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Revision 1

Tank 16 Annulus Cleaning Demonstration

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Attachment 1 through 5 Demonstration set up photographs

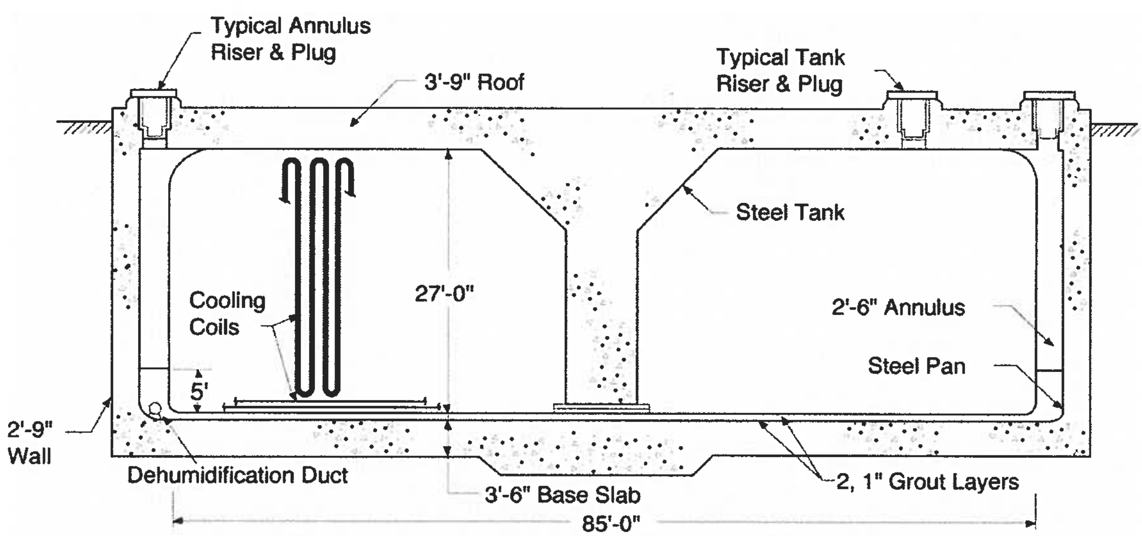
Attachment 6 "Lil Bertha" nozzle photograph

1.0 PURPOSE

The purpose of Tank 16 Annulus cleaning demonstration is to evaluate the ability to effectively clean a simulated Type II Tank annulus space which includes removing a simulate material from the inside as well as outside of the ventilation duct. The demonstration will also determine if these two cleaning methods will adversely impact the safety of personnel and/or results in the breach of the contamination boundary.

2.0 BACKGROUND

Tank 16H is a Type II tank that is currently empty and out of service. Historically, Tank 16 was used as a high heat waste receipt tank and was placed in service in May 1959. There are approximately 350 leak sites ranging in elevation from 16 inches to 288 inches from the tank bottom, which has allowed an accumulation of 7 to 16 inches of waste on the annulus floor. The following is a typical diagram of a Type II Tank Structure.



The annulus cleaning process consists of two phases. The first phase was a "demonstration" phase where the smaller scale mockup of the proposed waste removal design was tested to determine its feasibility. Based on the results from Phase I, if required, the design will be modified prior to the implementation of phase II. A brief description of each phase is given below.

Phase I – Demonstration Phase

The feasibility of the implementation and effectiveness of the proposed design solution were tested in a "mock up" of Tank 16 annulus. The detail of the demonstration set up is discussed in the following section. The test was carried out using vendor furnished equipment (high pressure rig, hoses, nozzles) to remove a non-radioactive simulant from the inside and outside of the ventilation duct. The simulant recipe was based on the sample analysis of Tank 16 annulus waste. This test was a "proof of concept" to validate that the proposed design solution can effectively remove the actual radioactive waste in Tank 16 annulus, provide for the safety of the workers, protect the environment and meet SRS safety requirements identified in the authorization basis (AB) documents. Mock-up scale was considered suitable to validate the design solutions.

