The document provides identification of waste transfer routes for high-level waste and low-activity waste staging in support of Phase I Privatization. The recommended alternative has been approved by DOE-RL.

The document title has been changed since release for review.

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- 5. Env. QA

**21. DOE APPROVAL (If required)**

- Ctrl. No. 1. [Approved] 2. [Approved w/comments] 3. [Disapproved w/comments]
Decision Document for Phase I Privatization Transfer System Needs

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Abstract: This decision document provides input for the Phase I Privatization waste staging plans for the High-Level Waste (HLW) and Low-Level Waste (LLW) Disposal Programs. This AGA report evaluates what infrastructure upgrades to existing 200 East waste transfer systems are necessary for delivery of HLW and LLW streams to the Phase I Privatization vendor. The AGA identifies the transfer routing alternatives for supernatant waste transfers from the 241-AN, 241-AW, and 241-AP Tank Farms to the 241-AP-102 tank and/or the 241-AP-104 tank. These two tanks have been targeted as the initial LLW feed staging tanks. In addition, this report addresses the transfer of slurry waste from the 241-AY and 241-AZ Tank Farms to the Phase I Privatization vendor’s facilities for HLW immobilization.

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DECISION DOCUMENT FOR PHASE I
PRIVATIZATION TRANSFER
SYSTEM NEEDS

May 1996

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U.S. Department of Energy
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LIST OF TERMS

AGA Alternative Generation and Analysis
DOE-RL U.S. Department of Energy-Richland Operations Office
DST Double-shell tank
FY Fiscal year
HLW High-level waste
LLW Low-level waste
NDE Nondestructive examination
NGTP New Generation Transfer Pump
PIP Privatization Infrastructure Project
TWRS Tank Waste Remediation System
WHC Westinghouse Hanford Company
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1.3 DECISION MAKER

The decision makers are Gary A. Meyer and John E. Truax. Mr. Meyer is the manager of Retrieval Programs for Westinghouse Hanford Company (WHC), and Mr. Truax is the manager of WHC's Tank Farm Transition Projects.

1.4 DECISION ACTION OFFICER

The decision action officer is John S. Garfield. Mr. Garfield is the manager of the Process Design Group within WHC's Disposal Engineering.
1.5 ALTERNATIVE SELECTED

The preferred waste transfer system upgrade will be Option LLW 4 and HLW 3 (see Figures 1-4 and 1-7). The combination of these options meets the hydraulic performance, schedule performance, and cost criteria.

The options selected are integrated with current plans by Project W-314 to upgrade waste transfer systems in the northern quadrant of the A Farm Complex. The remainder of transfer system upgrades are focused on providing new transfer lines to 241-AP-102 and 241-AP-104 tanks; the selected LLW intermediate waste staging tanks. The upgrades are targeted to modify line SN-650 by adding a new valve pit and providing three 7.6-cm (3-in) waste transfer lines. Two of the lines will be routed to 241-AP-102 and 241-AP-104 tanks for LLW staging and the third line will be routed to the HLW vendors processing facility. (NOTE: The evaluation for the HLW feed line assumed a scope of routing the line to the vendor HLW processing facility. The DOE is not committed to installing the HLW feed line to the vendors location unless negotiations with vendor stipulates otherwise. For follow-on project scoping evaluations the HLW line will be terminated outside the 241-AP tank farm East fence line.)

The selection of the LLW intermediate waste staging tanks was based on location, current use of tanks, waste type, and cost to upgrade the tanks to support intermediate feed staging. Other tanks that were considered for possible use were eliminated due in part to the cost for systems that would be required to retrieve and transfer their current inventory. Selecting 241-AP-102 and 241-AP-104 tanks also minimizes waste transfer distances and the number of process pits that need to be accessed during the transfer of waste to the vendors feed staging tanks, 241-AP-106 or 241-AP-108.

Responsible Decision Maker:  
J. E. Truax, WHC/Deputy Director, Tank Farm Transition Projects  
Date: 8/29/96

DOE Concurrence:  
W. J. Taylor, DOE/Director, Waste Disposal Division  
Date: 8/28/96

J. K. McClusky, DOE/Director, Waste Storage Division  
Date: 8/28/96

Action Officer:  
J. S. Garfield, WHC/Manager, Tank Waste Remediation System Disposal Process Design  
Date: 8/28/96
1.6 DECISION ISSUES

1.6.1 Function and Requirements

The Phase I privatization transfer system is considered to be part of the Retrieve Double-Shell Tank (DST) Waste function 4.2.2.2 (WHC 1996a). The waste retrieval system includes demonstration of technologies for Phase I HLW pretreatment processing for privatization and transfer of HLW and LLW to the Phase I processing facilities.

The requirements of the Phase I privatization transfer system identified in Function 4.2.2.2, Paragraph 3.2.3.18.1 are as follows:

- Interfacing waste sources shall be categorized according to the Waste Reactivity Group Compatibility Matrix and the potential chemical compatibility hazards identified before acceptance into a DST.
- Interfacing waste sources shall ensure that the criticality prevention limits are met before initiating waste transfers.
- The sum of the receiving tank waste and the source waste heat generation rate shall be less than or equal to the Operating Specification Document limit for the receiving tank in order for the transfer to take place.
- The waste solutions shall be transferred at a maximum waste temperature of 82 °C (180 °F), if collected in the 241-AP DST Farm.
- The specific gravity of the solution must be less than 1.41 SpG. If the SpG is > 1.41, then a detailed technical evaluation of potential for flammable gas accumulation in the commingled waste shall be performed.
- Following a waste transfer through a transfer pipeline, the waste generator shall flush the transfer pipeline with a volume of water that is equal to the transfer pipeline volume.
- Waste provided to the transfer managed tank waste system shall comply with the following parameters: Calculated Reynolds number for the waste transfer shall be ≥20,000, volume percent shall be ≤30 percent solids.

1.6.2 Open Issues

A viscosity of 10 cP was used as a basis for this analysis. However, the design range of the LLW and HLW viscosities varies from 1 to 94 cP (DOE 1995). If the Waste
Pumpability Rule (Fowler 1995) must be met and a higher viscosity is required, the upgrades to the existing transfer system would be more extensive than that presented in this analysis, or dilution of the waste would be required to meet the current transfer system design limits. This is because the head and pressure requirements for a system will increase by the square of the increase in the viscosity of the waste if the Reynolds number is constant.

The hydraulic performance of several of the options are limited by the design pressure of the existing transfer lines. It has been suggested that the existing transfer lines could be re-rated to new pressure and temperature design limits to allow their use at the higher operating conditions required for transferring the LLW and HLW. The minimum requirements to re-rate a transfer line are as follows (ASME 1993):

- Survey the existing piping to establish current conditions including thickness, layout, supports, and any other design factors.
- Review documentation for examination that was performed during initial fabrication and determine adequacy to the new design ratings.
- Perform design analysis of existing system to the new design conditions.
- Perform hydrostatic leak test based on the new design conditions.

Determining the physical condition of the existing transfer lines would be the limiting factor on re-rating the lines. Methodologies that are judged to be currently available for examination of encased underground piping was investigated by the Hanford onsite Architectural Engineer (see Appendix D). A number of contacts were made with offsite vendors to determine methodologies used at chemical processing facilities.

The findings of the investigation are as follows:

"Considering the transfer systems continuing failure from 1980, only a 100% examination of the pipeline to verify existing wall thickness would be acceptable to validate re-rating. The risk would not be acceptable to only perform a partial examination (approximately 33% of SN-213/200, based on 100 foot entry from each end of line). At the current time no system has been found that can traverse 100% of the lines length to determine remaining pipe wall thickness and attempting to re-rate the system is not recommended. If 100% of the transfer system were to be examined, the probability of increasing the design pressure is very low due to expected corrosion to be detected given past history on pipeline failures."
1.6.3 Function and Requirements Open Issues

- **Emergency Tank Waste Transfer Procedure Issue** *(WHC 1996a, Table 1, Appendix G, Page G-13)*

  In the event of a catastrophic failure the Hanford Site operating procedures require a method for transferring the contents of a leaking tank. In such an event the privatization contractor will transfer the contents to a DST. However, the procedures needed to enable such a transfer have not been determined.

  **Resolution:**

  This study has determined that the existing 200E Area waste transfer system is capable of supporting the emergency pumping operation. The privatization contractor will be required to develop a specific procedure with protocols for initiating the transfer.

  Since the waste residing in the privatization contractor's tank will be conditioned and compliant with the transfer system design requirements, the transfer can be accomplished. Receipt of the waste into another DST will be based on Waste Compatibility Rules.

- **HLW PHYSICAL INTERFACE ISSUE** *(WHC 1996a, Table 1, Appendix G, Page G-16)*

  What is the most sensible place to tie the privatization contractor into the service?

  **Resolution:**

  This study had determined the interface point to be the "new valve pit" located with the existing SN-650 line. The valve pit will either be located within the 241-AP tank farm, adjacent to the 241-AP-102 tank, or outside the 241-AP tank farm. The privatization contractor's HLW transfer line will be routed east of this location for tie-in to the privatization contractor's HLW processing facility. This line will be sloped to the processing facility to assure that no drain back to this new valve pit occurs.

- **LAW FEED PHYSICAL INTERFACE LOCATIONS ISSUE** *(WHC 1996a, Table 1, Appendix G, Page G-22)*

  What is the most sensible place to tie the privatization contractor's into the service?
Resolution:

This study has determined that connection to the existing waste transfer system will be at the central pump pit on the privatization contractor’s LLW waste feed staging tank (241-AP-106 or 241-AP-108). Using this location will allow the privatization contractor to access the 200E Area waste transfer system by the 241-AP tank farm valve pit. The transfer system provides the required capabilities to receive waste from the 241-AP-102 and 241-AP-104 LLW intermediate waste staging tanks.

• STRONTIUM/TRU/ENTRAINED SOLIDS PHYSICAL INTERFACE ISSUE (WHC 1996a, Table 1, Appendix G, page G-38)

The physical location of the interface and details of the interface need to be determined whether it shall be at the privatization contractor’s property line or at a location closer to the tank farms (making the contractor responsible for the transfer line).

Resolution:

It has been concluded that the interface point for return of strontium/TRU/entrained solids to be by the privatization contractor’s LLW waste feed staging tank central pump pit, (i.e., tanks 241-AP-106 and 241-AP-108). The privatization contractor will be responsible for the waste transfer line from their facilities to the LLW waste feed staging tank central pump pit and any jumpers needed within the pump pit. DOE will provide the necessary jumpers and routing from the central pump pit to the AP tank farm valve pit and the remainder of the DST transfer system. Transfer protocol and procedures must be developed to ensure compatibility with the receiving DST. This interface point will provide connection to the existing 200E Area waste transfer system.

• WASTE PUMPABILITY CRITERIA ISSUE (WHC 1996a, Table 1, Appendix G, Page G-44)

The physical and chemical properties may differ from source to source depending on the individual waste source that the managed transfer tank waste system will interface with.
Resolution:

The movement of tank waste through the combination of existing and upgraded waste transfer systems, as identified in this study, will be achievable. Each waste source will have to be sampled and analyzed to verify specific waste characteristics; e.g., viscosity, SpG, wt% solids, and thixotropic behavior. The results of the analysis will be used to specify the extent of waste conditioning required before initiating the waste transfer. All wastes will meet the limits on characteristics imposed by the transfer system design limits.

1.6.4 Scope

The objective of the Phase I Privatization is to deliver a LLW and HLW feed to the Phase I private contractors for vitrification. This report addresses the transfer of supernatant waste from the 241-AN Tank Farm to the 241-AP-102 and/or the 241-AP-104 Tanks. These two tanks have been designated as the Intermediate LLW Feed Staging Tanks. In addition, this report addresses the transfer of slurry waste from the 241-AZ and 241-AY Tank Farms to the Phase I vendor facilities for HLW immobilization.

The results of this AGA will provide input to the revised Phase I LLW and HLW Feed Staging Plans.

1.7 DESCRIPTION OF OPTIONS CONSIDERED

1.7.1 Low-Level Waste Options

The primary feed for the Phase I LLW immobilization considered in this AGA is the supernate contained in the 241-AN Tank Farm. There are four main option routings for the transfer of LLW from the 241-AN Tank Farm to the feed staging tanks in the 241-AP Tank Farm.

LLW Option 1 is the "Do Nothing" option. This option utilizes the existing waste transfer system routing with no upgrades. The option is illustrated in Figure 1-1.

LLW Option 2 is the "New 7.6-cm (3-in.) Line, 241-AN to 241-AX-B" option. This option would require a new 7.6-cm (3-in.) routing from the 241-AN-B Valve Pit (VP) to the 241-AX-B VP. This would allow the LLW to be transferred in 7.6-cm (3-in.) transfer lines from the source tank to the intermediate feed staging tanks. Project W-314 is planning to add a new 7.6-cm (3-in.) transfer route from the 241-AN Tank Farm to the 241-AX Valve Pits (WHC 1996b). The option is illustrated in Figure 1-2.
Figure 1-1. Low-Level Waste Option 1: "Do Nothing."
Figure 1-2. Low-Level Waste Option 2: "New 7.6-cm (3-in.) Line, 241-AN-B to 241-AX-B."
LLW Option 3 is the "New SN-650 Valve Pit" Option. This option would utilize the existing 5.1-cm (2-in.) and 7.6-cm (3-in.) transfer system. However, instead of transferring through the 241-AW Tank Farm, the waste would transfer through the 7.6-cm (3-in.) SN-650 line at the 241-A-B VP. This option would require adding a new valve pit and transfer line at the 241-AP Tank Farm to allow LLW transfers to either of the intermediate feed staging tanks. The option is illustrated in Figure 1-3.

LLW Option 4 is the "New 7.6-cm (3-in.) Line and Valve Pit" option. This option is a combination of Options 2 and 3. This option would add a 7.6-cm (3-in.) transfer line from the 241-AN-B VP to the 241-AX-B VP, and add a new valve pit and transfer lines on the 7.6-cm (3-in.) SN-650 line to allow for transfers to either intermediate feed staging tank. The option is illustrated in Figure 1-4.

1.7.2 High-Level Waste Options

The neutralized current acid waste (NCAW) sludges contained in tanks 241-AZ-101 and 241-AZ-102 and the high-heat sludge in tank 241-AY-102 (including retrieved solids from tank 241-C-106) are candidate feeds for the Phase I HLW vitrification (Manuel 1996). There are four optional routings for the transfer of HLW to the vendor. (Note: for the purpose of this evaluation the HLW feed line is analyzed to the vendors proposed HLW processing facility. The interface/tie-in point for the tank farm operating contractor and the HLW vendor have not been negotiated at this time.)

HLW Option 1 is the "Do Nothing" option. From the 241-AZ Tank Farm this option uses the existing waste transfer system routing with no upgrades except the addition of a new HLW feed line from the 241-AP Tank Farm to the vendor's processing facility. From the 241-AZ Tank Farm the "Do Nothing" option uses the existing 5.1-cm (2-in.) slurry lines to route waste back to tank 241-AZ-101. The waste would be staged in the 241-AZ-101 Tank and then routed to the vendor's processing facility using the selected HLW staging plan. The option is illustrated in Figure 1-5.

HLW Option 2 is the "New 7.6-cm (3-in.) Line, 241-AZ to 241-AX-A" option for the 241-AZ Tank Farm transfers and the "New 7.6-cm (3-in.) Line, 241-AY to 241-AX-B" option for the 241-AY Tank Farm transfers. From the 241-AZ Tank Farm this option would require the upgrade of the 5.1-cm (2-in.) SL-501 and 5.1-cm (2-in.) SL-500 transfer lines to 7.6-cm (3-in.). From the 241-AY Tank Farm this option would require the upgrade of the 5.1-cm (2-in.) SL-502 line to 7.6-cm (3-in.). Project W-314 is planning to replace the 5.1-cm (2-in.) SL-502 line with a new 5.1-cm (2-in.) transfer line (WHC 1996b). The option is illustrated in Figure 1-6.
Figure 1-3. Low-Level Waste Option 3: "New SN-650 Valve Pit."
Figure 1-4. Low-Level Waste Option 4: "New 7.6-cm (3-in.) Line and Valve Pit."
Figure 1-5. High-Level Waste Option 1: "Do Nothing."

