There are many established companies who focus on each of these types of NDE services for commercial applications. In principle, measuring the integrity of the DST primary tank ventilation ductwork is the same problem. However, one major obstacle that makes this problem more difficult than commercial applications is the lack of penetrations into the duct. Nearly all commercial UT and MFL inspections are done with full diameter probes or pigs and most of the technologies require close contact with the pipe walls for good measurements. These are typically installed on full diameter flanges and pushed with fluid pressure through the pipeline.

Because the DST ductwork has no full diameter accessible ports, the problem is to evaluate what technologies exist for small penetrations and what technology could be used if increasingly larger penetrations were added to the ductwork.

To determine which of the three feasible technologies is best-suited for evaluating the DST duct integrity, Kurion evaluated the ability of each technology to inspect the DST primary tank ventilation ductwork as discussed in the following sections.

As a point of reference, it is helpful to note that in 1996 an investigation of tank farm systems was performed under Project W-314, which included Report No. WHC-SD-W314-ES-022 *Initial Assessment Report HVAC Systems.* This report included limited ductwork assessment data for the AN, AP, AW, AY, AZ, SX, and SY tank farms. Inspection techniques for ductwork included visual and video camera inspection and ultrasonic inspection. Although only small sections of ductwork were evaluated due to accessibility and technology constraints, the general conclusion was that ductwork at all tank farms had light to moderate external corrosion and light internal corrosion. The data did not reveal any corrosion or damage that would indicate a breach of ductwork integrity. While it is not within the scope of this study to assess previous inspection technology results, the concepts for visual and UT inspection within the tank farms do have precedence.

5.1 Visual Borescope

5.1.1 Data

Borescopes can be used to visually inspect the interior of the duct. Visual inspections can provide qualitative information about the duct integrity and identify areas that may require further investigation. A visual inspection could identify areas of concern to make quantitative inspection methods more efficient.

Common borescope features include a video screen, rechargeable battery operation, and image data recording. Specialized features such as a camera head locator transmitter, image size characterization, and audio commentary are also available. Areas of concern located by a borescope inspection can be evaluated to the extent possible from a video image.

Table 1 summarizes the borescope options and capabilities (note that intermediate permutations exist between the three varieties selected below for comparison). The market survey conducted by Kurion was not restricted to intrinsically safe (IS) borescopes, so each borescope type considered is clearly identified as IS if applicable.

Table 1: Summary Comparison of Borescope Options

Borescope Type	Camera Diameter	Portion of Duct that Could be Visually Inspected	Estimated Length of Duct that Could be Visually Inspected
500 ft Long with Pan-and-Tilt Camera (IS)	2.36 in.	Bottom and Sides	100%
100 ft Long Non-Articulating Std. Camera	0.47 in. (12 mm)	Bottom only	73%
24.6 ft (7.5 m) Long Articulating	0.31 in. (8 mm)	Whole Duct	23%

5.1.2 Implementation Challenges

Borescopes come in a variety of sizes, lengths, and abilities (e.g., articulating, pan-and-tilt cameras, flexible, rigid). Figure 9 is an example of a pan-and-tilt borescope camera head. The available port size first considered for this application is restricted to 0.75 inches in diameter to prevent the need for further modification of the duct. Inspecting every foot of the duct is difficult due to the need to inspect duct runs greater than 50 feet long (up to 250 feet in the case of AP-101 and AP-107).

Figure 9: Example of Pan and Tilt Borescope Camera

Investigation of borescope manufacturer's data found no standard borescopes long enough to inspect every foot of duct while holding to a 0.75-inch diameter entry requirement. In addition, although there are off-the-shelf borescopes 100 feet long that could meet the entry criteria, these borescopes are non-articulating and would be restricted to views of the bottom of the duct with no ability to inspect the side or top of the ductwork.

If distance were de-emphasized in favor of maintaining the 0.75-inch access point, shorter borescopes could be used to inspect each surface of the duct along shorter duct runs. However, manipulation of a smaller diameter articulating borescope would likely require an additional holding arm beyond 6.5 feet (2 m) since the borescope is less rigid than the larger diameter non-articulating variety.

If a larger access point were available (up to 2.5 inches in diameter), then more effective borescopes could be deployed. For example, a 500 feet intrinsically safe borescope with a pan-and-tilt camera could be used to inspect the bottom and sides of the duct. The top of the duct would not be visible since the borescope would lie on the bottom of the duct and the camera does not provide a clear view of the top due to the limitations on lighting.

In all cases, the borescope would be difficult to push the whole length of the duct. The shorter, small diameter articulating borescopes may bunch up when navigating the duct. The longer borescopes would likely navigate the duct, but there would be little control over their path and they would become more difficult to push as the deployment length increased. Obstacles such as butterfly valves, pipe bends and corners, and debris could prevent further inspection of the ductwork. In addition, the camera lens could become covered by dirt or mud and damaged by moisture. Lastly, there would be a restriction on the number of bends the borescope could pass through due to the build-up of frictional forces.

5.1.3 Cost and Schedule

Many borescopes are stock items and can be ordered on short notice. Costs vary depending on complexity. The borescopes discussed here vary in price from about $8,000 to $35,000.

For each type of ductwork listed in Section 4.0 (Current Ventilation Duct Configurations), different borescopes may be deployed to optimize the visual inspection of the ductwork. For example, the duct run for AW-106 is 25 feet, so the smaller diameter articulating probe is likely adequate for such a task and would not require modifications to the access points. Also, Type 3 duct is above grade, so a system walk down coupled with an ultrasonic inspection would provide adequate information to determine the integrity of Type 3 duct without the use of a borescope. For the purposes of estimating the cost of inspection using a borescope, it is assumed that one 500 feet long borescope can be used to inspect every duct after modifying the access points to allow for a 2.5-inch diameter inspection port.

The total cost to deploy a 500-foot borescope would be approximately $2,422,000 and it would take approximately 264 working days to deploy. These cost and schedule estimates assume design, development, testing, fieldwork package preparation, duct modification and deployment. The schedule can be found in Appendix C.

5.2 Spot Ultrasonic (Push Probe)

5.2.1 Data

A small ultrasonic sensor that could be deployed using penetrations of similar size to a borescope (0.75-inch to 2.5-inch) could provide data within 10 feet of the flow port or modified inspection port. A small ultrasonic probe could be implemented with less expense than a full-size crawler, but the data obtained would be restricted to regions close to the flow port. Spot UT Push Probe testing could provide the duct wall thickness at discrete points along the bottom of the duct.

The data obtained using UT inspection methods would also require significant testing to better understand how to interpret the data. For example, data may be corrupted or difficult to read if the inspected surface is corroded. With proper testing, it may be possible to understand the difference between a reading that is corrupted by surface corrosion and a reading that indicates a more substantial integrity issue such as a void in the ductwork or gross corrosion of the metal body. The success of the UT inspection method may become dependent on the ability of controlled testing to provide usable data to characterize the integrity of the duct.

5.2.2 Implementation Challenges

Ultrasonic sensors are relatively small and could potentially be deployed through penetrations as small as 0.75 inches but certainly in penetrations below 2 inches. These probes would be mounted on push style probes that would lie on the bottom of the duct. These could be pushed up to and beyond 10 feet although this would have to be determined in testing. Like borescopes, the main factors would be the ability to push a semi-rigid cable. Figure 10 is an example of a typical push style ultrasonic probe.