Phase II – Additional Annulus Cleaning
This phase will be the actual removal of the residuals from Tank 16 annulus and from inside the annulus duct. The objective of this phase is to use tools, equipment and facilities necessary for mobilizing and removal of radioactive waste from Tank 16 Annulus and in preparation for Tank 16 closure. The proposed design is to transfer Tank 16 annulus waste to Tank 13. It is recommended to incorporate "lesson learned" from the mock up test into the design solutions for phase II.

3.0 DEMONSTRATION SET UP

A 40 foot Sea-Land with the inside modified was used to simulate a section of a Type II Tank's annulus space. The modification included vertical and horizontal sections of ventilation duct as depicted in Attachments 1 through 5. The duct was fabricated from 16 gauge galvanized sheet metal with 20 inch diameter reducing to 12 inch diameter with a tapered reducer. This represented the full scale model of the duct as installed in Tank 16 annulus. The simulant was mobilized by the kinetic energy of the water jets produced by nozzle(s). The nozzle design varied for the inside and outside of duct cleaning. Detail discussion of nozzles and the simulant removal process is given below.

Inside the duct

The supply system for mobilizing simulant inside the duct included a self-propelled high pressure hose and a spray nozzle (Attachment # 6, called "Lil-Bertha"). The high pressure equipment, hose, and nozzle were provided by external vendor Augusta Industrial (AI). The high pressure rig had a maximum capacity of 2000 psi at 60 gpm. The nozzle design enabled the nozzle to advance in the duct by the reaction of rear jets. Front jets were used to mobilize the material. Jet velocities were proportional to the supply pressure.

The transfer system was comprised of a suction screen, suction hose, a diaphragm pump, and a discharge hose to discharge slurry into a catch container. Two flush nozzles were provided at the suction screen to clear plugged up suction screen. The transfer system was suspended by a crane which enabled deployment of pump at the desired elevation.

Cameras were mounted on and inside the sea-land container to view the arosolization effect of the duct cleaning, performance of the nozzle when passing under the duct registers, flow pattern of the simulant, and plugging characteristic of simulant near the suction screen. A command center was set up about 100 feet away that housed display monitors to monitor and video tape simulant removal process.

Outside the duct

The process for mobilizing simulant from the outside of a duct uses a high pressure spray jet assembly with interchangeable spray nozzles. The jet assembly is mounted on a mast fabricated with an I-Beam. The vendor provided the high pressure (maximum of 2000 psi at 60 gpm) water source to the jet assembly. The jet assembly could be rotated on its vertical axis to aim water jets on either side of the duct.

The transfer system consisted of a suction screen, suction hose, diaphragm pump located at the far end of the Sea-Land trailer, and a discharge hose.

The camera mounted on the inside of the Sea-Land trailer monitored the jet action, simulant mobilization and flow pattern, and the transfer pump suction screen behavior.

Simulant Material

The primary component in the residuals inside Tank 16 annulus is Silica which is the residues from the previous sand blasting operation or from the sand bed between the Primary and Annulus floor. Hence, commercially available silicon sand (sandbox sand) was used as a simulant for both inside and outside of the duct. Sand was stacked about half full inside the duct while approximate ten to twelve inches was placed outside the duct. This represents more material than the expected material in the annulus.

4.0 PERFOMRANCE OBJECTIVES

4.1 Inside the duct cleaning

4.1.1 Determine the and effectiveness of "Lil Bertha" nozzle

a) Challenges in navigating nozzle through the duct
b) observe the flow pattern through registers
c) water pressure, hence the jet velocity required to effectively mobilize the solids and have a sustained flow of slurry for the continuous operation of the transfer pump
d) maximum pressure required for the optimum operation of nozzles
e) the nozzle behavior when passing under the duct's registers
f) the potential for aerosolization at the register and at the annulus duct inlet
g) ratio of water to solids to produce required flow and transferable slurry
h) effect of jet forces on the structural integrity of duct

4.1.2 Determine performance of the transfer system

a) capability of the transfer pump to pump out the slurry
b) air pressure needed to maintain sustained flow
c) observe the suction screen for pluggage
d) observe the flexibility of the suction hose for following the duct contour
e) synchronization of flow between supply through nozzle and transfer out through the transfer
f) effectiveness of flush water spray nozzles to remove pluggage
g) Vibration of the transfer pump

4.1.3 Asses the cleaning effectiveness of this process

a) Based on the material remaining in the duct, assess the cleaning effectiveness of this process