241-AZ

241-AY

241-AP

241-AW

VENDOR (M40300, M44500)

NEW 3"SM (~2820 FT)
BY VENDOR
Figure 1-6. High-Level Waste Option 2: "New 7.6-cm (3-in.) Line, 241-AZ to 241-AX-A" and "New 7.6-cm (3-in.) Line, 241-AY to 241-AX-B."

**LEGEND**

- [ ] EXISTING ROUTE
- [ ] NEW 3" SN ROUTE
HLW Option 3 is the "New 7.6-cm (3-in.) Lines to 241-AX-B and New SN-650 Valve Pit" option. This option would replace/upgrade the existing 5.1-cm (2-in.) transfer lines to 7.6-cm (3-in.) as in Option 2, however, the line from 241-AZ would tie in to the 241-AX-B VP. The waste would then be transferred through the 7.6-cm (3-in.) SN-200/213 replacement line (WHC 1996b) and then through the 7.6-cm (3-in.) SN-650 line at the 241-A-B VP. This option would require adding a new valve pit and transfer line at the 241-AP Tank Farm to transfer waste to the vendor(s). The option is illustrated in Figure 1-7.

HLW Option 4 is the New 7.6-cm (3-in.) Route, 241-AZ to Vendor option for the 241-AZ Tank Farm transfers and the New 7.6-cm (3-in.) Route, 241-AY to Vendor option for the 241-AY Tank Farm transfers. This option would upgrade the existing 5.1-cm (2-in.) transfer lines to 7.6-cm (3-in.) as in Option 2, and add a new 7.6-cm (3-in.) transfer line from the 241-A-A VP to the vendor's processing facility. The option is illustrated in Figure 1-8.

1.8 DECISION CRITERIA

Decision criteria are used to evaluate the options. The decision criteria were specified in the decision plan and were chosen in relation to the Phase I Privatization mission fulfillment. The criteria of Operability and Maintainability were specified in the decision plan, but will not be used in the decision criteria. None of the options differ in these two criteria. The criteria are described in the following sections.

1.8.1 Hydraulic Performance

The primary factors in the hydraulic performance criteria are the Reynolds number and the required pump head and pressure. An analysis was done on each waste routing option to develop the system head curve for each of the options generated (see Appendix A). The requirement to upgrade the existing transfer pump will be addressed for each option.

The Waste Pumpability Rule requires that the Reynolds number be above 20,000 for non-routine transfers (Fowler 1995). For the waste properties used in this AGA that would require a minimum velocity of 1.7 m/sec (5.6 ft/sec) in a 7.6-cm (3-in.) transfer line and around 2.6 m/sec (8.5 ft/sec) in a 2-in. transfer line.

The main limitation of the existing transfer lines is the design pressure. For each of the options, except the 241-AY Tank Farm "Do Nothing" option and HLW Option 3, the lowest design pressure was 1.6 MPa (230 psi), equivalent to approximately 107 m (350 ft) of head.
Figure 1-7. High-Level Waste Option 3: "New 7.6-cm (3-in.) Lines to 241-AX-B and New SN-650 Valve Pit"
Figure 1-8. High-Level Waste Option 4: "New 7.6-cm (3-in.) Route, 241-AZ to Vendor" and "New 7.6-cm (3-in.) Route, 241-AY to Vendor."
1.8.2 Cost

The cost criteria of each option will be the total project cost. Each viable option would have relatively the same life-cycle cost and, therefore, only initial project cost will be considered. The cost of the jumper manifolds in each of the main process pits is included. A recent life-cycle cost analysis was done that showed that the use of a jumper manifold system was cost effective (WHC 1995).

1.8.3 Schedule

The options should minimize schedule impacts with the 242-A Evaporator. This criterion deals with the use of the 241-AW-B VP and the 241-AW-02A Pump Pit, in addition to the use of common transfer lines. It is assumed that each option would incorporate a jumper manifold design in the main A-Farm Complex process pits. These jumper manifolds are needed to minimize the set-up time for the transfers by eliminating pit entries for routing changes. The design of a jumper manifold system in each of the process pits is discussed in Appendix B.

The HLW preliminary schedule assumes that there will be two batch transfers of HLW feed per fiscal year (FY) (Manuel 1996). This will have no impact in the screening of the options. In addition, the private contractors must provide 30 to 90 days notice in advance of the ready-for-feed date. The Management and Integration contractor must begin delivery of feed no earlier than the ready-for-feed date and complete delivery no later than 60 days after the ready-for-feed date. This requirement will not vary among the options, and, therefore, have no impact in the decision criteria.

The design and construction time for the different upgrades will be addressed. The LLW and HLW transfers to the vendor(s) are scheduled to begin in FY 2002.

A nodal analysis will be provided in the next revision of the revised Low-Level Waste Feed Staging Plan (Certa to be released). The analysis will quantify the schedule criteria and determine the benefits of the evaluated options.

1.8.4 Flexibility

Waste transfer flexibility will be a key operational value. Each option will be evaluated based on supporting sequential LLW and HLW transfers, concurrent 242-A Evaporator operation, routine waste management operations, and return of separated waste from the privatization contractor(s).
1.9 OPTIONS EVALUATION

The analysis of the options have been summarized in a tabular form in Tables 1-1, 1-2, and 1-3. In addition, Table 1-4 shows the cost breakdown of the options between Project W-314 and the Privatization Infrastructure Project (PIP), and Table 1-5 shows the combined cost of the options. The cost estimates for each option are provided in Appendix C.

LLW Option 4, the "New 7.6-cm (3-in.) Line and Valve Pit," is the only LLW option to satisfy all of the decision criteria. LLW Option 2 satisfied the hydraulic performance criteria and was lower in cost, but it causes possible schedule impacts with the 242-A Evaporator operation and HLW staging of waste. A nodal analysis in the revised Phase I privatization LLW staging plan will quantify the schedule criteria and determine if the benefits of Option 4 are cost effective. Options 1 and 3 do not satisfy the hydraulic performance criteria.

HLW Option 3, the "New 7.6-cm (3-in) Lines to 241-AX-B and New SN-650 Valve Pit" is the only HLW option to satisfy the hydraulic performance criteria. However, Option 3 will not meet the hydraulic performance criteria if the 7.6-cm (3-in.) SN-200/213 line is not upgraded due to the existing line's design pressure limit of 1.6 Mpa (230 psi). No other option satisfied the hydraulic performance criteria except Option 1 for the 241-AY Tank Farm transfers. However, Option 1 requires a double transfer and staging of the waste in the 241-AZ-101 tank. This would create additional scheduling problems. A nodal analysis in the next revision of the revised LLW Feed Staging Plan (Certa to be released) will quantify the schedule criteria for the combined LLW and HLW options.
### Table 1-1. Matrix of Low-Level Waste Options by Decision Criteria.

<table>
<thead>
<tr>
<th>Decision Criteria</th>
<th>Option 1 &quot;Do Nothing&quot;</th>
<th>Option 2 &quot;New 7.6-cm (3-in.) Line, 241-AN-B to 241-AX-B&quot;</th>
<th>Option 3 &quot;New SN-650 Valve Pit&quot;</th>
<th>Option 4 &quot;New 7.6-cm (3-in.) Line and Valve Pit&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Design Data</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Routing Length</td>
<td>1090 m (3570 ft)</td>
<td>1090 m (3570 ft)</td>
<td>1020 m (3340 ft)</td>
<td>1020 m (3340 ft)</td>
</tr>
<tr>
<td>Line Size(s)</td>
<td>5.1 cm and 7.6 cm (2 in. and 3 in.)</td>
<td>7.6 cm (3 in.)</td>
<td>5.1 cm and 7.6 cm (2 in. and 3 in.)</td>
<td>7.6 cm (3 in.)</td>
</tr>
<tr>
<td>Design Pressure</td>
<td>1.6 MPa (230 psi)</td>
<td>1.6 MPa (230 psi)</td>
<td>1.6 MPa (230 psi)</td>
<td>1.6 MPa (230 psi)</td>
</tr>
<tr>
<td>Hydraulic Performance&lt;sup&gt;d&lt;/sup&gt; (SpG = 1.5, viscosity = 10 cP)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flow Rate - L/min (gal/min)</td>
<td>490 (130)</td>
<td>320 (85)</td>
<td>490 (130)</td>
<td>490 (130)</td>
</tr>
<tr>
<td>Reynolds No.&lt;sup&gt;d&lt;/sup&gt;</td>
<td>20,000</td>
<td>13,500</td>
<td>20,000</td>
<td>20,000</td>
</tr>
<tr>
<td>Velocity</td>
<td>1.7 m/s (5.6 ft/s)</td>
<td>1.2 m/s (3.8 ft/s)</td>
<td>1.7 m/s (5.6 ft/s)</td>
<td>1.7 m/s (5.6 ft/s)</td>
</tr>
<tr>
<td>Pump Head</td>
<td>200 m (660 ft)</td>
<td>110 m (350 ft)</td>
<td>100 m (320 ft)</td>
<td>190 m (630 ft)</td>
</tr>
<tr>
<td>Line Pressure</td>
<td>3.0 MPa (430 psi)</td>
<td>1.6 MPa (230 psi)</td>
<td>1.5 MPa (210 psi)</td>
<td>2.8 MPa (410 psi)</td>
</tr>
<tr>
<td><strong>Cost ($ million)&lt;sup&gt;e&lt;/sup&gt;</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Line Upgrade</td>
<td>N/A&lt;sup&gt;b&lt;/sup&gt;</td>
<td>$0</td>
<td>$6.5</td>
<td>N/A&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Jumper Manifold</td>
<td>--</td>
<td>$6.8</td>
<td>$6.8</td>
<td>--</td>
</tr>
<tr>
<td>Pump Upgrade&lt;sup&gt;d&lt;/sup&gt;</td>
<td>--</td>
<td>$1.8</td>
<td>$1.8</td>
<td>--</td>
</tr>
<tr>
<td>Total Cost</td>
<td>--</td>
<td>$8.6</td>
<td>$15.1</td>
<td>--</td>
</tr>
<tr>
<td><strong>Schedule</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>PROS:</strong>&lt;sup&gt;f&lt;/sup&gt;</td>
<td>No design and design and Construction upgrades Construction upgrades</td>
<td>Possible schedule Possible schedule impacts with impacts with Evaporator Evaporator</td>
<td>Avoids Design and Design and Construction of Construction of the the upgrades upgrades in needed by needed by FY FY 2002 2002</td>
<td>No schedule No schedule impacts with impacts with Evaporator Evaporator</td>
</tr>
</tbody>
</table>
| **CONS:**<sup>f</sup> | Possible schedule Possible schedule impacts with impacts with Evaporator Evaporator | Possible Possible impacts to feed delivery to vendor to vendor | Design and Design and Construction of Construction of the the upgrades upgrades needed by needed by FY FY 2002 2002 | | | **CONS:**

---

<sup>a</sup> Based on the text provided, the data appears to be incomplete or partially extracted. Please ensure to fill in the missing values to complete the table.
Table 1-1. Matrix of Low-Level Waste Options by Decision Criteria.

<table>
<thead>
<tr>
<th>Decision Criteria</th>
<th>Option 1: &quot;Do Nothing&quot;</th>
<th>Option 2: &quot;New 7.6-cm (3-in.) Line, 241-AN-B to 241-AX-B&quot;</th>
<th>Option 3: &quot;New SN-650 Valve Pit&quot;</th>
<th>Option 4: &quot;New 7.6-cm (3-in.) Line and Valve Pit&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Flexibility</strong></td>
<td>CONS:</td>
<td>CONS:</td>
<td>PROS:</td>
<td>PROS:</td>
</tr>
<tr>
<td></td>
<td>• Routes waste</td>
<td>• Routes waste</td>
<td>• Supports concurrent</td>
<td>• Supports concurrent</td>
</tr>
<tr>
<td></td>
<td>through the 241-AW-B VP</td>
<td>through the 241-AW-B VP</td>
<td>Evaporator operation</td>
<td>Evaporator operation</td>
</tr>
<tr>
<td></td>
<td>and the 241-AW-02A PP</td>
<td>and the 241-AW-02A PP</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*The Waste Pumpability Rule requires that the Reynolds Number be $\geq 20,000$ for non-routine transfers.

*The head and pressure requirements for this option are unacceptable.

*The pump upgrade cost is based on the initial cost of the New Generation Transfer Pump and does not include removal/disposal of the existing transfer pump or electrical upgrades. Also, this is the cost for all seven pumps in the 241-AN Tank Farm.

*The shaded cells show the hydraulic performance of the option with the design pressure limitation.

*Table 1-4 shows the cost breakdowns between Project W-314 and the Privatization Infrastructure Project, and Table 1-5 shows a combined cost matrix for the options.
Table 1-2. Matrix of High-Level Waste Options  
(241-AZ Tank Farm) by Decision Criteria.

| Decision Criteria | Option 1: "Do Nothing" | Option 2: "New 7.6-cm (3-in.) Line, 241-AZ to 241-AX-A" | Option 3: "New 7.6-cm (3-in.) Lines to 241-AX-B and New SN-650 Valve Pit" | Option 4: "New 7.6-cm (3-in.) Route, 241-AZ to Vendor"
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Routing Length</td>
<td>1830 m (6000 ft)</td>
<td>1830 m (6000 ft)</td>
<td>1670 m (5480 ft)</td>
<td>1670 m (5470 ft)</td>
</tr>
<tr>
<td>Line Size(s)</td>
<td>5.1 cm (2 in.) and 7.6 cm (3 in.)</td>
<td>7.6 cm (3 in.)</td>
<td>7.6 cm (3 in.)</td>
<td>7.6 cm (3 in.)</td>
</tr>
<tr>
<td>Design Pressure</td>
<td>1.6 MPa (230 psi)</td>
<td>1.6 MPa (230 psi)</td>
<td>2.8 MPa (400 psi)</td>
<td>1.6 MPa (230 psi)</td>
</tr>
<tr>
<td>Hydraulic Performance*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flow Rate L/min (gal/min)</td>
<td>490 (130)</td>
<td>320 (85)</td>
<td>90 (130)</td>
<td>420 (110)</td>
</tr>
<tr>
<td>Reynolds No.*</td>
<td>20,000</td>
<td>13,000</td>
<td>20,000</td>
<td>17,000</td>
</tr>
<tr>
<td>Velocity</td>
<td>1.7 m/s (5.6 ft/s)</td>
<td>1.1 m/s (3.6 ft/s)</td>
<td>1.7 m/s (5.6 ft/s)</td>
<td>1.5 m/s (4.6 ft/s)</td>
</tr>
<tr>
<td>Pump Head</td>
<td>220 m (720 ft)</td>
<td>110 m (350 ft)</td>
<td>145 m (475 ft)</td>
<td>110 m (350 ft)</td>
</tr>
<tr>
<td>Line Pressure</td>
<td>3.2 MPa (470 psi)</td>
<td>1.6 MPa (230 psi)</td>
<td>2.1 MPa (310 psi)</td>
<td>1.6 MPa (230 psi)</td>
</tr>
<tr>
<td>Costb ($ million)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Line Upgrade</td>
<td>N/A§</td>
<td>$0</td>
<td>$4.2</td>
<td>$4.2</td>
</tr>
<tr>
<td>Jumper Manifold</td>
<td>--</td>
<td>$6.8</td>
<td>$6.8</td>
<td>$2.8+</td>
</tr>
<tr>
<td>Pump Upgrade</td>
<td>--</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>Total Cost</td>
<td>--</td>
<td>$6.8</td>
<td>$11.0</td>
<td>$17.1</td>
</tr>
</tbody>
</table>

PROS: No schedule impacts with Evaporator
CONS: Design and Construction of the upgrades needed by FY 2002

PROS: No schedule impacts with Evaporator
CONS: Design and Construction of the upgrades needed by FY 2002

PROS: No schedule impacts with Evaporator
CONS: Design and Construction of the upgrades needed by FY 2002

PROS: No schedule impacts with Evaporator
CONS: Design and Construction of the upgrades needed by FY 2002

Schedule

<table>
<thead>
<tr>
<th>Schedule</th>
<th>PROS: No design and Construction upgrades</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CONS: Possible schedule impacts with Evaporator</td>
</tr>
<tr>
<td></td>
<td>CONS: Possible impacts to feed delivery to vendor</td>
</tr>
</tbody>
</table>
Table 1-2. Matrix of High-Level Waste Options
(241-AZ Tank Farm) by Decision Criteria.