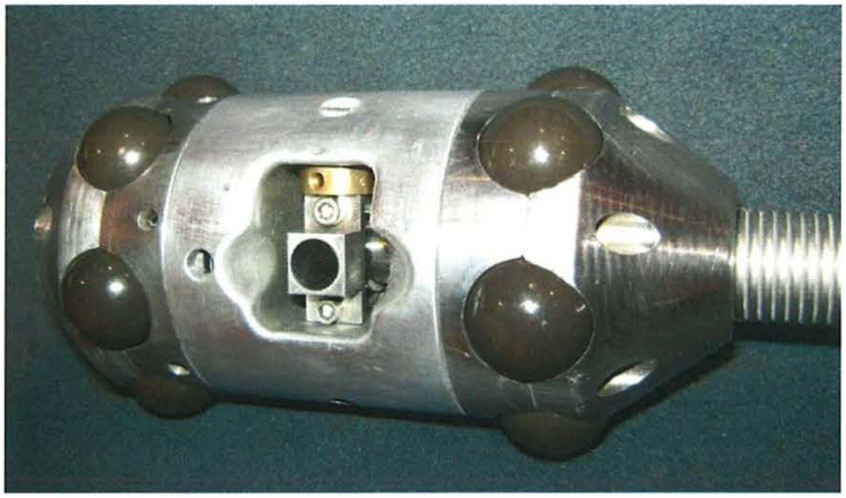

Figure 10: Example of Push Style Ultrasonic Probe

This simple device could take spot readings on the bottom of the duct only as it would have no actuation or ability to touch any other surfaces. Although this is a very limited area, it is likely that the worst corrosion has occurred at the bottom of the duct as this is where any liquids would lie.

Ultrasonic probes need good contact with the material, and based on testing it may be necessary to apply a small amount of gel or liquid couplant to ensure this contact. This involves a small tube connected to the probe that injects the couplant on the probe before it is applied to the surface.

The advantages of this approach are that it could be deployed using existing or very small penetrations. It could be pushed through butterfly valves and easily around bends. The technology is mature and well understood.

Disadvantages of this approach are that it can only sample the bottom surface and has limited reach. Additionally, ultrasonic does not work well through rust so this may limit its applicability. This option is feasible but has severe limitations and the success of this approach would be dependent on having extensive test experience so operators can properly interpret data during actual deployment.

Commercial units are available although some modification to the unique interface with the DST vents would be required. The costs are quite low although there would be some amount of design to adapt and test the equipment.

5.2.3 Cost and Schedule

For spot ultrasonic (push probe) costs, it is assumed that the 0.75 inch flow sample ports will be used for insertion of an UT probe, and measurements will be taken directly below or very close to the flow sample ports only. The total cost to deploy the first ultrasonic push probe would be similar to the cost to deploy a 500-foot borescope or approximately $2,422,000 and it would take approximately 264 working days to deploy. These cost and schedule estimates assume design, development, testing, fieldwork package preparation, duct modification, and deployment. The schedule can be found in Appendix C.

5.3 Spot Ultrasonic Crawler

5.3.1 Data

A larger UT test device could be deployed using penetrations of approximately 6 inches in diameter. Spot UT Crawler inspections could provide the duct wall thickness at discrete points along the circumference of the duct. The UT Crawler would be deployed with a camera to provide visual inspection data of the entire duct surface as well. However, the Crawler would not be able to obtain information on ductwork blocked by butterfly valves or other obstructions.

5.3.2 Implementation Challenges

This approach would require an articulated crawler with camera, lights, and drive power. This is a larger device and would require ports at least 6 inches in diameter. Additionally, this device would not be able to pass through butterfly valves. The technology for the UT sensor is mature, but a specialized crawler would have to be developed or adapted from an existing crawler. Although this is less mature, the basic technology for the crawler is well understood. Figure 11 is one example of an expanding pipe crawler.

Figure 11: Example of Expanding Pipe Crawler

The advantage of this approach is that it could measure anywhere in the pipe along its circumference; however, it also requires good contact with the surface and the use of a couplant may be necessary. Figure 12 shows a preliminary crawler concept with an articulating arm for ultrasonic testing. The crawler can be designed to apply couplant if necessary. This device would require some time to design and test, and it would also require new pipe penetrations which would require extensive engineering and on-site preparation. Also, testing will need to show the crawler would be able to maneuver around the worst case duct bend arrangements.

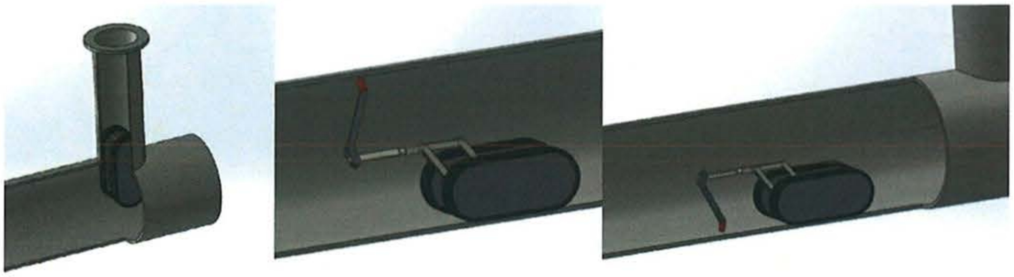

Figure 12: Concept of a Spot Ultrasonic Crawler Installed through a 6 Inch Penetration

Although every effort would be made to make a robust piece of equipment, multiple units may be needed to conduct all the inspections due to premature failure rates. This device, by nature, will be a small crawler with expanding mechanisms and sensors and the wear-and-tear of installation and operation may cause failures before all the ducts are inspected.

Like the Push Probe, the Crawler does not work well through rust so this may limit its applicability. This option is feasible but has limitations and the success of this approach would be dependent on having extensive test experience so operators can properly interpret data during actual deployment.

5.3.3 Cost and Schedule

For spot ultrasonic crawler costs, it is assumed that a 6-inch port will need to be installed in the duct close to the flow sample ports for insertion of the UT device. It is also assumed that the UT device will be re-usable for all ducts. The total cost to deploy the first ultrasonic crawler will be approximately $2,732,000 and it would take approximately 334 working days to deploy. These cost and schedule estimates assume design, development, testing, field work package preparation, duct modification, and deployment. The schedule can be found in Appendix C.

5.4 Magnetic Flux Leakage

5.4.1 Data

MFL is a method that creates a magnetic field near the pipe walls and then measures that field. Any change in the wall thickness (corrosion, pitting, holes, etc.) creates anomalies in the field that can be read. This technology would allow every surface of the pipe to be inspected with high confidence. However, these devices are large and must be the same diameter as the pipe. To install one would require a very large penetration into the ductwork. Any obstructions (butterfly valves) would not be tolerated. There are commercial systems available that can maneuver around bends (See Figure 13). However, testing will need to be performed to prove the MFL device(s) could maneuver around the DST duct bends.

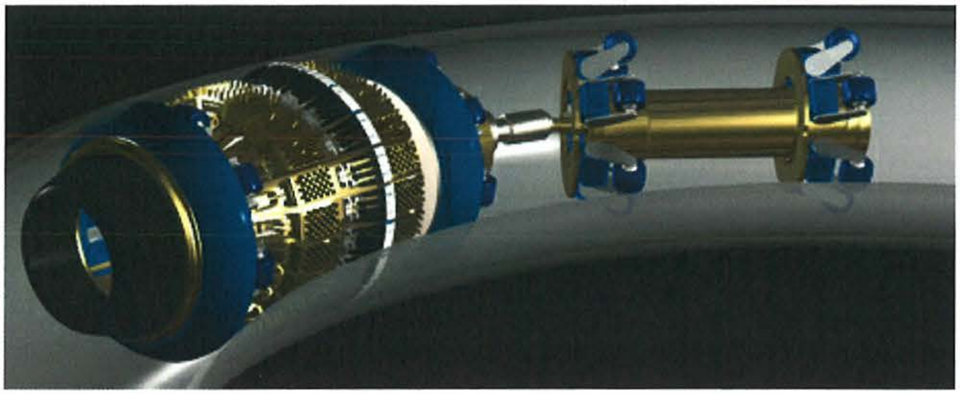

Figure 13: Magnetic Flux Leakage Device in Pipe Bend

5.4.2 Implementation Challenges

The technology of MFL is very well established and understood with extensive use in many commercial industries. However, developing the deployment for this device would take time and creating the new port would take a great deal of engineering and on-site work.