4.1.4 Safety

a) Assess the safety of personnel while performing stated task
b) Assess the possibility of releasing contaminants to the environment

4.1.5 Technical Bases Verification

Determine actual water:solid ratio for mobilizing solids to compare against the ratio used in the calculation

4.2 Outside the duct cleaning

4.2.1 Determine the effectiveness of jets and jet assembly

a) ease of maneuvering the mast manually against the jet forces
b) effectiveness of spray nozzles - determine which nozzle (10° and 30°) is most effective in mobilizing the material

c) Optimum height for each nozzle to maximize jet effectiveness in mobilizing solids
d) water pressure, hence the jet velocity required to effectively mobilize the solids and have a sustained flow of slurry for the continuous operation of the transfer pump
e) maximum pressure required for the optimum operation of nozzles
f) the potential for aerosolization at the annulus duct inlet
g) ratio of water to solids to produce required flow and transferable slurry
h) effect of jet forces on the structural integrity of duct

4.2.2 Determine performance of the transfer system

a) capability of the transfer pump to pump out the slurry
b) air pressure needed to maintain sustained flow
c) observe the suction screen for pluggage
d) synchronization of flow between supply through nozzle and transfer out through the transfer
e) effectiveness of flush water spray nozzles to remove pluggage
f) Vibration of the transfer pump

4.2.3 Assess the cleaning effectiveness

a) Based on the remaining material on the either side of the duct, assess the cleaning effectiveness of this process

4.2.4 Safety

a) Assess the safety of personnel while performing stated task
b) Assess the possibility of releasing contaminants to the environment

4.2.5 Technical Bases Verification

Determine actual water:solid ratio for mobilizing solids to compare against the ratio used in the calculation

5.0 RESULTS & OBSERVATIONS

5.1 Inside the duct cleaning

5.1.1 Solids mobilization and slurry flow pattern

5.1.1.1 Nozzle navigation

The nozzle navigated through the duct as designed with little to no hesitation. The initial pressure was 500 psig when the nozzle started advancing and it continued to advance as the pressure was increased. The nozzle slid on the bottom of the duct and did not lift up when pressure was increased. The maximum pressure to the nozzle was 1300 psig at the flowrate of 60 gpm. The rated capacity of vendor's equipment is 2000 psig. There was no interference to the nozzle propagation when it was passing under the register.

5.1.1.2 Solid's mobilization

The "Lil Bertha" nozzle was able to mobilize the solids as it advanced inside the duct. The jet forces did not have significant radial force to cause structural damage to the duct. The zone of jet's influence is judged to be approximately 2 in the longitudinal direction. The inside of 20 inch duct was completely covered with the jet, hence the effectiveness in the transverse (or radial) direction is judged to be at least 20 inches.

5.1.1.3 Flow pattern

As observed initially through the register, the mobilized material flowed towards the transfer pump suction in the slurry form. However, this could not be positively confirmed for the entire duration due to low visibility caused by the high volume of the water flowing under the register.

5.1.1.4 Water to Solids ratio

The following calculation estimates the ratio of water to solids required for mobilizing solids.

Total simulant in duct = 15 ft. length X 1.315 sq.ft. (half of ducts inside area)

= 19.7 ft3 = 147.1 gallons

Total water used = 60 gpm X 15 minutes = 900 gallons

Ratio of water: solids = 900/147 = 6.1

5.1.2 Pump Performance

5.1.2.1 Pump capability

The initial startup of the transfer pump was difficult with slurry. Some volume of the flush water was added at the pump suction to initiate the transfer. Once the flow was established, the pump was able to transfer the slurry synchronous with the supply flow. The pump operated intermittently throughout the demonstration. The intermittent flow is likely to result in to plugging of transfer line during the actual transfer.

5.1.2.2 Suction screen design

The current design of the suction screen is a cylindrical flat bottom with the flow entrances through the side notches of the screen. The difficulty in starting the flow initially without the addition of the flush water is attributed to the current design of the suction screen.

5.1.2.3 Suction hose maneuvering

There was some difficulty for the hose to pass through the "pants leg" of the duct. The hose was stiff enough not to follow the annulus contour which prevented suction head laying flat on the duct bottom. The condition of the duct in Tank 16 annulus is unknown. If the suction screen punctures the duct while lowering, the waste removal operation could be jeopardized.