<table>
<thead>
<tr>
<th>Decision Criteria</th>
<th>Option 1 “Do Nothing”</th>
<th>Option 2 “New 7.6-cm (3-in.) Line, 241-AZ to 241-AX-A”</th>
<th>Option 3 “New 7.6-cm (3-in.) Lines to 241-AX-B and New SN-650 Valve Pit”</th>
<th>Option 4 “New 7.6-cm (3-in.) Route, 241-AZ to Vendor”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexibility</td>
<td>CONS:</td>
<td>PROS:</td>
<td>PROS:</td>
<td>PROS:</td>
</tr>
<tr>
<td></td>
<td>Routes waste</td>
<td>Accommodates change to TWRS Treatment</td>
<td>Supports concurrent Evaporator operation</td>
<td>Supports concurrent Evaporator operation</td>
</tr>
<tr>
<td></td>
<td>through the AW-02A Pump Pit (PP)</td>
<td>Complex</td>
<td>CONS: Shares transfer lines with LLW transfers</td>
<td>CONS: Shares transfer lines with LLW transfers</td>
</tr>
<tr>
<td></td>
<td>Utilizes transfer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>lines with Clean-out Boxes (COBs)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*The Waste Pumpability Rule requires that the Reynolds Number be ≥ 20,000.

The "+" symbol indicates an unknown amount for design pressure upgrade analysis including NDE.

The head and pressure requirements for this option are unacceptable.

The pump upgrade is required on each of these options. However, it is assumed that Project W-211 will be installing the New Generation Transfer Pump in tanks 241-AZ-101 and 241-AZ-102.

The shaded cells show the hydraulic performance of the option with the existing design pressure limitation.

Table 1-4 shows the cost breakdowns between Project W-314 and the Privatization Infrastructure Project, and Table 1-5 shows a combined cost matrix for the options.
### Table 1-3. Matrix of High-Level Waste Options
(241-AY Tank Farm) by Decision Criteria.

<table>
<thead>
<tr>
<th>Decision Criteria</th>
<th>Option 1</th>
<th>Option 2</th>
<th>Option 3</th>
<th>Option 4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&quot;Do Nothing&quot; (to 241-AZ-101)</td>
<td>&quot;New 7.6-cm (3-in.) Line, 241-AY to 241-AX-B&quot;</td>
<td>&quot;New 7.6-cm (3-in.) Line to 241-AX-B and New SN-650 Valve Pit&quot;</td>
<td>&quot;New 7.6-cm (3-in.) Route, 241-AY to Vendor&quot;</td>
</tr>
<tr>
<td><strong>Design Data</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Routing Length</td>
<td>280 m (920 ft)</td>
<td>1700 m (5580 ft)</td>
<td>1530 m (5020 ft)</td>
<td>1540 m (5050 ft)</td>
</tr>
<tr>
<td>Line Size(s)</td>
<td>5.1 cm (2 in.)</td>
<td>7.6 cm (3 in.)</td>
<td>7.6 cm (3 in.)</td>
<td>7.6 cm (3 in.)</td>
</tr>
<tr>
<td>Design Pressure</td>
<td>2.6 MPa (375 psi)</td>
<td>1.6 MPa (230 psi)</td>
<td>2.8 MPa (400 psi)</td>
<td>1.6 MPa (230 psi)</td>
</tr>
<tr>
<td><strong>Hydraulic Performance</strong> ($\text{SpG} = 1.5$, viscosity = 10 cP)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flow Rate - L/min (gal/min)</td>
<td>340 (90)</td>
<td>490 (130)</td>
<td>435 (115)</td>
<td>490 (130)</td>
</tr>
<tr>
<td>Reynolds No. a</td>
<td>20,000</td>
<td>20,000</td>
<td>17,500</td>
<td>20,000</td>
</tr>
<tr>
<td>Velocity</td>
<td>2.6 m/s (8.6 ft/s)</td>
<td>1.7 m/s (5.6 ft/s)</td>
<td>1.5 m/s (4.9 ft/s)</td>
<td>1.7 m/s (5.6 ft/s)</td>
</tr>
<tr>
<td>Pump Head</td>
<td>90 m (300 ft)</td>
<td>135 m (440 ft)</td>
<td>110 m (350 ft)</td>
<td>115 m (385 ft)</td>
</tr>
<tr>
<td>Line Pressure</td>
<td>1.3 MPa (190 psi)</td>
<td>1.4 MPa (200 psi)</td>
<td>2.0 MPa (290 psi)</td>
<td>1.7 MPa (250 psi)</td>
</tr>
<tr>
<td><strong>Cost ($ million)$</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Line Upgrade</td>
<td>$0</td>
<td>$1.9+</td>
<td>$1.9</td>
<td>$0+ d</td>
</tr>
<tr>
<td>Jumper Manifold b</td>
<td>Not Required</td>
<td>Not Required</td>
<td>Not Required</td>
<td>Not Required</td>
</tr>
<tr>
<td>Pump Upgrade c</td>
<td>Not Required</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>Total Cost d</td>
<td>$0</td>
<td>$1.9+</td>
<td>$1.9</td>
<td>$0+</td>
</tr>
</tbody>
</table>

**Schedule**

**PROS:**
- No design and construction upgrades
- Possible impacts on feed delivery to vendor

**CONS:**
- Requires a double transfer to send waste to the vendor(s)

**PROS:**
- Possible schedule impacts with evaporator

**CONS:**
- Design and Construction of the upgrades needed by FY 2002

**PROS:**
- No schedule impacts with evaporator

**CONS:**
- Design and Construction of the upgrades needed by FY 2002

**PROS:**
- No schedule impacts with evaporator

**CONS:**
- Design and Construction of the upgrades needed by FY 2002
Table 1-3. Matrix of High-Level Waste Options (241-AY Tank Farm) by Decision Criteria.

<table>
<thead>
<tr>
<th>Decision Criteria</th>
<th>Option 1 “Do Nothing” (to 241-AZ-101)</th>
<th>Option 2 “New 7.6-cm (3-in.) Line, 241-AY to 241-AX-B”</th>
<th>Option 3 “New 7.6-cm (3-in.) Lines to 241-AX-B and New SN-450 Valve Pit”</th>
<th>Option 4 “New 7.6-cm (3-in.) Route, 241-AY to Vendor”</th>
</tr>
</thead>
</table>
| Flexibility       | Depends on HLW staging plan selection | PROS:  
  • Accommodates change to TWRS Treatment Complex | PROS:  
  • Supports concurrent Evaporator operation  
  • Shares transfer lines with LLW transfers | PROS:  
  • Supports concurrent Evaporator operation  
  • Accommodate change to TWRS Treatment Complex  
  • Allows for simultaneous HLW and LLW transfers |

*The Waste Pumpability Rule requires that the Reynolds Number be ≥ 20,000 for non-routine transfers.
*The “+” symbol indicates an unknown amount for design pressure upgrade analysis including NDE.
*The head and pressure requirements for this option are unacceptable.
*The cost that are covered in the corresponding AZ-Farm options are not included.
*The pump upgrade is required on each option unless mentioned otherwise. However, it is assumed that Project W-211 will be installing the New Generation Transfer Pump in tank 241-AY-102.
*The shaded cells show the hydraulic performance of the option with the existing design pressure limitation.
*Table 1-4 shows the cost breakdowns between Project: W-314 and the Privatization Infrastructure Project, and Table 1-5 shows a combined cost matrix for the options.
Table 1-4. Option Cost Breakdown between Project W-314 and the Privatization Infrastructure Project.

<table>
<thead>
<tr>
<th>Description of upgrade</th>
<th>PIP cost ($ million)</th>
<th>W-314 cost ($ million)</th>
<th>Option utilizing upgrade</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1 2 3 4</td>
<td>1 2 3 4</td>
</tr>
<tr>
<td>New 3-in. SN from AN-B Valve Pit (VP) to AZ-02A Pump Pit (PP)</td>
<td>-</td>
<td>3.2</td>
<td>✓</td>
</tr>
<tr>
<td>New 3-in. SN from AZ-02A PP to AX-B VP</td>
<td>-</td>
<td>3.3</td>
<td>✓</td>
</tr>
<tr>
<td>New SN-650 valve pit and 3-in. lines to 241-AP-102 and 241-AP-104</td>
<td>3.1</td>
<td>-</td>
<td>✓</td>
</tr>
<tr>
<td>Valve manifolds</td>
<td>-</td>
<td>6.8</td>
<td>✓</td>
</tr>
<tr>
<td>Pump upgrade</td>
<td>1.8</td>
<td>-</td>
<td>✓</td>
</tr>
<tr>
<td>Replacement of 2-in. SL-502</td>
<td>-</td>
<td>1.4</td>
<td>✓</td>
</tr>
<tr>
<td>Upgrade SL-502 replacement to 3-in. (Delta)</td>
<td>0.5</td>
<td>-</td>
<td>✓</td>
</tr>
<tr>
<td>New 3-in. SN from AZ-01A PP to AZ-02A PP</td>
<td>0.9</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>New 3-in. SN from AZ-02A PP to AX-A VP</td>
<td>3.3</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>New 3-in. SN from A-A VP to Vendor</td>
<td>3.6</td>
<td>-</td>
<td>✓</td>
</tr>
<tr>
<td>New 3-in. SN from new SN-650 valve pit*</td>
<td>1.5</td>
<td>-</td>
<td>✓</td>
</tr>
<tr>
<td>Replacement of 3-in. SN-200/213</td>
<td>-</td>
<td>1.5</td>
<td></td>
</tr>
<tr>
<td>Replacement of 3-in. SN-216</td>
<td>-</td>
<td>11.0</td>
<td></td>
</tr>
<tr>
<td>Replacement of 2-in. SL-504</td>
<td>-</td>
<td>0.7</td>
<td></td>
</tr>
</tbody>
</table>

Total Stand-Alone Cost ($ million) 8.6 15.1 11.7 18.2 6.8 12.9 15.9 16.5

PIP = Privatization Infrastructure Project

*Cost estimate covers installation of line from SN-650 valve pit to vendor High-level waste processing facility. The U.S. Department of Energy is not committed to providing the entire line at this time.
### Table 1-5: Matrix of Low-Level Waste and High-Level Waste Options

<table>
<thead>
<tr>
<th>High-Level Waste Option</th>
<th>Low-Level Waste Option</th>
<th>Combined Cost ($ million)</th>
<th>( (\text{PIP} \times 10^4) )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (W-314 S)</td>
<td>1 (W-314 S)</td>
<td>$8.6 ($6.8)</td>
<td>$11.7 ($8.8)</td>
</tr>
<tr>
<td>2 (W-314 S)</td>
<td>2 (W-314 S)</td>
<td>$14.7 ($14.7)</td>
<td>$21.2 ($14.7)</td>
</tr>
<tr>
<td>3 (W-314 S)</td>
<td>3 (W-314 S)</td>
<td>$17.7 ($16.2)</td>
<td>$20.9 ($9.6)</td>
</tr>
<tr>
<td>4 (W-314 S)</td>
<td>4 (W-314 S)</td>
<td>$18.3 ($13.2)</td>
<td>$24.7 ($10.1)</td>
</tr>
</tbody>
</table>

Shaded options do not meet the current hydraulic performance criteria, therefore the alternative option is not considered.
The U.S. Department of Energy, Richland Operations Office, is pursuing a new business strategy for remediation of Hanford Site tank waste. This strategy, commonly called privatization, involves hiring private contractors to perform specific functions on a pay-for-product basis. During Phase I, the technical, regulatory, and financial viability of the privatization concept will be demonstrated by processing a portion of the waste stored in the DST system. The Phase I Privatization mission will include supernatant pretreatment, LLW immobilization, and an optional HLW immobilization.

This AGA Report was prepared to determine the best waste transfer routing option. DST supernate and pretreated solids would be provided to the vendor(s) for processing.
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3.0 CONSTRAINTS AND ASSUMPTIONS

3.1 CONSTRAINTS

Constraints are requirements that are imposed by an external organization. The design, operation and maintenance of the Phase I privatization transfer system are affected by state and federal regulations, agreements, DOE Orders, and WHC requirements. In addition, there are guidelines and specifications that set forth engineering requirements deemed necessary for safe design and construction of the transfer system. The requirements and guidelines presented in these orders, regulations, codes, and agreements must be followed when designing and installing a transfer system. The format below establishes a hierarchy into the listed documents to be used during definitive the design stage of the transfer system:

DOE Order 6430.1A, General Design Criteria
DOE Order 5820.2A, Radioactive Waste Management
WAC 173-303-640, Dangerous Waste Regulations, Tank Systems
WHC-IP-1043, WHC Occupational ALARA Program
WHC-SD-GN-DGS-30011, Radiological Design Guide
WHC-CM-4-46, Safety Classification of Structures, Systems, and Components
WHC-SD-GN-DGS-30008, Design Loads for New Underground DSTs and Associated Underground Process Piping

3.2 ASSUMPTIONS

The following assumptions have been made in the analysis of the Phase I privatization transfer system:

- The waste fluid has a 1.5 SpG and a viscosity of 10 cP. The 1.5 SpG is the worst case value for the waste to be transferred. The issue of viscosity was discussed previously in Section 1.6.2. (Note: Current operations require a SpG of $\leq 1.41$, see Section 1.6.1. The use of 1.5 SpG was used to provide a more conservative head loss evaluation.)
The HLW will be staged in the vendor(s) processing plant per interface description 20: High-Level Waste Feed (DOE 1995).

The vendor's facility is located at the coordinates N40500 and W44500.

LLW intermediate feed staging will occur in 241-AP-102 and 241-AP-104 tanks.

Vendor(s) LLW feed staging tanks will be in 241-AP-106 and 241-AP-108, per Interface Description 20: Waste Feed Tanks (DOE 1995).

The evaluation has assumed that Project W-314, *Tank Farm Restoration and Safe Operations*, will upgrade the current master pump shutdown system (MPS). The MPS is an integral subsystem of the waste transfer system and therefore the functionality and reliability of the system can affect the efficient operation of waste transfers. Therefore this evaluation has assumed that the MPS is upgraded/restored by Project W-314 to a highly reliable system.
4.0 ANALYSIS OF OPTIONS

This section documents the methodology used to generate the options and documents any options that were screened. In addition, this section determines how well an option satisfies each selection criteria.

4.1 GENERATION OF OPTIONS

The option routings for transferring the LLW and HLW to the vendor(s) were developed by informal brainstorming. The only initial criteria used in the generation of the options was to avoid routing through the 242-A Evaporator. A description of each of the options is provided in Section 1.7.

The LLW Options considered by this study include the following:

Option 1: "Do Nothing"
Option 2: "New 7.6-cm (3-in.) Line, 241-AN to AX-B"
Option 3: "New SN-650 Valve Pit"
Option 4: "New 7.6-cm (3-in.) Route and Valve Pit."

The HLW Options (241-AZ Tank Farm) considered by this study include the following:

Option 1: "Do Nothing"
Option 2: "New 7.6-cm (3-in.) Line, 241-AZ to AX-A"
Option 3: "New 7.6-cm (3-in.) Lines to 241-AX-B and New SN-650 Valve Pit"
Option 4: "New 7.6-cm (3-in.) Route, 241-AZ to Vendor."

The HLW Options (241-AY-Tank Farm) considered by this study include the following:

Option 1: "Do Nothing"
Option 2: "New 7.6-cm (3-in.) Line, 241-AY to AX-B"
Option 3: "New 7.6-cm (3-in.) Lines to 241-AX-B and New SN-650 Valve Pit"
Option 4: "New 7.6-cm (3-in.) Route, 241-AY to Vendor."
4.2 SCREENING OF OPTIONS

The options generated could be initially screened against the requirement that the Reynolds number be \( \geq 20,000 \) (Fowler 1995). That would screen out LLW Options 1 and 3, and HLW Options 1, 2, and 4 for the 241-AZ Tank Farm and HLW Options 2 and 4 for the 241-AY Tank Farm. However, this requirement applies to non-routine transfers and does not have to be complied to if technical evaluation can show that plugging of the line will not occur at Reynolds numbers below this value. Therefore, each option is evaluated against the decision criteria and no options are screened.