The MFL device would also be limited by bends and obstructions such as butterfly valves. Development testing will need to be performed to prove maneuverability within the worst-case duct bend configurations.

5.4.3 Cost and Schedule

For MFL costs, it is assumed that a 12-inch port will need to be installed in the duct close to the flow sample ports for insertion of the MFL device. It is also assumed that the MFL device will be re-usable for all ducts. The total cost to deploy the first MFL device would be approximately $2,925,000 and it would take approximately 364 working days to deploy. These cost and schedule estimates assume design, development, testing, fieldwork package preparation, duct modification, and deployment. The schedule can be found in Appendix C.

6.0 Summary of Inspection Equipment

Visual inspection via a borescope is the least expensive and most accessible solution. However, the results obtained are qualitative and there is some risk that the borescope(s) will not be able to inspect significant portions of the duct due to obstructions or resistance due to friction. Ultrasonic inspection will require testing to ensure that the data obtained can be interpreted accurately, especially provided that Type 1 duct shows signs of corrosion and rust (see Figure 3). There is some risk that the UT inspection will not be able to inspect significant portions of the duct due to accessibility. Extensive UT inspection would also require the development or modification of a crawler. Lastly, the MFL inspection technique promises to provide ideal results, but it would be incapable of inspecting beyond obstructions or butterfly valves if deployed. Also, MFL may not be able to navigate the existing bends in the ductwork and would require large penetrations for deployment into the duct that could have a significant effect on the cost and schedule for deployment. A summary table for each duct configuration is included below:

Table 2: Summary Table of Inspection Equipment Technologies

Technology	Deployment Cost	Time Frame	Pros	Cons	Notes
Visual Borescope	$2.4M	264 Working Days	• Rapid deployment and examination results • Substantial and diverse viewing area • Easily transportable	• Debris could obstruct view • Possible maneuverability limitations due to length • Qualitative visual data only	• Long pan & tilt borescope requires 2.5 inch or larger access port • It is assumed that one system will be used for all duct inspections
Spot Ultrasonic Crawler	$2.7M	334 Working Days	• Provides quantitative wall thickness measurements	• May require couplant • Thickness measurements may be affected by corrosion • Limited movement through bends and valve areas	• Crawler requires 6 inch or larger access port • Push probe has limited range compared to crawler • It is assumed that one system will be used for all duct inspections
MFL	$2.9M	364 Working Days	• Provides quantitative data • Couplant not required • Detects pitting, corrosion, and other damage	• Very large port required • Range restricted by valves	• It is assumed that one system will be used for all duct inspections

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H-2-64400, Sh. 5, Rev 16. IEFD AY Tank Farm

H-2-64400, Sh. 6, Rev 8. IEFD AY Tank Farm

H-2-64400, Sh. 12, Rev 4. IEFD AY Tank Farm

H-2-68335, Sh. 3, Rev 12. IEFD Tank Farm

H-2-68335, Sh. 4, Rev 11. IEFD Tank Farm

H-2-68335, Sh. 7, Rev 14. IEFD Tank Farm

H-2-68335, Sh. 8, Rev 3. IEFD Tank Farm

H-2-68335, Sh. 11, Rev 1. IEFD Tank Farm

H-2-68335, Sh. 18, Rev 2. IEFD Tank Farm

H-2-68335, Sh. 19, Rev 2. IEFD Tank Farm

H-2-68335, Sh. 22, Rev 2. IEFD Tank Farm

H-2-68335, Sh. 23, Rev 3. IEFD Tank Farm

H-2-70337, Sh. 1, Rev 5. HVAC/Piping Vent Piping Plan 241 AW Tank Farm

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H-14-020101, Sh. 1, Rev 15. Ventilation Tank Primary System (VTP) O&M System P&ID

H-14-020101, Sh. 2, Rev 10. Ventilation Tank Primary System (VTP) O&M System P&ID

H-14-020101, Sh. 3, Rev 16. Ventilation Tank Primary System (VTP) O&M System P&ID

H-14-020101, Sh. 4, Rev 13. Ventilation Tank Primary System (VTP) O&M System P&ID

H-14-020101, Sh. 6, Rev 3. Ventilation Tank Primary System (VTP) O&M System P&ID

H-14-020101, Sh. 7, Rev 5. Ventilation Tank Primary System (VTP) O&M System P&ID

H-14-020101, Sh. 8, Rev 5. Ventilation Tank Primary System (VTP) O&M System P&ID

H-14-020101, Sh. 9, Rev 6. Ventilation Tank Primary System (VTP) O&M System P&ID

H-14-020101, Sh. 10, Rev 8. Ventilation Tank Primary System (VTP) A-Train O&M System P&ID

H-14-020101, Sh. 11, Rev 9. Ventilation Tank Primary System (VTP) B-Train O&M System P&ID

H-14-020101, Sh. 12, Rev 7. Ventilation Tank Primary System (VTP) A-Train O&M System P&ID

H-14-020101, Sh. 13, Rev 7. Ventilation Tank Primary System (VTP) B-Train O&M System P&ID

H-14-020102, Sh. 1, Rev 12. Ventilation Tank Primary System (VTP) O&M System P&ID

H-14-020102, Sh. 2, Rev 18. Ventilation Tank Primary System (VTP) O&M System P&ID

H-14-020102, Sh. 3, Rev 10. Ventilation Tank Primary System (VTP) Stack Monitor P&ID

H-14-020102, Sh. 4, Rev 5. P&ID 241-AW HVAC Symbol Legend

H-14-020102, Sh. 5, Rev 4. P&ID 241-AW HVAC Tank Pressure Monitoring

H-14-020102, Sh. 6, Rev 5. P&ID 241-AW HVAC Tank Pressure Monitoring

H-14-020102, Sh. 7, Rev 4. P&ID 241-AW HVAC Tank Pressure Monitoring

H-14-020102, Sh. 8, Rev 6. P&ID 241-AW-HVAC De-Entrainer

H-14-020102, Sh. 9, Rev 7. P&ID 241-AW HVAC Exhauster Train "A"

H-14-020102, Sh. 10, Rev 7. P&ID 241-AW HVAC Exhauster Train "B"

H-14-020102, Sh. 11, Rev 6. P&ID 241-AW HVAC Exhauster Train "A"

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H-14-020103, Sh. 1, Rev. 4. Ventilation Tank Primary System (VTP) O&M System P&ID

H-14-020103, Sh. 2, Rev. 13. Ventilation Tank Primary System (VTP) O&M System P&ID

H-14-020103, Sh. 3, Rev. 11. Ventilation Tank Primary System (VTP) Stack Monitor P&ID

H-14-020103, Sh. 10, Rev. 2. Ventilation Tank Primary System (VTP) A & B Train O&M SYS P&ID

H-14-020103, Sh. 11, Rev. 2. Ventilation Tank Primary System (VTP) A-Train O&M SYS P&ID

H-14-020103, Sh. 12, Rev. 2. Ventilation Tank Primary System (VTP) B-Train O&M SYS P&ID

H-14-020103, Sh. 13, Rev. 2. Ventilation Tank Primary System (VTP) A-Train O&M SYS P&ID

H-14-020103, Sh. 14, Rev. 2. Ventilation Tank Primary System (VTP) B-Train O&M SYS P&ID

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H-14-020106, Sh. 1, Rev 13. Ventilation Tank Primary System (VTP) O&M System P&ID

H-14-020106, Sh. 2, Rev 12. Ventilation Tank Primary System (VTP) O&M System P&ID