5.1.2.4 Effectiveness of the suction screen spray nozzle

The spray nozzles were not very effective to unplug the suction screen and start the transfer flow.

5.1.2.5 Transfer Pump performance

The transfer pump is a positive displacement pump designed to provide desired flow rate at 60 psig of air pressure. The pressure control valve on the manifold was set to 80 psig. However, due to compressor's limitation, the maximum pressure at the pump was 44 psig. The pump was capable of maintaining sustained flow of slurry at this pressure. The operation of the pump produced noticeable vibrations in the transfer system. The excessive vibration poses a challenge of resonance with other component/structure/system during actual operation.

5.1.3 Cleaning effectiveness

Initially, approximately quarter of 20 inches duct was filled with the sand. Hence, the maximum depth of sand at the center of the duct was 5 inches. At the completion of the process, the thickness of the remaining sand layer is estimated to be ½" to 1" with few bare spots. There was an increased accumulation of sand near the transfer pump suction as compared to the residual sand on the duct surface. The process did not remove all solids from inside of the ventilation duct. Based on the overall residual volume, the cleaning effectiveness is judged to be between 70 to 80 percent.

5.1.4 Safety

During the initial start up the nozzle is located in the vertical larger duct called "pants leg" area. A water vapor migrating up the ventilation duct was noticed when the jets were initially started. When the nozzle was passing under the register of a duct the water spray was noticed coming out of the register. The aerosolization in the actual waste removal process means possible release of the contaminants outside the tank boundary.

5.1.5 Technical Bases Verification

The water:solids ratio could not be positively verified since the estimate of residual simulant inside the duct could not be assessed. The estimate from outside duct cleaning will be used instead.

5.2 Outside the duct cleaning

5.2.1 Supply System

5.2.1.1 Jet mast assembly

The vertical jet assembly is pinned at the top of the simulated riser and designed to be operated by hand. It was done by an operator standing to one side of the mast and moving it side to side using an attached pipe. This was performed with relative ease including while jets were in operation. However, this was much shorter mast (about 6 ft.) as compared to the actual mast length in the tank (about 30 ft.). Since the moment arm will be significantly higher in actual operation, this test of "ease of operation" is not considered conclusive.

5.2.1.2 Nozzles

The design of the nozzles varied based on the inside diameter of the nozzle and the vertical angle with respect to the mast. The inside diameter were ¼" and 3/8", and angles from the horizontal plane were 10^0 and 30^0.

The ¼" inside diameter nozzle did not provide enough force to mobilize the large volume of solids. The 3/8" nipple did mobilize considerable volume of solids and maintained sustained flow.

The 30^0 angle nozzle did not reach far enough to the suction screen and created a ridge between the nozzle location and suction screen. This prevented continuous flow of the mixed slurry and left significant volume of solids unaffected by jets.

The 10^0 angle nozzle directed jet beyond the suction screen spraying on the side of the sea-land container and left large volume of the solids untouched.

In summary, different combinations of nozzle orientations and inside diameters did not produce results as expected. The most promising nozzle diameter is considered to be 3/8" although it will require re-design to achieve stated objectives.

5.2.1.3 Structural Integrity of the duct

No structural damage to the duct was noted during the test. However, the duct used in the test is new with no degradation in its structural strength. The material strength, remaining thickness and physical condition of the existing annulus duct in Tank 16 is unknown. It is likely that the jet forces striking directly on the duct during changeover from one side to the other side of the duct will cause damage to the duct. The consequence of the damaged duct is that the broken metal pieces can block the slurry flow and/or the transfer pump suction screen which cannot be unplugged by the flush nozzle.

5.2.2 Transfer Pump Performance

The pump was located at one end of the Sea-Land with its suction line straight down with a different style suction head. The transfer pump was able to pump slurry but the discharge was intermittent since the supply of slurry to the pump suction was not consistent due to the obstructed flow by sand ridge. The additional supply of water from the flush nozzles helped minimize this problem. The operation of the pump produced vibrations which were noticed on the suction leg and suction screen. The affect of vibration problems discussed in section 5.1.2.5 are also applicable here.