4.3 ANALYSIS OF LOW-LEVEL WASTE OPTIONS

This section determines how well each LLW option satisfies the decision criterion. In absence of a tangible means of comparison, engineering judgement has been used in determining how well a criteria has been meet by the options. The results of this analysis are summarized in Table 1-1. The next revision of the revised LLW Feed Staging Plan (Certa to be released) will analyze the combined LLW and HLW options against the schedule criteria.

Option 1 is not capable of meeting the hydraulic performance requirements. The head and pressure requirements to meet the Waste Pumpability Rule are beyond the capabilities of the existing transfer system. If the system was operated at its design pressure limit of 1.6 MPa (230 psi), the Reynolds number would be 13,500 and the velocity of the waste would be just over 1.1 m/sec (3.5 ft/sec). In addition, Option 1 does not eliminate the possibility of schedule conflicts with the 242-A Evaporator since common lines and pits are utilized. Finally, Option 1 does not provide the flexibility to support concurrent operation of the Evaporator or the HLW transfers. The total cost of Option 1 is $8.6 million.

Option 2 is capable of meeting the hydraulic performance requirements, however, the schedule and flexibility concerns from Option 1 still exist. The total cost of Option 2 is $15.1 million.

Option 3 eliminates the schedule and flexibility concerns of Option 1, however, the hydraulic performance requirements can not be met. The head and pressure requirements to meet the Waste Pumpability Rule are beyond the capabilities of the existing portions of this transfer system. If the system was operated at its design pressure limit of 1.6 MPa (230 psi), the Reynolds number would be 14,000 and the velocity of the waste would be just under 1.2 m/sec (4.0 ft/sec). The total cost of Option 3 is $11.7 million.

Option 4 is a combination of Options 2 and 3. This system is capable of meeting the hydraulic performance requirements as well as eliminating possible schedule conflicts with the Evaporator. In addition, Option 4 supports concurrent operation of the Evaporator and the HLW transfers. This is accomplished by not utilizing the 241-AW Tank Farm valve pits.
and by not using common transfer lines. The only concern with this option is that the required upgrades would need to be complete by FY 2002. The total cost of Option 4 is $18.2 million.

4.4 ANALYSIS OF HIGH-LEVEL WASTE OPTIONS

This section determines how well each HLW option satisfies the decision criterion. In absence of a tangible means of comparison, engineering judgement has been used in determining how well a criterion has been meet by the options. The results of this analysis are summarized in Table 1-2 and Table 1-3. The next revision of the revised LLW Feed Staging Plan (Certa to be released) will analyze the combined LLW and HLW options against the schedule criteria.

For the 241-AZ Tank Farm transfers, Option 1 is not capable of meeting the hydraulic performance requirements. The head and pressure requirements to meet the Waste Pumpability Rule are beyond the capabilities of the existing transfer system. If the system was operated at its design pressure limit of 1.6 MPa (230 psi), the Reynolds number would be 13,000 and the velocity of the waste would be just over 1.1 m/sec (3.5 ft/sec). In addition, Option 1 does not eliminate the possibility of schedule conflicts with the 242-A Evaporator and LLW transfers since common lines and pits are utilized. Also, Option 1 does not provide the flexibility to support concurrent operation of the Evaporator or the LLW transfers. The total cost of Option 1 is $6.8 million.

For the 241-AY Tank Farm transfers, Option 1 is capable of meeting the hydraulic performance requirements, however, this option adds additional scheduling concerns. The waste would be transferred to the 241-AZ-101 Tank, after the original contents have been transferred to the vendor, and staged there before continuing the transfer to the vendor(s). The other concerns with this option will depend on the option selected for the transfer from the 241-AZ Tank Farm. There would be no additional cost associated with this option.

Option 2 is short of meeting the hydraulic performance requirements. The main driver is the design pressure of the existing portions of this transfer system. If the design pressure of the transfer lines could be increased from 1.6 MPa (230 psi) to 2.1 MPa (310 psi), the hydraulic performance requirements could be met. The analysis required to increase the design pressure limit would require some nondestructive examination (NDE) of the existing lines. However, if the system was operated at its design pressure limit, the Reynolds number would be 17,000 and the velocity of the waste would be just over 1.4 m/sec (4.5 ft/sec) for transfers from the 241-AZ Tank Farm. The Reynolds number and velocity for transfer from the 241-AY Tank Farm would be 17,500 and just under 1.5 m/sec (5.0 ft/sec), respectively. In addition, Option 2 does not eliminate the possibility of schedule conflicts with the 242-A Evaporator since common lines and pits are utilized. Also, Option 2 does not provide the flexibility to support concurrent operation of the Evaporator or the LLW transfers. The total cost of Option 2 is $12.9 million.
Option 3 is capable of meeting the hydraulic performance requirements as well as eliminating possible schedule conflicts with the Evaporator. This is accomplished by not utilizing the 241-AW Tank Farm valve pits and by not utilizing common transfer lines. However, this alternative does share common transfer lines with the LLW transfers and does require that the SN-200/213 transfer line be replaced. The replacing of the SN-200/213 line makes the design pressure limit of the system 2.8 MPa (400 psi) instead of the 1.6 MPa (230 psi) for the existing transfer line. If the system was operated at its design pressure limit of 1.6 MPa (230 psi), the Reynolds number would be 18,000 and the velocity of the waste would be just under 1.5 m/sec (5.0 ft/sec) for transfers from the 241-AZ Tank Farm. The Reynolds number and velocity for transfer from the 241-AY Tank Farm would be 19,000 and just under 1.7 m/sec (5.5 ft/sec), respectively. The total cost of Option 3 is $15.9 million.

Option 4 is short of meeting the hydraulic performance requirements. The main driver is the design pressure of the existing portions of this transfer system. If the design pressure of the transfer lines could be increased from 1.6 MPa (230 psi) to 1.9 MPa (280 psi), the hydraulic performance requirements could be met. However, if the system was operated at a design pressure limit, the Reynolds number would be 18,000 and the velocity of the waste would be 1.5 m/sec (5.0 ft/sec) for transfers from the 241-AZ Tank Farm. The Reynolds number and velocity for transfer from the 241-AY Tank Farm would be 19,000 and just under 1.7 m/sec (5.5 ft/sec), respectively. However, Option 4 supports concurrent operation of the Evaporator and the LLW transfers. This is accomplished by not utilizing the 241-AW Tank Farm valve pits and by not using common transfer lines. Another concern with the Option is that the required upgrades would need to be complete by FY 2002. The total cost of Option 4 is $16.5 million.
5.0 FINDINGS

The decision process used to recommend the preferred options was to minimize the possible bad consequences. The findings of this AGA report are to be analyzed further in the next revision of the revised LLW Feed Staging Plan (Certa to be released). A nodal analysis will provide the decision makers with the cost benefits of the combined LLW and HLW options based on scheduling and sequencing requirements. The findings presented in this section are based primarily on meeting the hydraulic performance requirements.

For the LLW transfer system, Options 2 and 4 were capable of meeting the hydraulic performance criteria. Option 4 is capable of eliminating the schedule concerns with the Evaporator by avoiding the 241-AW and 241-AP valve pits. For the HLW transfer system, only Option 3 meets the hydraulic performance criteria.

The combined cost of LLW Option 2 and HLW Option 3 would be $24.0 million. This includes $8.3 million of LLW Option 2, $8.9 million for the additional HLW Option 3 upgrades, and $6.8 million for the jumper manifold system. Of the total cost, $16.2 million of this scope was included in the Project W-314 scope (WHC 1996b). This would leave a total project cost of $7.8 million for the PIP (see Table 1-4).

The combined cost of LLW Option 4 and HLW Option 3 would be $24.0 million. This includes $11.4 million of LLW Option 4, $5.8 million for the additional HLW Option 3 upgrades, and $6.8 million for the jumper manifold system. Of the total cost, $16.2 million of this scope was included in the Project W-314 scope (WHC 1996b). This would leave a total project cost of $7.8 million for the PIP (see Table 1-4).

Since the combined cost of the options that meet the hydraulic performance requirements are no different, LLW Option 4 and HLW Option 3 are the recommended options. If the decision makers want to operate the LLW and/or HLW transfer systems at a reduced hydraulic performance, the results of the nodal analysis in the revised waste staging plan can be used to show the cost versus performance trade-offs of the options based on scheduling and sequencing requirements.

Based on hydraulic performance calculations performed for this study it has been concluded that the system will also support return of separated waste ($^{90}$Sr/TRU/entrained solids) from the vendor(s). The interface point of connect by the vendor(s) will be the vendor(s) LLW waste feed staging (241-AP-106 and 241-AP-108) tank. This connection will provide access to the existing 200 East Area waste transfer system.
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6.0 REFERENCES


Certa, P. J., to be released, Low-Level Waste Feed Staging Plan, WHC-SD-WM-RPT-224, Rev. 0, Westinghouse Hanford Company, Richland, Washington.


APPENDIX A

CALCULATIONS
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This sheet shows the status and description of the attached Design Analysis sheets:

Discipline Piping, 27
WO/Job No. E44810
Calculation No. E44810-2701

Project No. & Name Phase I Privatization Transfer System Needs
Calculation Item Head Loss Calculation for HLW Feed from 241-AY Tanks (Alternative 1)

These calculations apply to:

Other (Study, CDR) Rev. No.

The status of these calculations is:

[ ] Preliminary Calculations
[X] Final Calculations
[ ] Check Calculations (On Calculation Dated)
[ ] Void Calculation (Reason Voided)

Incorporated in Final Drawings? [ ] Yes [ ] No
This calculation verified by independent "check" calculations? [ ] Yes [ ] No

Original and Revised Calculation Approvals:

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Originator

Checked by

Approved by

Checked Against

Approved Vendor Data

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Design Analysis

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ICF Kaiser Hanford

DESIGN ANALYSIS

Client: WHC
Subject: Head Loss Calculations for HLW Feed from 241-AY Tanks (Alternative 1)
Location: 200 East

1.0 OBJECTIVE

Determine the pump head requirements to transfer high-level waste (HLW) from the 241-AY-102 Tank to the 241-AZ-101 Tank. This analysis is in support of the Alternative Generation Analysis for the Phase I Transfer System Needs, WHC-SD-WM-TI-750 and corresponds to HLW Alternative 1 for the 241-AY Tank Farm.

2.0 DESIGN INPUTS

2.1 Given Data
- Absolute Viscosity: 10 cp
- Specific Gravity: 1.5
- Pipe Selection: 2" Schedule 40
- Inside Diameter: ID = 2.067

2.2 Assumptions
1. The sending and receiving tanks are at atmospheric pressure.
2. The head loss (including elevation and line loss) from the centerline of the discharge pump to the nozzle of the first transfer line is 50 feet.
3. Purex Connectors were assumed to have losses equal to a 90° miter bend.
4. Pipeline friction factors are based on clean commercial steel pipe.
5. The pit head losses for the AX valve pits and the AZ pump pit are based on 10 feet of pipe, four 90° LR elbows, two three-way ball valves, and four Purex Connectors. The two AY process pits are assumed to have 10 ft jumpers with two 90° LR elbows, one three-way ball valve, and two Purex Connectors.

2.3 References
   Friction factors: Fittings, f_r, Page A-26; Pipe, f_p, Page A-25

2.4 Method
The method used for the determination of the pressure loss in the piping system is based upon the Darcy-Weisbach formula. Pressure losses in fittings are determined using experimental resistance coefficients (K) along with friction factors. The losses of all the fittings, valves, and pipe are totaled and using the Bernoulli Theorem, the pressure loss of the system can be determined. The computer program Mathcad, Version 4.0, is used.

3.0 CONCLUSION

See Body of Calculation A-4
4.0 AY-FARM HLW TRANSFER HEAD LOSSES

The head loss for transfers from the 241-AY-102 Tank will be calculated. The analysis will be based on a flow rate of 90 gpm to maintain a minimum Reynolds Number of 20,000 (Ref. 4).

4.1 Constant Data

Volumetric Flow Rate,

\[ Q_{90} = 90 \text{ gal/min} \]

\[ Q_{90} = 0.13368 \text{ ft}^3/\text{min} \]

\[ q = \frac{Q_{90}}{60 \text{ sec}} = 0.20 \text{ ft}^3/\text{sec} \]

Pipe Diameter,

2 inch pipe

\[ d_{2\text{in}} = 2.067 \text{ in} \]

\[ D_{2\text{in}} = \frac{d_{2\text{in}}}{12} = 0.17 \text{ ft} \]

Area of Flow,

2 inch pipe

\[ A_{2\text{in}} = \frac{\pi D_{2\text{in}}^2}{4} = 0.02 \text{ ft}^2 \]

Velocity of Flow,

2 inch pipe

\[ v_{2\text{in}} = \frac{q}{A_{2\text{in}}} = 8.6 \text{ ft/sec} \]

Density of Liquid,

\[ \rho = \text{SpG} = 1.5 \]

\[ \rho = \text{SpG}-62.371 \text{ lb/ft}^3 \]

\[ \rho = 93.6 \text{ lb/ft}^3 \]

(62.371 lb/cu. ft is the density of water at 60°F, Ref. 4, Page A-6)

Absolute Viscosity,

\[ \mu = 10 \text{ cp} \] (Ref. 2)

\[ \mu_e = \mu \left(6.72 \times 10^{-4}\right) \text{ lb-ft/sec} \]

\[ \mu_e = 0.007 \text{ lb-ft/sec} \]

Reynolds Number,

2 inch pipe

\[ \text{Re}_{2\text{in}} = \frac{D_{2\text{in}} v_{2\text{in}} \rho}{\mu_e} = 20635 \]

Friction Factor (Ref. Crane, Page A-25 and A-26),

2 inch pipe

\[ f_{2\text{in}} = 0.028 \]

\[ f_{T2\text{in}} = 0.019 \]

Bernoulli's Theorem,

\[ z_1 + \frac{144 P_1}{\rho_1} + \frac{v_1^2}{2g} + H_L = z_2 + \frac{144 P_2}{\rho_2} + \frac{v_2^2}{2g} + H_L \]
4.2 PROCESS PIT HEAD LOSSES

The HLW transfer route from 241-AY-102 will pass through six process pits: The 241-AY-02A Pump Pit (PP), the 241-AY-02D Sluice Pit (SP), the 241-AX-B Valve Pit (VP), the 241-AX-A VP, the 241-AZ-02A PP, and the 241-AZ-01A PP (See Attachment A).

4.2.1 AY-Farm Process Pits

The AY-Farm pump pit and sluice pit are assumed to have 2-inch jumpers that are 10 feet in length. In addition, each jumper is assumed to contain two 90 degree LR elbows, one three-way ball valve, and two Purex Connectors.

10.0 ft - 2" Pipe Length:

\[ L_1 = 10 \text{ ft} \]

\[ K_1 = f_{2\text{in}} \frac{L_1}{D_{2\text{in}}} \]

\[ K_1 = 1.6 \]

2 - 2" Connectors (assume 90 Mitre Bend):

\[ K_2 = (60 \cdot f_{2\text{in}})^2 \]

\[ K_2 = 2.3 \]

2 - 2" Long Radius Elbow:

\[ K_3 = (14 \cdot f_{2\text{in}})^2 \]

\[ K_3 = 0.5 \]

1 - 2" 3-Way Ball Valve (assume 90 Mitre Bend):

\[ K_4 = (60 \cdot f_{2\text{in}})^2 \cdot 1 \]

\[ K_4 = 1.1 \]

Head Loss for each pit:

\[ h_{ay\_pit} = \frac{v^{2\text{in}}}{2 \cdot g} \sum_{i=1}^{4} K_i \]

\[ h_{ay\_pit} = 6.4 \cdot \text{ft} \]

Head Loss for both AY-Farm pits:

\[ h_{ay102\_pits} = 2 \cdot h_{ay\_pit} = 12.8 \cdot \text{ft} \]
4.2.2 Remaining Process Pits

The remaining four process pits have jumper manifolds and are assumed to have 2-inch jumpers that are 10 feet in length. In addition, each jumper is assumed to contain four 90 degree LR elbows, two three-way ball valves, and four Purex Connectors.