H-14-020107, Sh. 1, Rev 15. Ventilation Tank Primary System (VTP) O&M System P&ID

H-14-020107, Sh. 2, Rev 14. Ventilation Tank Primary System (VTP) O&M System P&ID

H-14-020107, Sh. 3, Rev 9. Ventilation Tank Primary System (VTP) O&M System P&ID

H-14-020107, Sh. 4, Rev 6. Ventilation Tank Primary System (VTP) O&M System P&ID

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H-14-020107, Sh. 7, Rev 0. Ventilation Tank Primary System (VTP) O&M System Schedules

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H-14-020131, Sh. 5, Rev 4. Ventilation Tank Primary System (VTP) O & M System P&ID

H-14-020131, Sh. 10, Rev 2. Ventilation Tank Primary System (VTP) A & B Train O&M SYS P&ID

H-14-020131, Sh. 11, Rev 3. Ventilation Tank Primary System (VTP) A-Train O&M SYS P&ID

H-14-020131, Sh. 12, Rev 3. Ventilation Tank Primary System (VTP) B-Train O&M SYS P&ID

H-14-020131, Sh. 13, Rev 3. Ventilation Tank Primary System (VTP) A-Train O&M SYS P&ID

H-14-020131, Sh. 14, Rev 3. Ventilation Tank Primary System (VTP) B-Train O&M SYS P&ID

H-14-020131, Sh. 15, Rev 1. Ventilation Tank Primary System (VTP) O&M System P&ID

Appendix A: Review of Ductwork Drawings and Configurations

DST PRIMARY VENTILATION DRAWING REVIEW

TANK FARM	TANK #	DUCT SIZE TO FLOW TEST PORT	FLOW TEST PORT SIZE	FLOW TEST PORT LOCATION	BELOW/ABOVE GRADE?	APPROX. DUCT LENGTH TO BE TESTED	VALVE IN DUCT TO BE TESTED?	OTHER POTENTIAL INST. INSERTION LOCATIONS	REFERENCES
AN FARM	101	12"EXH-M40, 12" BLACK CS, ASTM A135, .133' WALL	2 EA, ¾" DIA. W/ 1 ½" PIPE PLUG (*NEW) 1 EA, 2" DIA. PORT (**OLD)	VENT INSTRUMENT PIT #2	BELOW GRADE	50'	No butterfly valve down stream of flow test ports.	May be large ports at demister. There is one butterfly valve in the duct between the demister and the duct to be inspected.	B-130-C7, SECT. 15415 ECN-12-000467 H-14-020101 H-2-72031 H-2-72042
	102	12"EXH-M40, 12" BLACK CS, ASTM A135, .133' WALL	2 EA, ¾" DIA. W/ 1 ½" PIPE PLUG (*NEW) 1 EA, 2" DIA. PORT (**OLD)	VENT INSTRUMENT PIT #1	BELOW GRADE	150'	No butterfly valve down stream of flow test ports.	May be large ports at demister. There is one butterfly valve in the duct between the demister and the duct to be inspected.	B-130-C7, SECT. 15415 ECN-12-000467 H-14-020101 H-2-72031 H-2-72042
	103	12"EXH-M40, 12" BLACK CS, ASTM A135, .133' WALL	2 EA, ¾" DIA. W/ 1 ½" PIPE PLUG (*NEW) 1 EA, 2" DIA. PORT (**OLD)	VENT INSTRUMENT PIT #1	BELOW GRADE	50'	No butterfly valve down stream of flow test ports.	May be large ports at demister. There is one butterfly valve in the duct between the demister and the duct to be inspected.	B-130-C7, SECT. 15415 ECN-12-000467 H-14-020101 H-2-72031 H-2-72042
	104	12"EXH-M40, 12" BLACK CS, ASTM A135, .133' WALL	2 EA, ¾" DIA. W/ 1 ½" PIPE PLUG (*NEW) 1 EA, 2" DIA. PORT (**OLD)	VENT INSTRUMENT PIT #2	BELOW GRADE	150'	No butterfly valve down stream of flow test ports.	May be large ports at demister. There is one butterfly valve in the duct between the demister and the duct to be inspected.	B-130-C7, SECT. 15415 ECN-12-000467 H-14-020101 H-2-72031 H-2-72042
	105	12"EXH-M40, 12" BLACK CS, ASTM A135, .133' WALL	2 EA, ¾" DIA. W/ 1 ½" PIPE PLUG (*NEW) 1 EA, 2" DIA. PORT (**OLD)	VENT INSTRUMENT PIT #3	BELOW GRADE	50'	No butterfly valve down stream of flow test ports.	May be large ports at demister. There is one butterfly valve in the duct between the demister and the duct to be inspected.	B-130-C7, SECT. 15415 ECN-12-000467 H-14-020101 H-2-72031 H-2-72042
	106	12"EXH-M40, 12" BLACK CS, ASTM A135, .133' WALL	2 EA, ¾" DIA. W/ 1 ½" PIPE PLUG (*NEW) 1 EA, 2" DIA. PORT (**OLD)	VENT INSTRUMENT PIT #3	BELOW GRADE	150'	No butterfly valve down stream of flow test ports.	May be large ports at demister. There is one butterfly valve in the duct between the demister and the duct to be inspected.	B-130-C7, SECT. 15415 ECN-12-000467 H-14-020101 H-2-72031 H-2-72042
	107	12"EXH-M40, 12" BLACK CS, ASTM A135, .133' WALL	2 EA, ¾" DIA. W/ 1 ½" PIPE PLUG (*NEW) 1 EA, 2" DIA. PORT (**OLD)	VENT INSTRUMENT PIT #3	BELOW GRADE	100'	No butterfly valve down stream of flow test ports.	May be large ports at demister. There is one butterfly valve in the duct between the demister and the duct to be inspected.	B-130-C7, SECT. 15415 ECN-12-000467 H-14-020101 H-2-72031 H-2-72042