5.2.3 Cleaning Effectiveness

Significant volume of material remained after cleaning on either side of the duct. It was difficult to quantify the effectiveness however a subjective evaluation judged the residual volume of sand was approximately 50% of the original volume. Hence the cleaning effort is judged to be unsatisfactory. A ridge can be seen after the cleaning, which prevented the flow of slurry to the transfer pump suction screen.

5.2.4 Safety

All nozzles had a spray pattern that would cause a concern for aerosolation in the annulus. Significant water vapor was noticed when jets were striking on the outside of the duct during the change from one side of the duct to the other side. At times, the water vapor aerosolization was significant enough to impair the visibility through the camera, hence the mast operator could not judge the location of the jet strike.

5.2.5 Technical Bases Verification

Water required for mobilizing the solids was considerably higher than initially estimated. The majority of water need was to keep solids in slurry form and maintain a sustained flow towards the transfer pump suction screen. Based on the supply flow rate of water and total time required to complete the process, the water:solids ratio is estimated to be 6:1.

6.0 RECOMMENDATIONS

6.1 Redesign the mast to achieve variable nozzle orientation

Having only two spray angles, 10° and 30° is restrictive in mobilizing the entire length of solids. It is recommended to redesign the mast to provide variable adjustability of the nozzle to direct jets to the desired location. Also, the current design of the mast does not allow adjustment on its height. Redesign to allow mast to be pinned at various heights.

6.2 Suction screen pluggage

a) Redesign suction screen
   The current flat bottom design of the suction screen is prone to plugging. Redesigned the suction screen with a larger suction area and curved surface.

b) Redesign drain lines
   Redirect the existing self-drain line to the suction screen to provide additional liquid to avoid pump starving.

6.3 Suction hose flexibility

Provide universal joints in the suction hose to allow it to easily follow duct's contour and enable positioning suction screen close to the duct's bottom.

6.4 Cleaning effectiveness

a) Redesign mast and nozzle mechanism (see 6.1)
b) Redesign nozzle(s) with offset to direct jets straight on the solids and avoid hitting on the duct surface.
c) For the outside cleaning, provide offset to the suction hose so it can be lowered between the duct and the annulus wall.
d) Redesign nozzles to achieve better nozzle profile and effective jet velocity.

6.5 Aerosolization

Redesign nozzle to reduce spray at the nozzle exit. This may reduce the water vapor but it is not likely to eliminate it.

6.6 Safety

a) Provide sleeve protection to camera cables around riser to avoid crushing between the mast and riser.

b) As discussed in sections 5.1.1.4 and 5.2.1.4 this process is likely to results into aerosolization in the tank annulus space and out of the tank through the duct's vertical section. Increased negative ventilation in the annulus during actual waste removal operation may avoid release of contaminants outside the tank boundary. However mitigating the risk of worker and outside contamination due to aerosolization coming from the duct poses a design/operational challenge.

6.7 Technical Bases

The current radiation dose rate is based on the water to solid dilution ratio of 3:1. Recalculate the flow sheet with dilution ratio of 6:1 to reduce the dose rate and hence the shielding requirements.

7.0 CONCLUSION

7.1 The volume of the residual waste inside the duct is likely to be low.

7.2 The volume of the residual waste outside the duct is likely to be significantly higher.

7.3 The modifications suggested in section 6.0 may improve the effectiveness.

7.4 The aerosolization of the waste is a likely event. Therefore, if this system is deployed, additional safety systems will have to be designed and installed and the facility will be required to a Hazard Category 2 (HC 2).