**10.0 ft - 2" Pipe Length:**

\[ L_1 = 10 \text{ ft} \]

\[ K_1 = \frac{L_1}{D_{2\text{in}}} \]

\[ K_1 = 1.6 \]

**4 - 2" Connectors (assume 90 Mitre Bend):**

\[ K_2 = (60 \text{ ft} - 2\text{in}) \cdot 4 \]

\[ K_2 = 4.6 \]

**4 - 2" Long Radius Elbow:**

\[ K_3 = (14 \text{ ft} - 2\text{in}) \cdot 4 \]

\[ K_3 = 1.1 \]

**2 - 2" 3-Way Ball Valve (assume 90 Mitre Bend):**

\[ K_4 = (60 \text{ ft} - 2\text{in}) \cdot 2 \]

\[ K_4 = 2.3 \]

**Head Loss for each pit:**

\[ h_{\text{pits}} = \frac{v_{2\text{in}}^2}{2 \cdot g} \sum_{i=1}^{4} K_i \]

\[ h_{\text{pits}} = 11 \text{ ft} \]

**Head Loss for four remaining pits:**

\[ h_{\text{valve pits}} = 4 \cdot h_{\text{pits}} \]

\[ h_{\text{valve pits}} = 43.9 \text{ ft} \]
4.3 TRANSFER LINE HEAD LOSSES

The HLW transfers from the 241-AY-102 will pass through five transfer lines: 2"SL-503, 2"SL-502, 2"SL-110, 2"SL-500, and 2"SL-501 to the 241-AZ-101 Tank (See Attachment A).

4.3.1 2"SL-503 (AY-02A PP to AY-02D SP)

11' - 2" Pipe Length: \[ L_1 = 11\text{ ft} \]
\[ K_1 = \frac{f_{2\text{in}} L_1}{D_{2\text{in}}} \]
\[ K_1 = 1.8 \]

2 - 36" Radius Bends (r/d=18):
\[ K_2 = \left(46 f_{T2\text{in}}\right)^2 \]
\[ K_2 = 1.7 \]

Elevation at Start of Transfer (pit exit nozzle):
\[ z_{\text{start}} = 675.0\text{ ft} \]
(See Assumption 2)

Head Loss:
\[ h_{\text{sl-503}} = \frac{v_{2\text{in}}^2}{2 g} \sum_{i=1}^{2} K_i \]
\[ h_{\text{sl-503}} = 4\text{ ft} \]

4.3.2 2"SL-502 (AY-02D SP to AX-B VP)

235' - 2" Pipe Length: \[ L_1 = 235\text{ ft} \]
\[ K_1 = \frac{f_{2\text{in}} L_1}{D_{2\text{in}}} \]
\[ K_1 = 38.2 \]

5 - 36" Radius Bends (r/d=18):
\[ K_2 = \left(46 f_{T2\text{in}}\right)^2 \]
\[ K_2 = 4.4 \]

1 - Clean-Out Boxes (COB) (assume Tee - thru):
\[ K_3 = \left(20 f_{T2\text{in}}\right)^1 \]
\[ K_3 = 0.4 \]

Head Loss:
\[ h_{\text{sl-502}} = \frac{v_{2\text{in}}^2}{2 g} \sum_{i=1}^{3} K_i \]
\[ h_{\text{sl-502}} = 49\text{ ft} \]
4.3.3 2"SL-110 (AX-A VP to AX-B VP)

5.5' - 2" Pipe Length:

\[ L_1 = 5.5 \text{ ft} \]

\[ K_1 = f_{2in} \frac{L_1}{D_{2in}} \]

\[ K_1 = 0.9 \]

4 - 36" Radius Bends (r/d=18):

\[ K_2 = (46 f_{2in})^4 \]

\[ K_2 = 3.5 \]

Head Loss:

\[ h_{sl-110} = \frac{v_{2in}^2}{2g} \sum_{i=1}^{2} K_i \]

\[ h_{sl-110} = 5 \text{ ft} \]

4.3.4 2"SL-500 (AZ-02A PP to AX-A VP)

530' - 2" Pipe Length:

\[ L_1 = 530 \text{ ft} \]

\[ K_1 = f_{2in} \frac{L_1}{D_{2in}} \]

\[ K_1 = 86.2 \]

14 - 36" Radius Bends (r/d=18):

\[ K_2 = (46 f_{2in})^{14} \]

\[ K_2 = 12.2 \]

5 - Clean-Out Boxes (COB) (assume Tee - thru):

\[ K_3 = (20 f_{2in})^5 \]

\[ K_3 = 1.9 \]

Head Loss:

\[ h_{sl-500} = \frac{v_{2in}^2}{2g} \sum_{i=1}^{3} K_i \]

\[ h_{sl-500} = 115 \text{ ft} \]

4.3.5 2"SL-501 (AZ-01A PP to AZ-02A PP)

140' - 2" Pipe Length:

\[ L_1 = 140 \text{ ft} \]

\[ K_1 = f_{2in} \frac{L_1}{D_{2in}} \]

\[ K_1 = 22.8 \]

4 - 36" Radius Bends (r/d=18):

\[ K_2 = (46 f_{2in})^4 \]

\[ K_2 = 3.5 \]

Elevation at End of Transfer:

\[ z_{end} = 668.4 \text{ ft} \]

Head Loss:

\[ h_{sl-501} = \frac{v_{2in}^2}{2g} \sum_{i=1}^{2} K_i \]

\[ h_{sl-501} = 30 \text{ ft} \]
4.4 TOTAL HEAD LOSS: 241-AY ALTERNATIVE 1

Process Pit Losses:
\[ h_1 = h_{ay102\_pits} + h_{valve\_pits} \]
\[ h_1 = 57\text{ ft} \]

Transfer Path Losses:
\[ h_2 = h_{sl\_503} + h_{sl\_502} + h_{sl\_110} + h_{sl\_500} + h_{sl\_501} \]
\[ h_2 = 204\text{ ft} \]

Elevation Change (w/ 50 ft suction lift):
\[ h_3 = 50\text{ ft} + z_{end} - z_{start} \]
\[ h_3 = 43.4\text{ ft} \quad \text{(Assumption 2)} \]

Total Head Loss:
\[ \text{TDH}_{90\_alt1} = \sum h_i \]
\[ \text{TDH}_{90\_alt1} = 304\text{ ft} \]

Pressure Drop:
\[ \Delta P_{90\_alt1} = \frac{\text{TDH}_{90\_alt1} \cdot \rho}{144 \text{ in}^2 \text{ ft}^2} \]
\[ \Delta P_{90\_alt1} = 198\text{ lb} \text{ in}^2 \]

The lowest design pressure in the system is 375 psi. Therefore, the above operating point is acceptable.
HLW ALTERNATIVE 1
"DO NOTHING"

241-AZ

241-AY

241-AW

241-AP

VENDOR

NEW 3"SN (~2820 FT)
BY VENDOR
2” SL-503, 504, 505

(AY-FARM)

241-AY-01A PUMP PIT

U12

SL-505

5.5’

7’

241-AY-01D SLUICE PIT

U2

U3

241-AY-02A PUMP PIT

U3

U8

2.1’

4.5’

14.5’

73.4’

16.6’

7’

SL-504

SL-503

SL-505

NOTE: ALL NOZZLES AT EL 675 UNLESS OTHERWISE NOTED

REFERENCES:

H-2-70764
H-2-64313
H-2-64314
B-131-C1

SUMMARY:

LENGTH
3’R BENDS

SL-503
11 FT
2

SL-504
116 FT
4

SL-505
18 FT
2

DESIGN:

PRESSURE
400 PSIG

TEMP
200 °F

PREPARED BY: T.B. SALZANO 4/5/96
CHECKED BY: J.P. NICOLSON 4/5/96
2" SL-502

REFERENCES:
- H-2-69245
- H-2-70763
- H-2-70764
- H-2-70780
- B-131-C1

SUMMARY:
- LENGTH: 234.7 FT
- 3'R BENDS: 5
- COBs: 1
- REDUCERS: 1

DESIGN:
- PRESSURE: 400 PSIG
- TEMP: 200 'F

PREPARED BY: T.B. SALZANO 4/5/96
CHECKED BY: [Signature] 4/5/96
2" SL-501
(AZ-FARM)

REFERENCES:
H-2-70765
H-2-68304 B-iZi-Ci
B-131-C1

SUMMARY:
LENGTH 137.8 FT
3'R BENDS 4

DESIGN:
PRESSURE 400 PSIG
TEMP 200 °F

PREPARED BY: T.B. SALZANO 4/5/96
CHECKED BY: [Signature] 4/5/96
This sheet shows the status and description of the attached Design Analysis sheets:

**Discipline: Piping, 27**

**WO/Job No.: E44810**

**Calculation No.: E44810-2702**

**Project No. & Name: Phase I Privatization Transfer System Needs**

**Calculation Item: Head Loss Calculation for HLW Feed from 241-AY Tanks (Alternative 2)**

These calculations apply to:

- **Dwg. No.**
- **Rev. No.**
- **Dwg. No.**
- **Rev. No.**
- **Other (Study, CDR)**

The status of these calculations is:

- [ ] Preliminary Calculations
- [X] Final Calculations
- [ ] Check Calculations (On Calculation Dated)
- [ ] Void Calculation (Reason Voided)

Incorporated in Final Drawings? [ ] Yes [ ] No

This calculation verified by independent "check" calculations? [ ] Yes [ ] No

### Original and Revised Calculation Approvals:

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<tr>
<td>Checked Against: Approved Vendor Data</td>
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1.0 OBJECTIVE

Determine the pump head requirements to transfer high-level waste (HLW) from the 241-AY-102 Tank to one of the Phase I Privatization Vendors. This calculation will develop the system curve for transfers from the 241-AY-102 to the vendor including the upgrade of the 2-in. transfer lines. This system corresponds to HLW Alternative 2.

2.0 DESIGN INPUTS

2.1 Given Data

<table>
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<th>Parameter</th>
<th>Value</th>
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<tr>
<td>Absolute Viscosity</td>
<td>10 cp</td>
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<tr>
<td>Specific Gravity</td>
<td>1.5</td>
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Pipe Selection:

- 2" Schedule 40
- 3" Schedule 40

Inside Diameter:

- ID = 2.067
- ID = 3.068

2.2 Assumptions

1. The sending and receiving tanks are at atmospheric pressure.
2. The head loss (including elevation and line loss) from the centerline of the discharge pump to the nozzle of the first transfer line is 50 feet.
3. Purex Connectors were assumed to have losses equal to a 90° miter bend.
4. Pipeline friction factors are based on clean commercial steel pipe.
5. The pit head losses are based on 10 feet of pipe, four 90° LR elbows, two three-way ball valves, and four Purex Connectors. The two AY process pits are assumed to have 10 ft jumpers with two 90° LR elbows, one three-way ball valve, and two Purex Connectors.
6. The ending elevation of the system at the vendor(s) facility is 670.0 feet (Ref. 3).

2.3 References


Friction factors: Fittings, \( f_f \), Page A-26; Pipe, \( f_{pipe} \), Page A-25

2.4 Method

The method used for the determination of the pressure loss in the piping system is based upon the Darcy-Weisbach formula. Pressure losses in fittings are determined using experimental resistance coefficients (K) along with friction factors. The losses of all the fittings, valves, and pipe are totaled and using the Bernoulli Theorem, the pressure loss of the system can be determined. The computer program Mathcad, Version 4.0, is used.

3.0 CONCLUSION

See Body of Calculation
4.0 AY-FARM HLW TRANSFER HEAD LOSSES

The head losses for transfers from the 241-AY-102 Tank will be calculated. The first analysis will be based on a flow rate of 140 gpm to maintain a minimum Reynolds number of 20,000 (Ref. 4).

4.1 Constant Data

Volumetric Flow Rate,

\[ Q_{140} = 140 \frac{\text{gal}}{\text{min}} \]

\[ Q_{140} = 0.13368 \frac{\text{ft}^3}{\text{gal}} \]

\[ q = 0.31 \frac{\text{ft}^3}{\text{sec}} \]

Pipe Diameter,

2 inch pipe

\[ d_{2\text{in}} = 2.067 \text{ in} \]

\[ D_{2\text{in}} = 0.17 \text{ ft} \]

3 inch pipe

\[ d_{3\text{in}} = 3.068 \text{ in} \]

\[ D_{3\text{in}} = 0.26 \text{ ft} \]

Area of Flow,

2 inch pipe

\[ A_{2\text{in}} = \frac{\pi \cdot D_{2\text{in}}^2}{4} \]

\[ A_{2\text{in}} = 0.02 \text{ ft}^2 \]

3 inch pipe

\[ A_{3\text{in}} = \frac{\pi \cdot D_{3\text{in}}^2}{4} \]

\[ A_{3\text{in}} = 0.05 \text{ ft}^2 \]

Velocity of Flow,

2 inch pipe

\[ v_{2\text{in}} = \frac{q}{A_{2\text{in}}} \]

\[ v_{2\text{in}} = 13.4 \frac{\text{ft}}{\text{sec}} \]

3 inch pipe

\[ v_{3\text{in}} = \frac{q}{A_{3\text{in}}} \]

\[ v_{3\text{in}} = 6.1 \frac{\text{ft}}{\text{sec}} \]
ICF Kaiser Hanford

DESIGN ANALYSIS

Client: WHC
Subject: Head Loss Calculations for HLW
Feed from 241-AY Tanks (Alternative 2)
Location: 200 East

Calc. No. E44810-2702
Revision 0
Page No. 3 of 28

Density of Liquid,
\[ \rho = \text{SpG} \times 62.371 \frac{\text{lb}}{\text{ft}^3} \]
\[ \rho = 93.6 \times 62.371 \frac{\text{lb}}{\text{ft}^3} \]

(62.371 lb/cu. ft is the density of water at 60°F, Ref. 4, Page A-6)

Absolute Viscosity,
\[ \mu = 10 \text{ cp} \]
\[ \mu_e = \mu \times (6.72 \times 10^{-4}) \text{ ft} \cdot \text{sec} \]
\[ \mu_e = 0.007 \frac{\text{lb}}{\text{ft} \cdot \text{sec}} \]

Reynolds Number,
\[ \text{Re}_{2\text{in}} = \frac{D \times v}{\mu_e} \]
\[ \text{Re}_{2\text{in}} = 32100 \]
\[ \text{Re}_{3\text{in}} = \frac{D \times v}{\mu_e} \]
\[ \text{Re}_{3\text{in}} = 21626 \]

Friction Factor (Ref. Crane, Page A-25 and A-26),
\[ f_{2\text{in}} = 0.026 \]
\[ f_{3\text{in}} = 0.027 \]

Bernoulli's Theorem,
\[ z_1 + \frac{144 \times P_1}{\rho_1} + \frac{v_1^2}{2g} = z_2 + \frac{144 \times P_2}{\rho_2} + \frac{v_2^2}{2g} + h_L \]
4.2 PROCESS PIT HEAD LOSSES

The HLW Alternative 2 transfer route from 241-AY-102 will pass through nine process pits: The 241-AY-02A Pump Pit (PP), the 241-AY-02D Sluice Pit (SP), the 241-AX-A Valve Pit (VP), the 241-AX-A VP, the 241-A-A VP, the 241-AW-A VP, the 241-AW-02A PP, the 241-AP VP, and the 241-AP-08A PP.

4.2.1 AY-Farm Process Pits

The AY-Farm pump pit and sluice pit are assumed to have 2-inch jumpers that are 10 feet in length. In addition, each jumper is assumed to contain two 90 degree LR elbows, one three-way ball valve, and two Purex Connectors.