DST PRIMARY VENTILATION DRAWING REVIEW

TANK FARM	TANK #	DUCT SIZE TO FLOW TEST PORT	FLOW TEST PORT SIZE	FLOW TEST PORT LOCATION	BELOW/ABOVE GRADE?	APPROX. DUCT LENGTH TO BE TESTED	VALVE IN DUCT TO BE TESTED?	OTHER POTENTIAL INST. INSERTION LOCATIONS	REFERENCES
AP FARM	**101**	12"EXH-M40 12" BLACK CS, ASTM A53, TYPE S, GR B OR ASTM A106, GR B, SCH 20	2 EA, ¾" DIA. W/ 1 ½" PIPE PLUG (*NEW) 1 EA, 2" DIA. PORT (**OLD)	VENT PIT 1	BELOW GRADE	250'	No butterfly valve down stream of flow test ports.	May be large ports at demister. There is one butterfly valve in the duct between the demister and the duct to be inspected.	B-340-C7 H-14-020103 ECN-12-000461 H-2-90510 H-2-90835
	102	12"EXH-M40 12" BLACK CS, ASTM A53, TYPE S, GR B OR ASTM A106, GR B, SCH 20	2 EA, ¾" DIA. W/ 1 ½" PIPE PLUG (*NEW) 1 EA, 2" DIA. PORT (**OLD)	VENT PIT 1	BELOW GRADE	200'	No butterfly valve down stream of flow test ports.	May be large ports at demister. There is one butterfly valve in the duct between the demister and the duct to be inspected.	B-340-C7 H-14-020103 ECN-12-000461 H-2-90510
	103	12"EXH-M40 12" BLACK CS, ASTM A53, TYPE S, GR B OR ASTM A106, GR B, SCH 20	2 EA, ¾" DIA. W/ 1 ½" PIPE PLUG (*NEW) 1 EA, 2" DIA. PORT (**OLD)	VENT PIT 1	BELOW GRADE	100'	No butterfly valve down stream of flow test ports.	May be large ports at demister. There is one butterfly valve in the duct between the demister and the duct to be inspected.	B-340-C7 H-14-020103 ECN-12-000461 H-2-90510
	104	12"EXH-M40 12" BLACK CS, ASTM A53, TYPE S, GR B OR ASTM A106, GR B, SCH 20	2 EA, ¾" DIA. W/ 1 ½" PIPE PLUG (*NEW) 1 EA, 2" DIA. PORT (**OLD)	VENT PIT 1	BELOW GRADE	40'	No butterfly valve down stream of flow test ports.	May be large ports at demister. There is one butterfly valve in the duct between the demister and the duct to be inspected.	B-340-C7 H-14-020103 ECN-12-000461 H-2-90510
	105	12"EXH-M40 12" BLACK CS, ASTM A53, TYPE S, GR B OR ASTM A106, GR B, SCH 20	2 EA, ¾" DIA. W/ 1 ½" PIPE PLUG (*NEW) 1 EA, 2" DIA. PORT (**OLD)	VENT PIT 2	BELOW GRADE	100'	No butterfly valve down stream of flow test ports.	May be large ports at demister. There is one butterfly valve in the duct between the demister and the duct to be inspected.	B-340-C7 H-14-020103 ECN-12-000461 H-2-90510
	106	12"EXH-M40 12" BLACK CS, ASTM A53, TYPE S, GR B OR ASTM A106, GR B, SCH 20	2 EA, ¾" DIA. W/ 1 ½" PIPE PLUG (*NEW) 1 EA, 2" DIA. PORT (**OLD)	VENT PIT 2	BELOW GRADE	30'	No butterfly valve down stream of flow test ports.	May be large ports at demister. There is one butterfly valve in the duct between the demister and the duct to be inspected.	B-340-C7 H-14-020103 ECN-12-000461 H-2-90510
	107	12"EXH-M40 12" BLACK CS, ASTM A53, TYPE S, GR B OR ASTM A106, GR B, SCH 20	2 EA, ¾" DIA. W/ 1 ½" PIPE PLUG (*NEW) 1 EA, 2" DIA. PORT (**OLD)	VENT PIT 2	BELOW GRADE	250'	No butterfly valve down stream of flow test ports.	May be large ports at demister. There is one butterfly valve in the duct between the demister and the duct to be inspected.	B-340-C7 H-14-020103 ECN-12-000461 H-2-90510
	108	12"EXH-M40 12" BLACK CS, ASTM A53, TYPE S, GR B OR ASTM A106, GR B, SCH 20	2 EA, ¾" DIA. W/ 1 ½" PIPE PLUG (*NEW) 1 EA, 2" DIA. PORT (**OLD)	VENT PIT 2	BELOW GRADE	200'	No butterfly valve down stream of flow test ports.	May be large ports at demister. There is one butterfly valve in the duct between the demister and the duct to be inspected.	B-340-C7 H-14-020103 ECN-12-000461 H-2-90510

DST PRIMARY VENTILATION DRAWING REVIEW

TANK FARM	TANK #	DUCT SIZE TO FLOW TEST PORT	FLOW TEST PORT SIZE	FLOW TEST PORT LOCATION	BELOW/ABOVE GRADE?	APPROX. DUCT LENGTH TO BE TESTED	VALVE IN DUCT TO BE TESTED?	OTHER POTENTIAL INST. INSERTION LOCATIONS	REFERENCES
AW FARM	101	12"V-M40 12" BLACK CS, ASTM A135, GR A, .133" WALL	2 EA, ¾" DIA. W/ 1 ½" PIPE PLUG (*NEW) 1 EA, 2" DIA. PORT (**OLD)	VENT INST PIT 1	BELOW GRADE	150'	No butterfly valve down stream of flow test ports.	May be large ports at demister. There is one butterfly valve in the duct between the demister and the duct to be inspected.	B-120-C7, Sect 15415 H-2-70337 H-14-020102 H-2-70341 ECN-12-000465
	102	12"V-M40 12" BLACK CS, ASTM A135, GR A, .133" WALL	2 EA, ¾" DIA. W/ 1 ½" PIPE PLUG (*NEW) 1 EA, 2" DIA. PORT (**OLD)	VENT INST PIT 3	BELOW GRADE	150'	No butterfly valve down stream of flow test ports.	May be large ports at demister. There is one butterfly valve in the duct between the demister and the duct to be inspected.	B-120-C7, Sect 15415 H-2-70337 H-14-020102 H-2-70341 ECN-12-000465
	103	12"V-M40 12" BLACK CS, ASTM A135, GR A, .133" WALL	2 EA, ¾" DIA. W/ 1 ½" PIPE PLUG (*NEW) 1 EA, 2" DIA. PORT (**OLD)	VENT INST PIT 1	BELOW GRADE	50'	No butterfly valve down stream of flow test ports.	May be large ports at demister. There is one butterfly valve in the duct between the demister and the duct to be inspected.	B-120-C7, Sect 15415 H-2-70337 H-14-020102 H-2-70341 ECN-12-000465
	104	12"V-M40 12" BLACK CS, ASTM A135, GR A, .133" WALL	2 EA, ¾" DIA. W/ 1 ½" PIPE PLUG (*NEW) 1 EA, 2" DIA. PORT (**OLD)	VENT INST PIT 3	BELOW GRADE	50'	No butterfly valve down stream of flow test ports.	May be large ports at demister. There is one butterfly valve in the duct between the demister and the duct to be inspected.	B-120-C7, Sect 15415 H-2-70337 H-14-020102 H-2-70341 ECN-12-000465
	105	12"V-M40 12" BLACK CS, ASTM A135, GR A, .133" WALL	2 EA, ¾" DIA. W/ 1 ½" PIPE PLUG (*NEW) 1 EA, 2" DIA. PORT (**OLD)	VENT INST PIT 2	BELOW GRADE	75'	No butterfly valve down stream of flow test ports.	May be large ports at demister. There is one butterfly valve in the duct between the demister and the duct to be inspected.	B-120-C7, Sect 15415 H-2-70337 H-14-020102 H-2-70341 ECN-12-000465
	106	12"V-M40 12" BLACK CS, ASTM A135, GR A, .133" WALL	2 EA, ¾" DIA. W/ 1 ½" PIPE PLUG (*NEW) 1 EA, 2" DIA. PORT (**OLD)	VENT INST PIT 2	BELOW GRADE	25'	No butterfly valve down stream of flow test ports.	May be large ports at demister. There is one butterfly valve in the duct between the demister and the duct to be inspected.	B-120-C7, Sect 15415 H-2-70337 H-14-020102 H-2-70341 ECN-12-000465
AY FARM	101	10"V-AY12000-M9, 10" SST, 304L, ASTM A312, SCH 10	2 EA, ¾" DIA. W/ 1 ½" PIPE PLUG	WITHIN RECIRC. BUILDING	BELOW GRADE	100'	Yes, multiple butterfly valves in duct between tank riser and flow test ports.	Port in duct close to tank unknown size and assumed to be below grade.	HWS-7792 H-14-020106 ECN-12-000924
	102	10"V-AY12000-M9, 10" SST, 304L, ASTM A312, SCH 10	2 EA, ¾" DIA. W/ 1 ½" PIPE PLUG	WITHIN RECIRC. BUILDING	BELOW GRADE	100'	Yes, multiple butterfly valves in duct between tank riser and flow test ports.	Port in duct close to tank unknown size and assumed to be below grade. 8" port inside recirc/cooling building with butterfly valve.	HWS-7792 H-14-020106 ECN-12-000924 H-2-64400