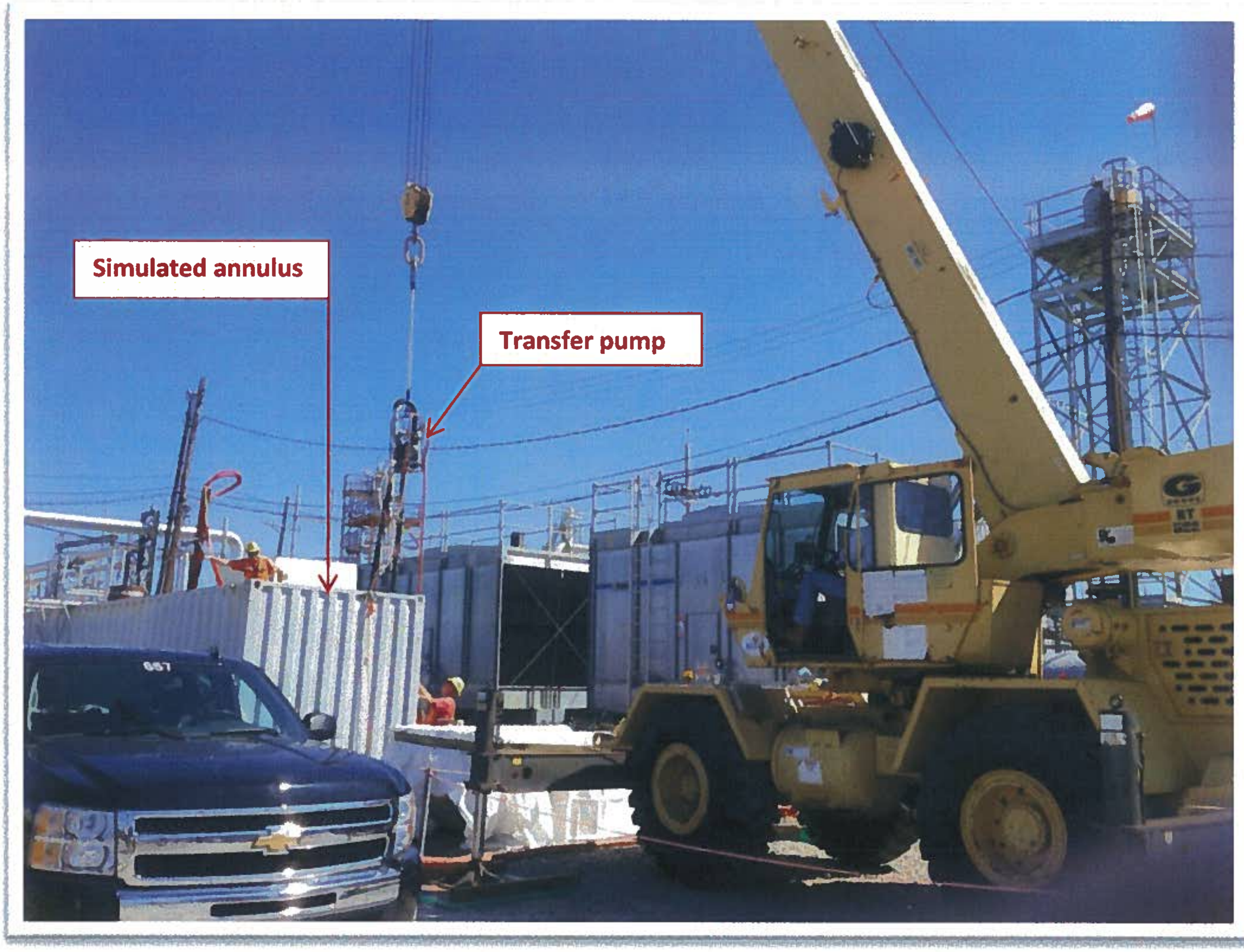
7.5 The structural integrity of the duct is likely to be maintained during the "inside duct" waste removal operation. However duct may be damaged during the "outside duct" waste removal.

8.0 COMPLIANCE MATRIX

The following matrix provide section numbers establishing correlations between the performance objectives, results, and recommendations/conclusions.

Performance objectives	Results	Recommendations/Conclusions
4.1.1	5.1.1	6.5, 7.1
4.1.2	5.1.2	6.2, 6.3
4.1.3	5.1.3	7.2
4.1.4	5.1.4	6.6, 7.4, 7.5
4.1.5	5.2.5	6.7
4.2.1	5.2.1	6.1, 6.5, 6.6
4.2.2	5.2.2	6.2, 6.5
4.2.3	5.2.3	6.4, 7.2, 7.3, 7.5
4.2.4	5.2.4	6.6, 7.4
4.2.5	5.2.5	6.7