$10.0$ ft - $2''$ Pipe Length: $L_1 = 10$ ft

$K_1 = f_{2in} \cdot \frac{L_1}{D_{2in}}$ $K_1 = 1.5$

2 - $2''$ Connectors (assume 90 Mitre Bend):

$K_2 = (60f_{2in})^2$ $K_2 = 2.3$

2 - $2''$ Long Radius Elbow:

$K_3 = (14f_{2in})^2$ $K_3 = 0.5$

1 - $2''$ 3-Way Ball Valve (assume 90 Mitre Bend):

$K_4 = (60f_{2in})^1$ $K_4 = 1.1$

Head Loss for each pit:

$h_{pit_{2in}} = \frac{v^{2in}}{2g} \sum_{i=1}^{4} K_i$

$h_{pit_{2in}} = 15.2$ ft

Head Loss for both AY-Farm pits:

$h_{ay\_pits} = 2 \cdot h_{pit_{2in}}$

$h_{ay\_pits} = 30.4$ ft
4.2.2 Remaining Process Pits

The remaining seven process pits are assumed to have 3-inch jumpers that are 10 feet in length. In addition, each jumper is assumed to contain four 90 degree elbows, two three-way ball valves, and four Purex Connectors.

10.0 ft - 3" Pipe Length:

\[ L_1 = 10 \text{ ft} \]

\[ K_1 = \frac{f_{3\text{in}}}{D_{3\text{in}}} \]

\[ K_1 = 1.1 \]

4 - 3" Connectors (assume 90 Mitre Bend):

\[ K_2 = (60 \text{ ft}_{3\text{in}})^{0.4} \]

\[ K_2 = 4.3 \]

4 - 3" Long Radius Elbow:

\[ K_3 = (14 \text{ ft}_{3\text{in}})^{0.4} \]

\[ K_3 = 1.0 \]

2 - 3" 3-Way Ball Valve (assume 90 Mitre Bend):

\[ K_4 = (60 \text{ ft}_{3\text{in}})^{0.2} \]

\[ K_4 = 2.2 \]

Head Loss for each pit:

\[ h_{\text{pit}_3\text{in}} = \frac{v_{3\text{in}}^2}{2g} \sum_{i=1}^{4} K_i \]

\[ h_{\text{pit}_3\text{in}} = 4.9 \text{ ft} \]

Head Loss for all seven remaining pits:

\[ h_{\text{valve_pits}} = 7 \times h_{\text{pit}_3\text{in}} \]

\[ h_{\text{valve_pits}} = 34.3 \text{ ft} \]
4.3 TRANSFER LINE HEAD LOSSES

The HLW transfers from the 241-AY-102 will pass through nine transfer lines: 2"SL-503, new 3"SL-502, 3"SN-210, 3"SN-201/214, 3"SN-220, 3"SN-267, 3"SN-610, 3"SN-618, and a new 3" SN line to the Phase 1 vendor (See Attachment A).

4.3.1 2"SL-503 (AY-02A PP to AY-02D SP)

\[ L_1 = 11 \text{ ft} \]

\[ K_1 = f_{2\text{in}} \frac{L_1}{D_{2\text{in}}} \]

\[ K_1 = 1.7 \]

2 - 36" Radius Bends (r/d=18):

\[ K_2 = \left( 46 f_{1\text{in}} \right)^2 \]

\[ K_2 = 1.7 \]

Elevation at Start of Transfer (pit exit nozzle):

\[ z_{start} = 675.0 \text{ ft} \]

Head Loss:

\[ h_{sl\_503} = \frac{v_{2\text{in}}^2}{2 g} \sum_{i=1}^{2} K_i \]

\[ h_{sl\_503} = 9 \text{ ft} \]

4.3.2 NEW 3"SL-502 (AY-02D SP to AX-B VP)

\[ L_1 = 235 \text{ ft} \]

\[ K_1 = f_{3\text{in}} \frac{L_1}{D_{3\text{in}}} \]

\[ K_1 = 24.8 \]

5 - 36" Radius Bends (r/d=12):

\[ K_2 = \left( 34 f_{3\text{in}} \right)^5 \]

\[ K_2 = 3.1 \]

Head Loss:

\[ h_{new\_sl\_502} = \frac{v_{3\text{in}}^2}{2 g} \sum_{i=1}^{2} K_i \]

\[ h_{new\_sl\_502} = 16 \text{ ft} \]
4.3.3 3" SN-210 (AX-B VP to AX-A VP)

6' - 3" Pipe Length:

\[ L_1 = 6 \text{ ft} \]

\[ K_1 = f \frac{L_1}{D_{3\text{in}}} \]

\[ K_1 = 0.6 \]

4 - 36" Radius Bends (r/d=12):

\[ K_2 = \left(34 f_{T3\text{in}}\right)^2 \]

\[ K_2 = 2.4 \]

Head Loss:

\[ h_{sn\_210} = \frac{v_{3\text{in}}^2}{2g} \sum_{i=1}^{2} K_i \]

\[ h_{sn\_210} = 2.8 \text{ ft} \]

4.3.4 3" SN-201/214 (AX-A VP to A-A VP)

650' - 3" Pipe Length:

\[ L_1 = 650.4 \text{ ft} \]

\[ K_1 = f \frac{L_1}{D_{3\text{in}}} \]

\[ K_1 = 68.6 \]

17 - 36" Radius Bends (r/d=12):

\[ K_2 = \left(34 f_{T3\text{in}}\right)^{17} \]

\[ K_2 = 10.4 \]

Head Loss:

\[ h_{sn\_201\_214} = \frac{v_{3\text{in}}^2}{2g} \sum_{i=1}^{2} K_i \]

\[ h_{sn\_201\_214} = 45.4 \text{ ft} \]

4.3.5 3" SN-220 (A-A VP to AW-A VP)

577' - 3" Pipe Length:

\[ L_1 = 577 \text{ ft} \]

\[ K_1 = f \frac{L_1}{D_{3\text{in}}} \]

\[ K_1 = 60.9 \]

12 - 36" Radius Bends (r/d=12):

\[ K_2 = \left(34 f_{T3\text{in}}\right)^{12} \]

\[ K_2 = 7.3 \]

Head Loss:

\[ h_{sn\_220} = \frac{v_{3\text{in}}^2}{2g} \sum_{i=1}^{2} K_i \]

\[ h_{sn\_220} = 39.4 \text{ ft} \]
4.3.6 3'' SN-267 (AW-A VP to AW-02A PP)

106' - 3'' Pipe Length: \[ L_1 = 106 \text{ ft} \]

\[ K_1 = f_{3\text{in}} \frac{L_1}{D_{3\text{in}}} \] \( K_1 = 11.2 \)

5 - 36'' Radius Bends (r/d=12):

\[ K_2 = \left(34 f_{3\text{in}}\right)^5 \] \( K_2 = 3.1 \)

Head Loss:

\[ h_{sn-267} = \frac{v^2}{2g} \sum_{i=1}^{2} K_i \]

\[ h_{sn-267} = 8 \cdot \text{ft} \]

4.3.7 3'' SN-610 (AW-02A PP to AP VP)

750' - 3'' Pipe Length: \[ L_1 = 750 \text{ ft} \]

\[ K_1 = f_{3\text{in}} \frac{L_1}{D_{3\text{in}}} \] \( K_1 = 79.2 \)

17 - 36'' Radius Bends (r/d=12):

\[ K_2 = \left(34 f_{3\text{in}}\right)^{17} \] \( K_2 = 10.4 \)

Head Loss:

\[ h_{sn-610} = \frac{v^2}{2g} \sum_{i=1}^{2} K_i \]

\[ h_{sn-610} = 51 \cdot \text{ft} \]

4.3.8 3'' SN-618 (AP VP to AP-08A PP)

425' - 3'' Pipe Length: \[ L_1 = 425 \text{ ft} \]

\[ K_1 = f_{3\text{in}} \frac{L_1}{D_{3\text{in}}} \] \( K_1 = 44.9 \)

8 - 36'' Radius Bends (r/d=12):

\[ K_2 = \left(34 f_{3\text{in}}\right)^8 \] \( K_2 = 4.9 \)

Head Loss:

\[ h_{sn-618} = \frac{v^2}{2g} \sum_{i=1}^{2} K_i \]

\[ h_{sn-618} = 29 \cdot \text{ft} \]

A-24
4.3.9 NEW 3" SN LINE (AP-08A PP to VENDOR)

The length and number of bends for this new line are from the analysis done in support of the Feed Staging Plan (Ref. 2).

2820' - 3'' Pipe Length:  \[ L_1 = 2820 \text{ ft} \]
\[ K_1 = f \frac{L_1}{D_{	ext{3in}}} \]
\[ K_1 = 297.8 \]

50 - 36'' Radius Bends (r/d=12):
\[ K_2 = (34 f_{13in})^{50} \]
\[ K_2 = 30.6 \]

Elevation at End of Transfer:
\[ z_{\text{end}} = 670.0 \text{ ft} \]  
(Assumption 5)

Head Loss:
\[ h_{\text{sn-vendor}} = \frac{v_{3in}^2}{2g} \sum_{i=1}^{2} K_i \]
\[ h_{\text{sn-vendor}} = 188 \cdot \text{ft} \]

4.4 TOTAL HEAD LOSS: 241-AY ALTERNATIVE 2

Process Pit Losses:
\[ h_i = h_{\text{ay-pits}} + h_{\text{valve-pits}} \]
\[ h_i = 65 \cdot \text{ft} \]

Transfer Path Losses:
\[ h_2 = h_{\text{sl-503}} + h_{\text{new-si-502}} + h_{\text{sn-210}} + h_{\text{sn-201-214}} + h_{\text{sn-220}} + h_{\text{sn-267}} + h_{\text{sn-610}} + h_{\text{sn-618}} + h_{\text{sn-vendor}} \]
\[ h_2 = 388 \cdot \text{ft} \]

Elevation Change:
\[ h_3 = 50 \cdot \text{ft} + z_{\text{end}} - z_{\text{start}} \]
\[ h_3 = 45 \cdot \text{ft} \]  
(Assumption 2)

Total Head Loss:
\[ i = 1, 2, 3 \]
\[ \text{TDH}_{140 \_alt2} = \sum_i h_i \]
\[ \text{TDH}_{140 \_alt2} = 498 \cdot \text{ft} \]

Pressure Drop:
\[ \Delta P_{140 \_alt2} = \frac{\text{TDH}_{140 \_alt2} \cdot p}{144 \cdot \text{in}^2 / \text{ft}^2} \]
\[ \Delta P_{140 \_alt2} = 324 \cdot \text{lb} / \text{in}^2 \]
5.0 SYSTEM CURVE DEVELOPMENT

A system-head curve is a graphical representation of the relationship between flow and hydraulic losses in a given piping system. The system curve can be used with a pump characteristic curve to develop the operating point of the system. For this system, the friction losses at flow rates of 140 (previously calculated), 120, 100, 80, and 60 gpm will be used to develop the system-head curve.

5.1 120 GPM: 241-AY

5.1.1 Constant Data

Volumetric Flow Rate, 

\[ Q_{120} = 120 \text{ gal/min} \]

\[ q = 120 \times 0.13368 \times \frac{ft^3}{gal} \times \frac{60 \text{ sec}{min}}{min} = 0.27 \text{ ft}^3/\text{sec} \]

Velocity of Flow,

\[ v_{2\text{in}} = \frac{q}{A_{2\text{in}}} \]
\[ v_{2\text{in}} = 11.5 \text{ ft/sec} \]

\[ v_{3\text{in}} = \frac{q}{A_{3\text{in}}} \]
\[ v_{3\text{in}} = 5.2 \text{ ft/sec} \]

Reynolds Number,

\[ Re_{2\text{in}} = \frac{D_{2\text{in}} v_{2\text{in}}}{\mu_c} \]
\[ Re_{2\text{in}} = 27514 \]

\[ Re_{3\text{in}} = \frac{D_{3\text{in}} v_{3\text{in}}}{\mu_c} \]
\[ Re_{3\text{in}} = 18537 \]

Friction Factor (Ref. Crane, Page A-25 and A-26),

\[ f_{2\text{in}} = 0.026 \]
\[ f_{2\text{in}} = 0.019 \]

\[ f_{3\text{in}} = 0.0275 \]
\[ f_{3\text{in}} = 0.018 \]

Bernoulli's Theorem,

\[ z_1 + \frac{144 P_1}{\rho_1} + \frac{v_1^2}{2g} = z_2 + \frac{144 P_2}{\rho_2} + \frac{v_2^2}{2g} + h_L \]
5.1.2.1 AY-Farm Process Pits

10.0 ft - 2" Pipe Length:

\[ K_1 = \frac{f_2 \text{in}}{D_2 \text{in}} \times L_1 \]

\[ K_1 = 1.5 \]

2 - 2" Connectors (assume 90 Mitre Bend):

\[ K_2 = \left( \frac{60 \text{ ft}}{D_2 \text{in}} \right)^2 \]

\[ K_2 = 2.3 \]

2 - 2" Long Radius Elbow:

\[ K_3 = \left( \frac{14 \text{ ft}}{D_2 \text{in}} \right)^2 \]

\[ K_3 = 0.5 \]

1 - 2" 3-Way Ball Valve (assume 90 Mitre Bend):

\[ K_4 = \left( \frac{60 \text{ ft}}{D_2 \text{in}} \right)^2 \]

\[ K_4 = 1.1 \]

Head Loss for each pit:

\[ h_{\text{pit,2in}} = \frac{\gamma v_{\text{2in}}^2}{2g} \sum_{i=1}^{4} K_i \]

\[ h_{\text{pit,2in}} = 11.2 \text{-ft} \]

Head Loss for both AY-Farm pits:

\[ h_{\text{ay,pits}} = 2 \times h_{\text{pit,2in}} \]

\[ h_{\text{ay,pits}} = 22.3 \text{-ft} \]
5.1.2.2 Remaining Process Pits

10.0 ft - 3" Pipe Length: \( L_1 \) = 10 ft

\[ K_1 = f_{3in} \frac{L_1}{D_{3in}} \]

\[ K_1 = 1.1 \]

4 - 3" Connectors (assume 90 Mtr Bend):

\[ K_2 = (60 f_{3in})^4 \]

\[ K_2 = 4.3 \]

4 - 3" Long Radius Elbow:

\[ K_3 = (14 f_{3in})^4 \]

\[ K_3 = 1.0 \]

2 - 3" 3-Way Ball Valve (assume 90 Mtr Bend):

\[ K_4 = (60 f_{3in})^2 \]

\[ K_4 = 2.2 \]

Head Loss for each pit:

\[ h_{pit\_3in} = \frac{v_{3in}^2}{2g} \sum_{i=1}^{4} K_i \]

\[ h_{pit\_3in} = 3.6 \text{ ft} \]

Head Loss for all seven remaining pits:

\[ h_{valve\_pits} = 7 \cdot h_{pit\_3in} \]

\[ h_{valve\_pits} = 25.3 \text{ ft} \]

5.1.3 TRANSFER LINE HEAD LOSSES

2" Pipe Length:

\[ L_{2in} = 11 \text{ ft} \]

\[ K_1 = f_{2in} \frac{L_{2in}}{D_{2in}} \]

\[ K_1 = 1.7 \]

2" Pipe - 36" Radius Bends (r/d=18):

\[ N_{2in\_bends} = 2 \]

\[ K_2 = (46 f_{2in}) \cdot N_{2in\_bends} \]

\[ K_2 = 1.7 \]
ICF Kaiser Hanford

DESIGN ANALYSIS

Client: WHC
Subject: Head Loss Calculations for HLW
Feed from 241-AY Tanks (Alternative 2)
Location: 200 East

Calc. No. E44810-2702
Revision 0
Page No. 13 of 28

By: T.B. Salzano

3" Pipe Length:

\[ L_{3\text{in}} = 235\text{ ft} + 6\text{ ft} + 650\text{ ft} + 577\text{ ft} + 106\text{ ft} + 750\text{ ft} + 425\text{ ft} + 2820\text{ ft} \]

\[ K_3 = \frac{f_{3\text{in}} L_{3\text{in}}}{D_{3\text{in}}} \]

\[ K_3 = 599 \]

3" Pipe - 36" Radius Bends (r/d=12):

\[ N_{3\text{in bends}} = 5 + 4 + 17 + 12 + 5 + 17 + 8 + 50 \]

\[ K_4 = (34 f_{3\text{in}}) \cdot N_{3\text{in bends}} \quad K_4 = 72.2 \]

5.1.4 TOTAL HEAD LOSS: 241-AY ALTERNATIVE 2

Process Pit Losses:

\[ h_1 = h_{ay\_pits} + h_{valve\_pits} \quad h_1 = 48\text{ ft} \]