DST PRIMARY VENTILATION DRAWING REVIEW

TANK FARM	TANK #	DUCT SIZE TO FLOW TEST PORT	FLOW TEST PORT SIZE	FLOW TEST PORT LOCATION	BELOW/ABOVE GRADE?	APPROX. DUCT LENGTH TO BE TESTED	VALVE IN DUCT TO BE TESTED?	OTHER POTENTIAL INST. INSERTION LOCATIONS	REFERENCES
AZ FARM	101	10"V-AZ12000-M9, 10" SST, 304L, ASTM A312, SCH 10	2 EA, ¾" DIA W/ 1 ½" PIPE PLUG	WITHIN RECIRC. BUILDING	BELOW GRADE	100'	Yes, multiple butterfly valves in duct between tank riser and flow test ports.	Port in duct close to tank unknown size and assumed to be below grade. 8" port inside recirc/cooling building with butterfly valve.	HWS-7792 H-14-020107 ECN-12-000924 H-2-68335
	102	10"V-AZ12000-M9, 10" SST, 304L, ASTM A312, SCH 10	2 EA, ¾" DIA W/ 1 ½" PIPE PLUG	WITHIN RECIRC. BUILDING	BELOW GRADE	100'	Yes, multiple butterfly valves in duct between tank riser and flow test ports.	Port in duct close to tank unknown size and assumed to be below grade. 8" port inside recirc/cooling building with butterfly valve.	HWS-7792 H-14-020107 ECN-12-000924 H-2-68335
SY FARM	101	12" DUCTIONG SCH 40 GALVANIZED OR PLAIN CS	2 EA, ¾" DIA W/ 1 ½" PIPE PLUG (*NEW)	Ports added to duct per ECN-12-000466	ABOVE GRADE	10'	Yes, butterfly valve in duct between tank riser and flow test port.	May be large ports available at portable exhauster connection. However, there is at least two butterfly valves in the duct between the portable exhauster port and the duct to be inspected.	ECN-12-000466 H-2-37745 H-2-37746 H-14-020131
	102	12" DUCTIONG SCH 40 GALVANIZED OR PLAIN CS	2 EA, ¾" DIA W/ 1 ½" PIPE PLUG (*NEW)	Ports added to duct per ECN-12-000466	ABOVE GRADE	10'	Yes, butterfly valve in duct between tank riser and flow test port.	May be large ports available at portable exhauster connection. However, there is at least two butterfly valves in the duct between the portable exhauster port and the duct to be inspected.	ECN-12-000466 H-2-37745 H-2-37746 H-14-020131
	103	12" DUCTIONG SCH 40 GALVANIZED OR PLAIN CS	2 EA, ¾" DIA W/ 1 ½" PIPE PLUG (*NEW)	Ports added to duct per ECN-12-000466	ABOVE GRADE	75'	Yes, butterfly valve in duct between tank riser and flow test port.	May be large ports available at portable exhauster connection. However, there is at least two butterfly valves in the duct between the portable exhauster port and the duct to be inspected.	ECN-12-000466 H-2-37745 H-2-37746 H-14-020131

TYPE 1 – SMALL FLOW SAMPLE PORTS ADDED TO DUCT (AN, AP and AW FARMS)

TYPE 2 – LARGE SAMPLE PORT AVALABLE (AY/AZ FARM)

TYPE 3 – SMALL SAMPLE PORTS ADDED TO DUCT-ABOVE GRADE (SY FARM)