ATTACHMENT # 1



TANK 16 ANNULUS CLEANING MOCK UP

ATTACHMENT # 2

Mock Up Location in H Tank Farm

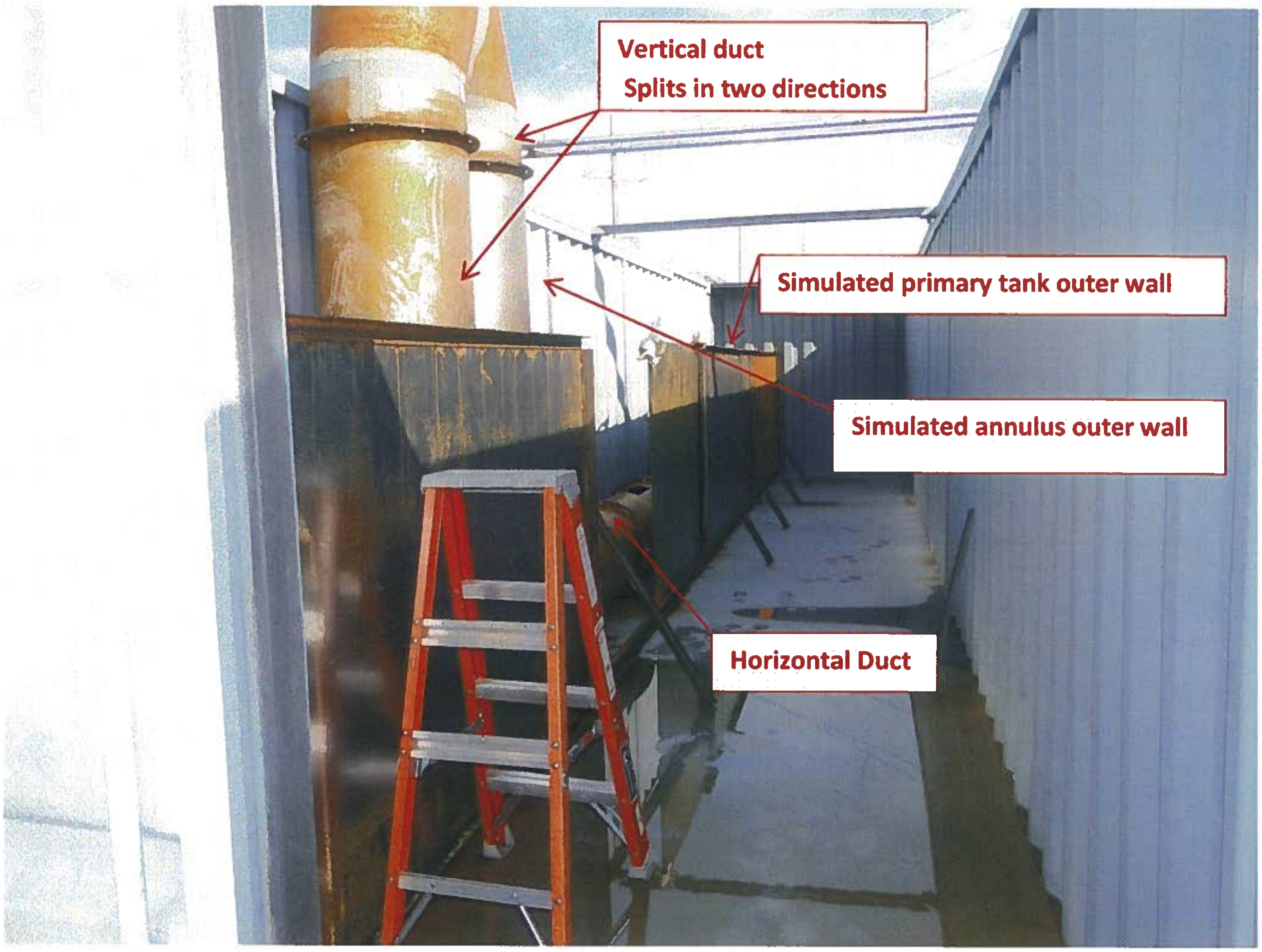
ATTACHMENT – 3

Tank 16 Annulus Dehumidification Duct Simulation

ATTACHMENT – 4

Tank 16 Annulus Dehumidification Duct Simulation

ATTACHMENT – 5



Tank 16 Annulus Duct Simulation

ATTACHMENT - 6

Tank 16 Annulus Duct Inside cleaning nozzle – "Lil Bertha"