Transfer Path Losses:

\[ h_2 = \frac{v^{2\text{in}}}{2g} \sum_{i=1}^{2} K_i + \frac{v^{3\text{in}}}{2g} \sum_{i=3}^{4} K_i \quad h_2 = 290\text{ ft} \]

Elevation Change:

\[ h_3 = 50\text{ ft} + z_{\text{end}} - z_{\text{start}} \quad h_3 = 45\text{ ft} \quad (\text{Assumption 2}) \]

Total Head Loss:

\[ i = 1, 2, 3 \]

\[ \text{TDH}_{120\_alt2} = \sum_{i} h_i \quad \text{TDH}_{120\_alt2} = 382\text{ ft} \]

Pressure Drop:

\[ \Delta P_{120\_alt2} = \frac{\text{TDH}_{120\_alt2}}{144 \text{ in}^2} \quad \Delta P_{120\_alt2} = 249\text{ lb/in}^2 \]
5.2 100 GPM: 241-AY

5.2.1 Constant Data

Volumetric Flow Rate, 

\[ Q_{100} = 100 \text{ gal/min} \]

\[ q = \frac{Q_{100}}{60 \text{ sec/min}} = 0.22 \text{ ft}^3/\text{sec} \]

Velocity of Flow,

\[ v_{2\text{in}} = \frac{q}{A_{2\text{in}}} \]
\[ v_{3\text{in}} = \frac{q}{A_{3\text{in}}} \]

Reynolds Number,

\[ \text{Re}_{2\text{in}} = \frac{D_{2\text{in}} v_{2\text{in}} \mu_e}{\rho} \]
\[ \text{Re}_{3\text{in}} = \frac{D_{3\text{in}} v_{3\text{in}} \mu_e}{\rho} \]

Friction Factor (Ref. Crane, Page A-25 and A-26),

\[ f_{2\text{in}} = 0.027 \]
\[ f_{3\text{in}} = 0.029 \]

Bernoulli's Theorem,

\[ z_1 + \frac{144 \rho_1}{\rho_2} \cdot \frac{v_1^2}{2g} = z_2 + \frac{144 \rho_2}{\rho_2} \cdot \frac{v_2^2}{2g} + h_L \]
5.2.2 PROCESS PIT HEAD LOSSES

5.2.2.1 AY-Farm Process Pits

10.0 ft - 2" Pipe Length:

\[ L_1 = 10.0 \text{ ft} \]

\[ K_1 = f_{2\text{in}} \frac{L_1}{D_{2\text{in}}} \]

\[ K_1 = 1.6 \]

2 - 2" Connectors (assume 90 Mitre Bend):

\[ K_2 = \left(60 f_{T2\text{in}}\right)^2 \]

\[ K_2 = 2.3 \]

2 - 2" Long Radius Elbow:

\[ K_3 = \left(14 f_{T2\text{in}}\right)^2 \]

\[ K_3 = 0.5 \]

1 - 2" 3-Way Ball Valve (assume 90 Mitre Bend):

\[ K_4 = \left(60 f_{T2\text{in}}\right)^1 \]

\[ K_4 = 1.1 \]

Head Loss for each pit:

\[ h_{\text{pit,2in}} = \frac{v_{2\text{in}}^2}{2g} \sum_{i=1}^{4} K_i \]

\[ h_{\text{pit,2in}} = 7.8 \text{ ft} \]

Head Loss for both AY-Farm pits:

\[ h_{\text{ay pits}} = 2 \cdot h_{\text{pit,2in}} \]

\[ h_{\text{ay pits}} = 15.7 \text{ ft} \]
5.2.2.2 Remaining Process Pits

10.0 ft - 3" Pipe Length:

\[ L_1 = 10.0 \text{ ft} \]

\[ K_1 = \frac{f \cdot 3\text{in}}{D \cdot 3\text{in}} \]

4 - 3" Connectors (assume 90 Mitre Bend):

\[ K_2 = \left( \frac{50 \cdot f \cdot T \cdot 3\text{in}}{4} \right) \]

4 - 3" Long Radius Elbow:

\[ K_3 = \left( \frac{14 \cdot f \cdot T \cdot 3\text{in}}{4} \right) \]

2 - 3" 3-Way Ball Valve (assume 90 Mitre Bend):

\[ K_4 = \left( \frac{50 \cdot f \cdot T \cdot 3\text{in}}{2} \right) \]

Head Loss for each pit:

\[ h_{\text{pit}_{-3\text{in}}} = \frac{v^2 \cdot 3\text{in}}{2 \cdot g} \sum_{i=1}^{4} K_i \]

\[ h_{\text{pit}_{-3\text{in}}} = 2.5 \text{ ft} \]

Head Loss for all seven remaining pits:

\[ h_{\text{valve pits}} = 7 \cdot h_{\text{pit}_{-3\text{in}}} \]

\[ h_{\text{valve pits}} = 17.7 \text{ ft} \]

5.2.3 TRANSFER LINE HEAD LOSSES

2" Pipe Length:

\[ L_{2\text{in}} = 11.0 \text{ ft} \]

\[ K_1 = \frac{f \cdot 2\text{in}}{D \cdot 2\text{in}} \]

2" Pipe - 36" Radius Bends (r/d=18):

\[ N_{2\text{in bends}} = 2 \]

\[ K_2 = \left( \frac{46 \cdot f \cdot T_{2\text{in}}}{N_{2\text{in bends}}} \right) \]

\[ K_2 = 1.7 \]
3" Pipe Length:

\[ L_{3\text{in}} = 235\text{ ft} + 6\text{ ft} + 650\text{ ft} + 577\text{ ft} + 106\text{ ft} + 750\text{ ft} + 425\text{ ft} + 2820\text{ ft} \]

\[ K_3 = \frac{L_{3\text{in}}}{D_{3\text{in}}} \]

\[ K_3 = 631.7 \]

3" Pipe - 36" Radius Bends (r/d=12):

\[ N_{3\text{in.bends}} = 5 + 4 + 17 + 12 + 5 + 17 + 8 + 50 \]

\[ K_4 = (34 \cdot f_{T3\text{in}}) \cdot N_{3\text{in.bends}} \]

\[ K_4 = 722 \]

5.2.4 TOTAL HEAD LOSS: 241-AY ALTERNATIVE 2

Process Pit Losses:

\[ h_1 = h_{\text{ay.pits}} + h_{\text{valve.pits}} \]

\[ h_1 = 33\text{ ft} \]

Transfer Path Losses:

\[ h_2 = \frac{v_{2\text{in}}^2}{2g} \sum_{i=1}^{2} K_i + \frac{v_{3\text{in}}^2}{2g} \sum_{i=3}^{4} K_i \]

\[ h_2 = 211\text{ ft} \]

Elevation Change:

\[ h_3 = 50\text{ ft} + z_{\text{end}} - z_{\text{start}} \]

\[ h_3 = 45\text{ ft} \] (Assumption 2)

Total Head Loss:

\[ i = 1, 2, 3 \]

\[ TDH_{100\_alt2} = \sum_{i} h_i \]

\[ TDH_{100\_alt2} = 289\text{ ft} \]

Pressure Drop:

\[ \Delta P_{100\_alt2} = \frac{TDH_{100\_alt2}}{144\text{ in}^2/\text{ft}^2} \]

\[ \Delta P_{100\_alt2} = 188\_\text{lb/in}^2 \]
5.3 80 GPM: 241-AY

5.3.1 Constant Data

Volumetric Flow Rate,

\[ Q_{80} = 80 \frac{\text{gal}}{\text{min}} \]

\[ q = \frac{Q_{80}}{60 \frac{\text{sec}}{\text{min}}} = \frac{0.13368 \text{ ft}^3}{\text{gal}} \]

\[ q = 0.18 \frac{\text{ft}^3}{\text{sec}} \]

Velocity of Flow,

\[ v_{2\text{in}} = \frac{q}{A_{2\text{in}}} \]

\[ v_{3\text{in}} = \frac{q}{A_{3\text{in}}} \]

Reynolds Number,

\[ Re_{2\text{in}} = \frac{D_{2\text{in}} v_{2\text{in}} \rho}{\mu_e} \]

\[ Re_{3\text{in}} = \frac{D_{3\text{in}} v_{3\text{in}} \rho}{\mu_e} \]

Friction Factor (Ref. Crane, Page A-25 and A-26),

\[ f_{2\text{in}} = 0.028 \]

\[ f_{3\text{in}} = 0.03 \]

Bernoulli's Theorem,

\[ z_1 + \frac{144 \cdot P_1}{\rho_1} + \frac{v_1^2}{2g} = z_2 + \frac{144 \cdot P_2}{\rho_2} + \frac{v_2^2}{2g} + h_L \]
5.3.2 PROCESS PIT HEAD LOSSES

5.3.2.1 AY-Farm Process Pits

10.0 ft - 2" Pipe Length:  
\[ L_1 = 10.0 \text{ ft} \]

\[ K_1 = f_{2in} \frac{L_1}{D_{2in}} \]

\[ K_1 = 1.6 \]

2 - 2" Connectors (assume 90 Mitre Bend):  
\[ K_2 = (50 \cdot f_{T2in})^2 \]

\[ K_2 = 2.3 \]

2 - 2" Long Radius Elbow:  
\[ K_3 = (14 \cdot f_{T2in})^2 \]

\[ K_3 = 0.5 \]

1 - 2" 3-Way Ball Valve (assume 90 Mitre Bend):  
\[ K_4 = (60 \cdot f_{T2in})^1 \]

\[ K_4 = 1.1 \]

Head Loss for each pit:  
\[ h_{pit\_2in} = \frac{v_{2in}^2}{2g} \sum_{i=1}^{4} K_i \]

\[ h_{pit\_2in} = 5.1 \text{ ft} \]

Head Loss for both AY-Farm pits:  
\[ h_{ay\_pits} = 2 \cdot h_{pit\_2in} \]

\[ h_{ay\_pits} = 10.1 \text{ ft} \]
5.3.2.2 Remaining Process Pits

10.0 ft - 3" Pipe Length: \( L_1 = 10.0 \text{ ft} \)
\[ K_1 = f_{\frac{3}{3}} \frac{L_1}{D_{\frac{3}{3}}} \quad K_1 = 1.2 \]

4 - 3" Connectors (assume 90 Mitre Bend):
\[ K_2 = (50 f_{\frac{T3}{3}})^4 \quad K_2 = 4.3 \]

4 - 3" Long Radius Elbow:
\[ K_3 = (14 f_{\frac{T3}{3}})^4 \quad K_3 = 1.0 \]

2 - 3" 3-Way Ball Valve (assume 90 Mitre Bend):
\[ K_4 = (60 f_{\frac{T3}{3}})^2 \quad K_4 = 2.2 \]

Head Loss for each pit:
\[ h_{\text{pit,3in}} = \frac{v^2}{2g} \sum_{i=1}^{4} K_i \]
\[ h_{\text{pit,3in}} = 1.6 \text{ ft} \]

Head Loss for all seven remaining pits:
\[ h_{\text{valve_pits}} = 7 \cdot h_{\text{pit,3in}} \]
\[ h_{\text{valve_pits}} = 11.4 \text{ ft} \]

5.3.3 TRANSFER LINE HEAD LOSSES

2" Pipe Length:
\[ L_{\frac{2}{2}} = 11 \text{ ft} \]
\[ K_1 = f_{\frac{2}{2}} \frac{L_{\frac{2}{2}}}{D_{\frac{2}{2}}} \quad K_1 = 1.8 \]

2" Pipe - 36° Radius Bends (\( r/d = 18 \)):
\[ N_{\frac{2}{2}_{\text{bends}}} = 2 \]
\[ K_2 = (46 f_{\frac{T2}{2}})^{N_{\frac{2}{2}_{\text{bends}}}} \quad K_2 = 1.7 \]
3" Pipe Length:

\[ L_{3\text{in}} = 235 \text{ ft} + 6 \text{ ft} + 650 \text{ ft} + 577 \text{ ft} + 106 \text{ ft} + 750 \text{ ft} + 425 \text{ ft} + 2820 \text{ ft} \]

\[ K_3 = \frac{L_{3\text{in}}}{D_{3\text{in}}} \]

\[ K_3 = 653.5 \]

3" Pipe - 36° Radius Bends (r/d=12):

\[ N_{3\text{in\_bends}} = 5 + 4 + 17 + 12 + 5 + 17 + 8 + 50 \]

\[ K_4 = (34. f_{3\text{in}} \cdot N_{3\text{in\_bends}}) \]

\[ K_4 = 72.2 \]

5.3.4 TOTAL HEAD LOSS: 241-AY ALTERNATIVE 2

Process Pit Losses:

\[ h_1 = h_{\text{ay\_pits}} + h_{\text{valve\_pits}} \]

\[ h_1 = 21 \text{ ft} \]

Transfer Path Losses:

\[ h_2 = \frac{\nu_{2\text{in}}}{2 \cdot g} \sum_{i=1}^{2} K_{i} + \frac{\nu_{3\text{in}}}{2 \cdot g} \sum_{i=3}^{4} K_{i} \]

\[ h_2 = 139 \text{ ft} \]

Elevation Change:

\[ h_3 = 50 \text{ ft} + z_{\text{end}} - z_{\text{start}} \]

\[ h_3 = 45 \text{ ft} \]  

(Assumption 2)

Total Head Loss:

\[ i = 1, 2, 3 \]

\[ \text{TDH}_{80\_alt2} = \sum_{i} h_i \]

\[ \text{TDH}_{80\_alt2} = 206 \text{ ft} \]

Pressure Drop:

\[ \Delta P_{80\_alt2} = \frac{\text{TDH}_{80\_alt2} \cdot \rho}{144 \cdot \frac{\text{in}^2}{\text{ft}^2}} \]

\[ \Delta P_{80\_alt2} = 134 \cdot \frac{\text{lb}}{\text{in}^2} \]
5.4 60 GPM: 241-AY

5.4.1 Constant Data

Volumetric Flow Rate,

\[ Q_{60} = \frac{60 \text{ gallon}}{\text{min}} \]

\[ q = \frac{Q_{60}}{60 \text{ gallon} \cdot \text{sec}^{-1}} = \frac{0.13368 \text{ ft}^3}{\text{gal} \cdot \text{min}} \]

\[ q = 0.13 \cdot \text{ft}^3 \cdot \text{sec}^{-1} \]

Velocity of Flow,

\[ v_{2in} = \frac{q}{A_{2in}} \]

\[ v_{2in} = 5.7 \cdot \text{ft} \cdot \text{sec}^{-1} \]

\[ v_{3in} = \frac{q}{A_{3in}} \]

\[ v_{3in} = 2.6 \cdot \text{ft} \cdot \text{sec}^{-1} \]

Reynolds Number,

\[ \text{Re}_{2in} = \frac{D_{2in} v_{2in} \rho_e}{\mu_e} \]

\[ \text{Re}_{2in} = 13757 \]

\[ \text{Re}_{3in} = \frac{D_{3in} v_{3in} \rho_e}{\mu_e} \]

\[ \text{Re}_{3in} = 9268 \]

Friction Factor (Ref. Crane, Page A-25 and A-26),

\[ f_{2in} = 0.03 \]

\[ f_{T2in} = 0.019 \]

\[ f_{3in} = 0.032 \]

\[ f_{T3in} = 0.018 \]

Bernoulli's Theorem,

\[ z_1 + \frac{144 \cdot P_1}{\rho_1} + \frac{v_1^2}{2g} = z_2 + \frac{144 \cdot P_2}{\rho_2} + \frac{v_2^2}{2g} + h_L \]
5.4.2 PROCESS PIT HEAD LOSSES

5.4.2.1 AY-Farm Process Pits

10.0 ft - 2" Pipe Length: \( L_1 = 10 \, \text{ft} \)

\[
K_1 = f_{2\text{in}} \frac{L_1}{D_{2\text{in}}} \quad K_1 = 1.7
\]

2 - 2" Connectors (assume 90 Mitre Bend):

\[
K_2 = (60 \, f_{2\text{in}})^2 \quad K_2 = 2.3
\]