* **FLOW SAMPLE PORTS ADDED RECENTLY**

** **PORT INSTALLED AT CONSTRUCTION OF TANK FARM**

Appendix B: Referenced Figures

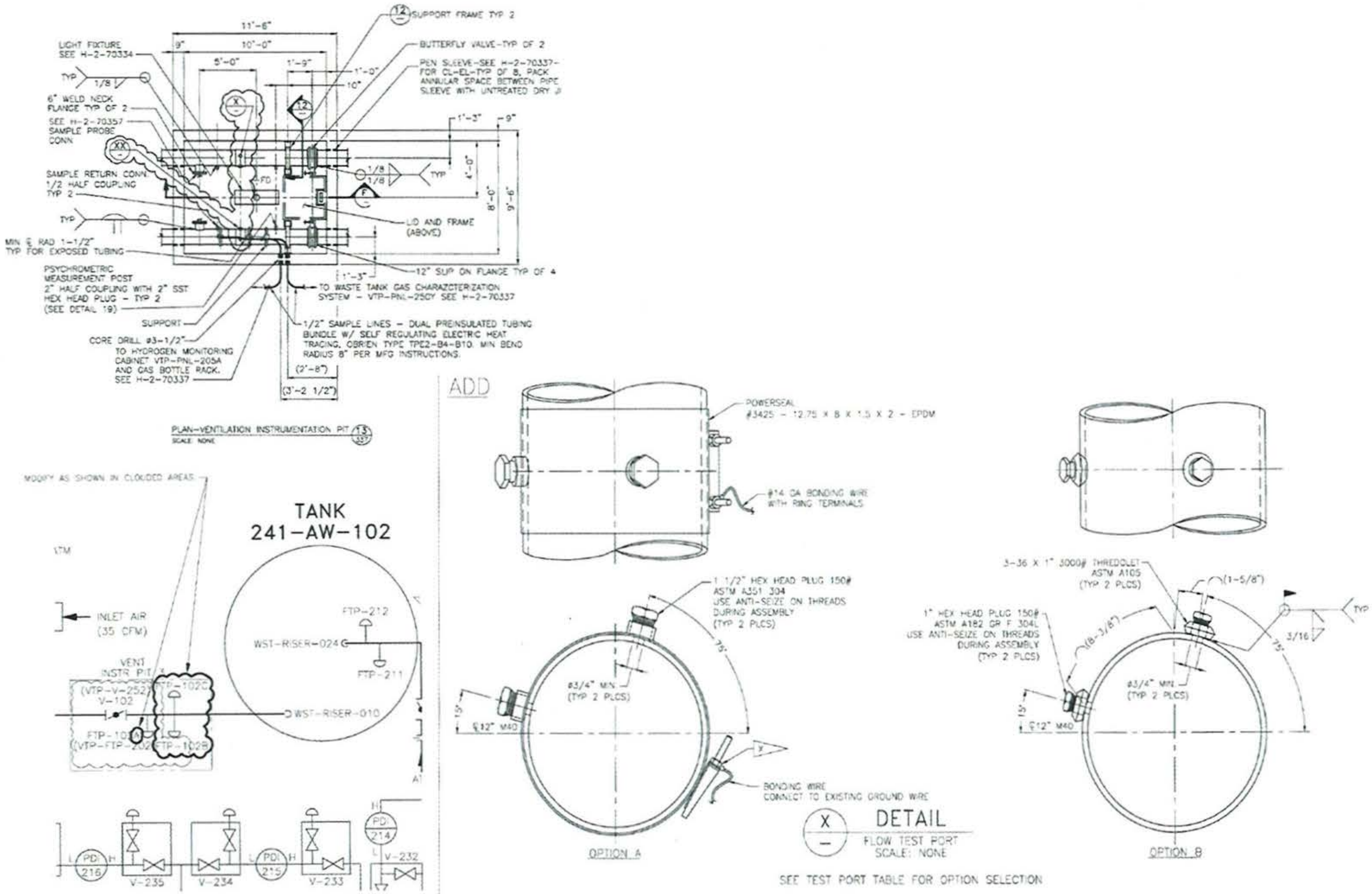


Figure B-1: Excerpt from ECN-12-000465

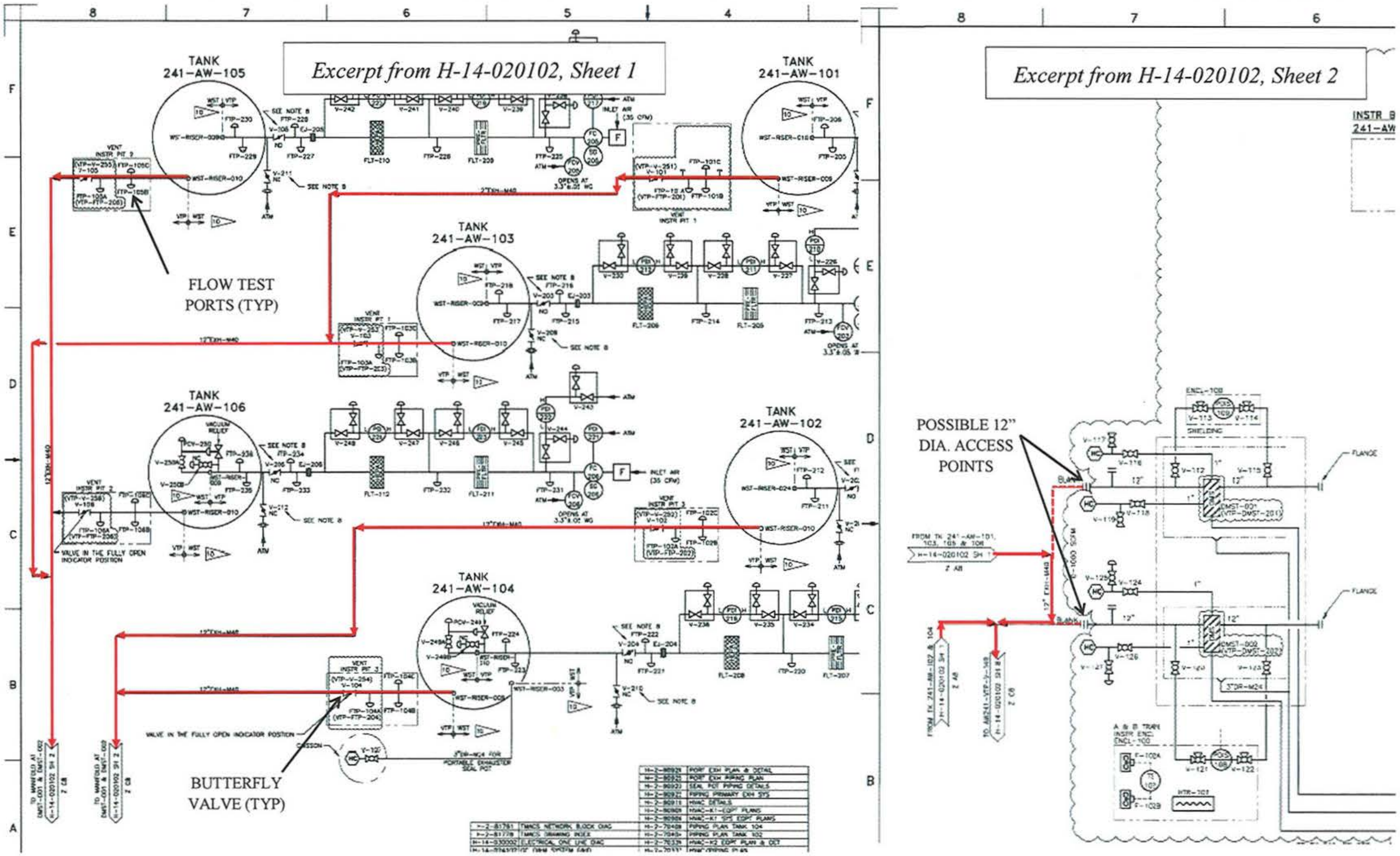


Figure B-2: AW Farm Primary Ventilation P&ID (H-14-020102, Sh. 1 & 2) with Annotations in Red

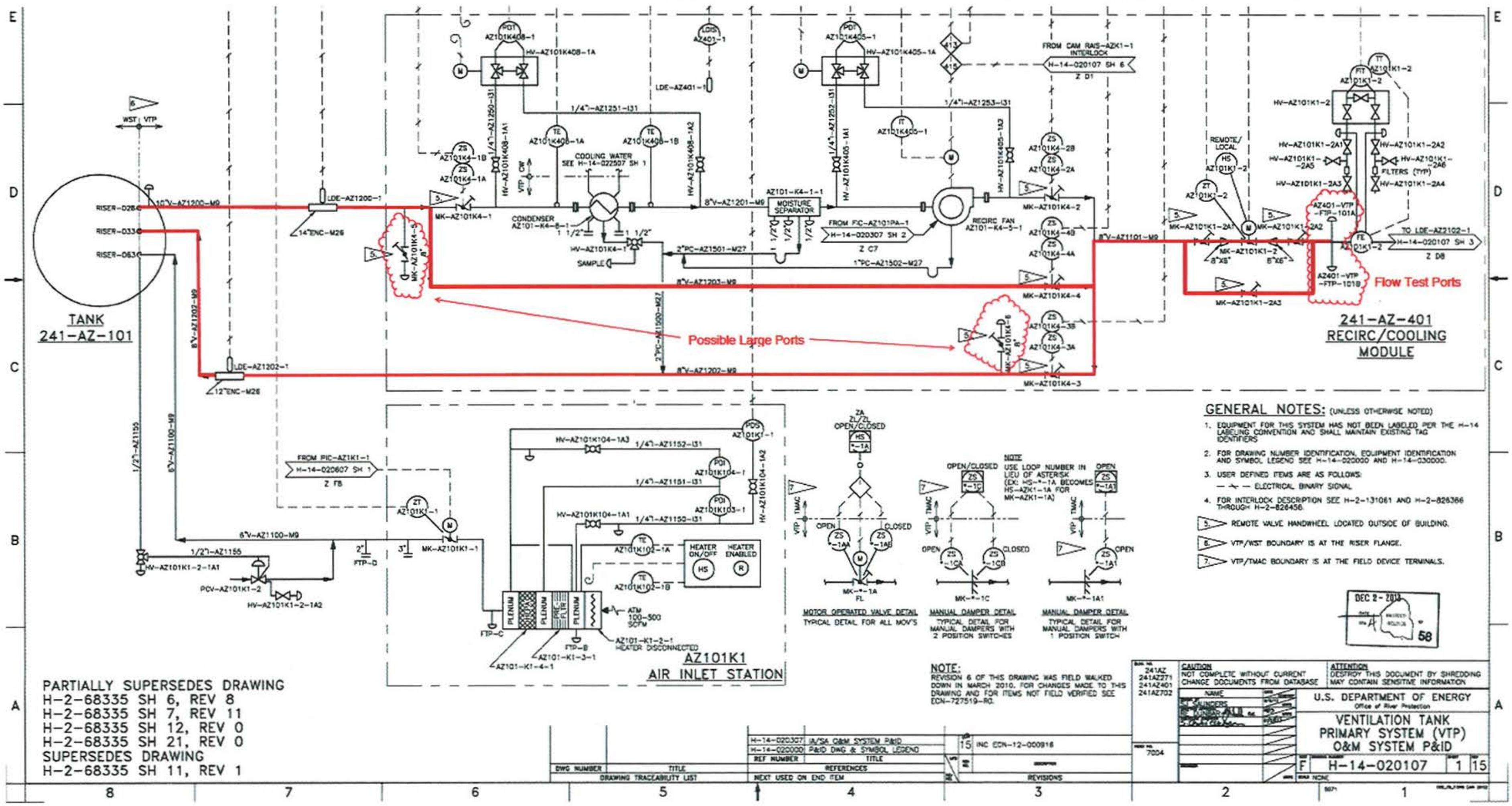


Figure B-3: AZ-101 Primary Ventilation P&ID (H-14-020107, Sh. 1) with Annotations in Red

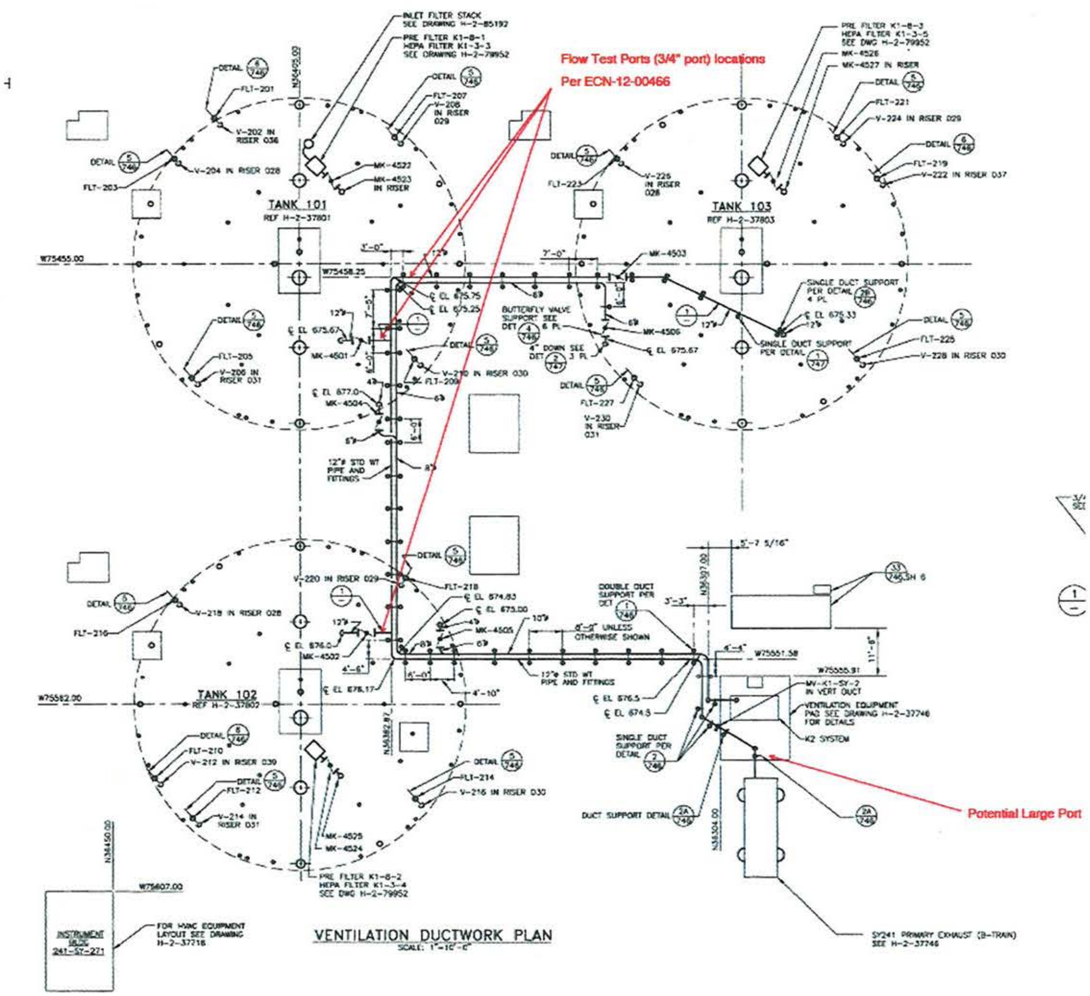
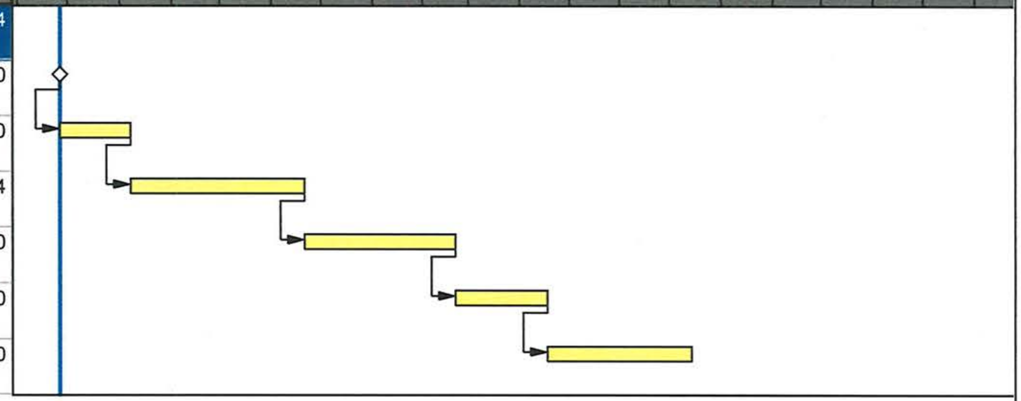


Figure B-4: SY Farm Ventilation Ductwork (H-2-37745

Appendix C: Schedule Estimate Information

[PROVIDED BY WRPS]

Option 1 - Visual Inspection		264
1	Option 1 Kickoff	0
VIS-1-3-01	Development Testing	30
VIS-1-3-02	Engineering Design	74
VIS-1-3-03	Work Package Planning	60
VIS-1-3-04	Field Work	40
VIS-1-3-05	Final Report	60



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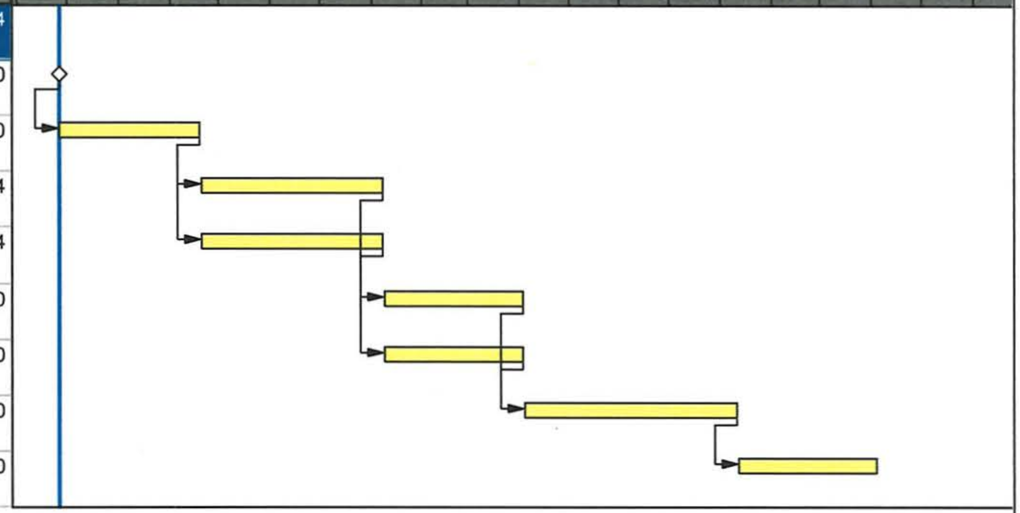
Option 2 - Ultrasonic Testing		344	
2	Option 2 Kickoff	0	
UT-1-3-01	Development Testing	60	
UT-1-3-02	Engineering Design	74	
UT-1-3-03	Crawler Design / Test Requirements (Kurion Input)	74	
UT-1-3-04	Work Package Planning	60	
UT-1-3-05	Crawler Procurement / Fabrication (Kurion Input)	60	
UT-1-3-06	Field Work	90	
UT-1-3-07	Final Report	60	



Option 3 - Mag Flux Testing		388
3	Option 3 Kickoff	0
MF-1-3-01	Development Testing	84
MF-1-3-02	Engineering Design	84
MF-1-3-03	Mag Flux Design / Test Requirements (Kurion Input)	84
MF-1-3-05	Work Package Planning	60
MF-1-3-04	Mag Flux Procurement / Fabrication (Kurion Input)	60
MF-1-3-06	Field Work	100
MF-1-3-07	Final Report	60