2 - 2" Long Radius Elbow:

\[
K_3 = (14 \, f_{2\text{in}})^2 \quad K_3 = 0.5
\]

1 - 2" 3-Way Ball Valve (assume 90 Mitre Bend):

\[
K_4 = (60 \, f_{2\text{in}}) \quad K_4 = 1.1
\]

Head Loss for each pit:

\[
h_{\text{pit, 2in}} = \frac{v_{2\text{in}}^2}{2 \, g} \sum_{i=1}^{4} K_i
\]

\[
h_{\text{pit, 2in}} = 2.9 \, \text{ft}
\]

Head Loss for both AY-Farm pits:

\[
h_{\text{ay, pits}} = 2 \cdot h_{\text{pit, 2in}}
\]

\[
h_{\text{ay, pits}} = 5.8 \, \text{ft}
\]
5.4.2.2 Remaining Process Pits

10.0 ft - 3" Pipe Length:

\[ L = 10 \text{ ft} \]

\[ K_1 = f_{3\text{in}} \cdot \frac{L}{D_{3\text{in}}} \]

\[ K_1 = 1.3 \]

4 - 3" Connectors (assume 90 Mitre Bend):

\[ K_2 = (60 f_{3\text{in}})^{-4} \]

\[ K_2 = 4.3 \]

4 - 3" Long Radius Elbow:

\[ K_3 = (14 f_{3\text{in}})^{-4} \]

\[ K_3 = 1.0 \]

2 - 3" 3-Way Ball Valve (assume 90 Mitre Bend):

\[ K_4 = (60 f_{3\text{in}})^{-2} \]

\[ K_4 = 2.2 \]

Head Loss for each pit:

\[ h_{\text{pit,3in}} = \frac{V_{3\text{in}}^2}{2 g} \cdot \sum_{i=1}^{4} K_i \]

\[ h_{\text{pit,3in}} = 0.9 \cdot \text{ft} \]

Head Loss for all seven remaining pits:

\[ h_{\text{valve,pits}} = 7 \cdot h_{\text{pit,3in}} \]

\[ h_{\text{valve,pits}} = 6.4 \cdot \text{ft} \]

5.4.3 TRANSFER LINE HEAD LOSSES

2" Pipe Length:

\[ L_{2\text{in}} = 11 \text{ ft} \]

\[ K_1 = f_{2\text{in}} \cdot \frac{L_{2\text{in}}}{D_{2\text{in}}} \]

\[ K_1 = 1.9 \]

2" Pipe - 36" Radius Bends (r/d=18):

\[ N_{2\text{in}_bends} = 2 \]

\[ K_2 = (46 f_{2\text{in}}) \cdot N_{2\text{in}_bends} \]

\[ K_2 = 1.7 \]

A-40
ICF Kaiser Hanford

DESIGN ANALYSIS

Client: WHC
Subject: Head Loss Calculations for HLW
Feed from 241-AY Tanks (Alternative 2)
Location: 200 East

3" Pipe Length:
\[ L_{3\text{in}} = 235\text{ ft} + 6\text{ ft} + 650\text{ ft} + 577\text{ ft} + 106\text{ ft} + 750\text{ ft} + 425\text{ ft} + 2820\text{ ft} \]
\[ K_3 = \frac{f_{3\text{in}} L_{3\text{in}}}{D_{3\text{in}}} \]

3" Pipe - 36" Radius Bends (r/d=12):
\[ N_{3\text{in}_\text{bends}} = 5 + 4 + 17 + 12 + 5 + 17 + 8 + 50 \]
\[ K_4 = (34 f_{3\text{in}}) N_{3\text{in}_\text{bends}} \]

5.4.4 TOTAL HEAD LOSS: 241-AY ALTERNATIVE 2

Process Pit Losses:
\[ h_1 = h_{ay\_pits} + h_{valve\_pits} \quad h_1 = 12\text{ ft} \]

Transfer Path Losses:
\[ h_2 = \frac{v_{2\text{in}}^2}{2g} \sum_{i=1}^{2} K_i + \frac{v_{3\text{in}}^2}{2g} \sum_{i=3}^{4} K_i \quad h_2 = 83\text{ ft} \]

Elevation Change:
\[ h_3 = 50\text{ ft} + z_{end} - z_{start} \quad h_3 = 45\text{ ft} \quad \text{(Assumption 2)} \]

Total Head Loss:
\[ i = 1,2,3 \]
\[ TDH_{60\_alt2} = \sum_{i} h_i \quad TDH_{60\_alt2} = 140\text{ ft} \]

Pressure Drop:
\[ \Delta P_{60\_alt2} = \frac{TDH_{60\_alt2} \rho}{144\frac{\text{in}^2}{\text{ft}^2}} \quad \Delta P_{60\_alt2} = 91\frac{\text{lb}}{\text{in}^2} \]
6.0 SYSTEM CURVE

The system curve can now be generated. The curve will be used to determine different possible operating points for the system. A pump could then be selected to meet the needed operating requirements. The main operating points to be considered are at a Reynolds number of 20,000 and at the design pressure limit of the system.

6.1 SYSTEM CURVE DATA: 241-AY

The system curve for the 241-AY-102 Tank transfers to the vendor’s processing facility can now be generated.

Flow Rate: \[
\begin{bmatrix}
Q_{60} \\
Q_{80} \\
Q_{100} \\
Q_{120} \\
Q_{140}
\end{bmatrix}
\]

Total Head: \[
\begin{bmatrix}
TDH_{60_{alt2}} \\
TDH_{80_{alt2}} \\
TDH_{100_{alt2}} \\
TDH_{120_{alt2}} \\
TDH_{140_{alt2}}
\end{bmatrix}
\]
**6.2 SYSTEM CURVE**

\[ i = 0.4 \]

HLW Transfers from 241-AY-102 to the Vendor (Alternative 2)
6.3 SPECIFIC OPERATING POINTS

6.3.1 Operating Point at Reynolds Number > 20,000: 241-AY ALTERNATIVE 2

This operating point occurs at a flow rate of 130 gpm. From the above graph,

\[ Q_{Re} = 130 \text{ gpm} \quad \text{and} \quad TDH_{Re} = 440 \text{ ft} \]

Therefore, the pressure drop and velocity in the 3 inch lines are as follows.

Velocity:

\[ \frac{Q_{Re}}{60 \text{ sec/min}} = \frac{0.13368 \text{ ft}^3}{\text{gal}} \quad \Rightarrow \quad \frac{q_{Re}}{60 \text{ sec/min}} = \frac{0.29 \text{ ft}^3}{\text{sec}} \]

\[ v_{Re_{3in}} = \left( \frac{q_{Re}}{A_{3in}} \right) \quad \Rightarrow \quad v_{Re_{3in}} = 5.6 \frac{\text{ft}}{\text{sec}} \]

Pressure Drop:

\[ \frac{\Delta P_{Re}}{144 \text{ in}^2/\text{ft}^2} = \frac{TDH_{Re} p}{\rho} \quad \Rightarrow \quad \Delta P_{Re} = 286 \frac{\text{lb}}{\text{in}^2} \]

6.3.2 Operating Point at Lowest Pipeline Design Pressure: 241-AY ALTERNATIVE 2

The lowest design pressure is 230 psi (See Attachment A). This is equivalent to the following Head:

\[ \Delta P_{DP} = 230 \frac{\text{lb}}{\text{in}^2} \]

\[ \Delta P_{DP} \cdot 144 \text{ in}^2/\text{ft}^2 \quad \Rightarrow \quad TDH_{DP} = 354 \text{ ft} \]

From the above graph,

\[ Q_{DP} = 113 \text{ gpm} \]

Therefore, the velocity in the 3 inch lines is as follows.

Velocity:

\[ \frac{Q_{DP}}{60 \text{ sec/min}} = \frac{0.13368 \text{ ft}^3}{\text{gal}} \quad \Rightarrow \quad \frac{q_{DP}}{60 \text{ sec/min}} = \frac{0.25 \text{ ft}^3}{\text{sec}} \]

\[ v_{DP_{3in}} = \left( \frac{q_{DP}}{A_{3in}} \right) \quad \Rightarrow \quad v_{DP_{3in}} = 4.9 \frac{\text{ft}}{\text{sec}} \]
HLW ALTERNATIVE 2

"NEW 3" LINE, AZ TO AX-A", AND
"NEW 3" LINE, AY TO AX-B"

LEGEND

--- EXISTING ROUTE
--- NEW 3"SN ROUTE

241-AZ

241-AY

241-AW

241-AP

VENDOR
(N40500, W44500)

NEW 3"SN (±2820 FT) BY VENDOR

CAPTILE: H.L. ALT2

A-45
2\" SL-503,504,505 (AY-FARM)

NOTE: ALL NOZZLES AT EL 675 UNLESS OTHERWISE NOTED

REFERENCES:
H-2-70764
H-2-64313
H-2-64314
B-131-C1

SUMMARY:

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<td>LENGTH</td>
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<td>116 FT</td>
<td>18 FT</td>
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<td>3'R BENDS</td>
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DESIGN:

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<tr>
<td>TEMP</td>
<td>200 °F</td>
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</tbody>
</table>

PREPARED BY: T.R. SALZANO 4/5/86
CHECKED BY: JUDI NICHOLSON 4/5/86
REFERENCES:

- H-2-69245
- H-2-70763
- H-2-70764
- H-2-70780
- B-131-C1

SUMMARY:

- LENGTH: 234.7 FT
- 3' R BENDS: 5
- COBs: 1
- REDUCERS: 1

DESIGN:

- PRESSURE: 400 PSIG
- TEMP: 200 °F
3" SN-201/214

REFERENCES:
H-2-69244
H-2-69241
H-2-69240
H-2-69184
H-2-70397
H-2-69188
B-102-C1

SUMMARY:
LENGTH 648.1 FT
3'R BENDS 17

DESIGN:
PRESSURE 230 PSIG
TEMP 330 'F

241-AX-A VALVE PIT

PREPARED BY: T.B. SALZANO 4/5/96
CHECKED BY: Jacob Miller 4/5/96
3" SN-267  
(AW-FARM)

REFERENCES:  
H-2-70399  
H-2-70401  
H-2-70404  
B-120-C7  

SUMMARY:  
LENGTH 106.1 FT  
3'R BENDS 5  

DESIGN:  
PRESSURE 275 PSIG  
TEMP 340 'F  

241-AW-A  
VALVE PIT  

PREPARED BY: T.B. SALZANO 4/5/96  
CHECKED BY: J.D. NEILDON 4/5/96
3" SN-618
(AP-FARM)

241-AP VALVE PIT
EL 676.6
6.7'
64.1'
89.8'
70.3'
10.5'
66.7'
54.7'
19.3'

REFERENCE:
H-2-90547
H-2-90548
H-2-90560
B-340-C7

SUMMARY:
LENGTH 425.4 FT
3'R BENDS 8

DESIGN:
PRESSURE 400 PSIG
TEMP 340 'F

PREPARED BY: T.B. SALZANO 4/5/96
CHECKED BY: J. W. NICELIN 4/5/96
This sheet shows the status and description of the attached Design Analysis sheets.

**Discipline:** Piping, 27  
**W/Job No.:** E44810  
**Calculation No.:** E44810-2703

**Project No. & Name:** Phase I Privatization Transfer System Needs

**Calculation Item:** Head Loss Calculation for HLW Feed from 241-AY Tanks (Alternatives 3 and 4)

These calculations apply to:

|----------|----------|----------|----------|-------------------|----------|

The status of these calculations is:

- [ ] Preliminary Calculations
- [X] Final Calculations
- [ ] Check Calculations (On Calculation Dated )
- [ ] Void Calculation (Reason Voided )

**Incorporated in Final Drawings?**  
[ ] Yes  [ ] No

**This calculation verified by independent "check" calculations?**  
[ ] Yes  [ ] No

**Original and Revised Calculation Approvals:**

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<th>Rev. 1 Signature/Date</th>
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**Checked Against Approved Vendor Data**

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**KEH 0378.00 (06/92) KEF072**

**A-53**
1.0 OBJECTIVE

Determine the pump head requirements to transfer high-level waste (HLW) from the AY-Farm to one of the Phase I Privatization Vendors. This calculation will develop the system curve for transfers from the 241-AY-102 to the vendor via transfer line SN-650 including upgrade of SL-502 to 3-inch. In addition, the system curve including a new transfer line parallel to SN-650 to the vendor will be developed. These two systems correspond to HLW Alternatives 3 and 4, respectively.

2.0 DESIGN INPUTS

2.1 Given Data

<table>
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<tr>
<th>Absolute Viscosity: 10 cp</th>
<th>Specific Gravity: 1.5</th>
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<tr>
<td>Pipe Selection:</td>
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<tr>
<td>2&quot; Schedule 40</td>
<td>3&quot; Schedule 40</td>
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<tr>
<td>Inside Diameter: ID = 2.067</td>
<td>ID = 3.068</td>
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2.2 Assumptions

1. The sending and receiving tanks are at atmospheric pressure.
2. The head loss (including elevation and line loss) from the centerline of the discharge pump to the nozzle of the first transfer line is 50 feet.
3. Purex Connectors were assumed to have losses equal to a 90° miter bend.
4. Pipeline friction factors are based on clean commercial steel pipe.
5. The pit head losses are based on 10 feet of pipe, four 90° LR elbows, two three-way ball valves, and four Purex Connectors. The two AY process pits are assumed to have 10 ft jumpers with two 90° LR elbows, one three-way ball valve, and two Purex Connectors.
6. The ending elevation of the system at the vendor(s) facility is 670.0 feet (Ref. 3).

2.3 References

   Fitting Resistance Coefficients, K: "K" factor table, Page A-26 to A-29
   Friction factors: Fittings, $f_f$, Page A-28; Pipe, $f_p$, Pipe, Page A-25

2.4 Method

The method used for the determination of the pressure loss in the piping system is based upon the Darcy-Weisbach formula. Pressure losses in fittings are determined using experimental resistance coefficients (K) along with friction factors. The losses of all the fittings, valves, and pipe are totaled and using the Bernoulli Theorem, the pressure loss of the system can be determined. The computer program Mathcad, Version 4.0, is used.

3.0 CONCLUSION

See Body of Calculation A-54
4.0 AY-FARM HLW TRANSFER HEAD LOSSES

The head losses for transfers from the 241-AY-102 Tank will be calculated. The first analysis will be based on a flow rate of 140 gpm to maintain a minimum Reynolds number of 20,000 (Ref. 4).

4.1 Constant Data

Volumetric Flow Rate,

\[ Q_{140} = 140 \text{ gal/min} \]

\[ q = \frac{Q_{140} \times 13368 \text{ ft}^3}{60 \text{ sec/min}} = 0.31 \text{ ft}^3/\text{sec} \]

Pipe Diameter,

\[ d_{2\text{ in}} = 2.067 \text{ in} \]

\[ D_{2\text{ in}} = \frac{d_{2\text{ in}}}{12 \text{ in/ft}} = 0.174 \text{ ft} \]

\[ d_{3\text{ in}} = 3.068 \text{ in} \]

\[ D_{3\text{ in}} = \frac{d_{3\text{ in}}}{12 \text{ in/ft}} = 0.26 \text{ ft} \]

Area of Flow,

\[ A_{2\text{ in}} = \frac{\pi D_{2\text{ in}}^2}{4} = 0.02 \text{ ft}^2 \]

\[ A_{3\text{ in}} = \frac{\pi D_{3\text{ in}}^2}{4} = 0.05 \text{ ft}^2 \]

Velocity of Flow,

\[ v_{2\text{ in}} = \frac{q}{A_{2\text{ in}}} \]

\[ v_{2\text{ in}} = \frac{13.4 \text{ ft/sec}}{0.174 \text{ ft}} \]

\[ v_{3\text{ in}} = \frac{q}{A_{3\text{ in}}} \]

\[ v_{3\text{ in}} = \frac{6.1 \text{ ft/sec}}{0.26 \text{ ft}} \]
Density of Liquid, $\rho = \text{SpG} \times 62.371 \frac{\text{lb}}{\text{ft}^3}$

$\rho = 93.6 \frac{\text{lb}}{\text{ft}^3}$

(62.371 lb/cu. ft is the density of water at 60°F, Ref. 4, Page A-6)

Absolute Viscosity, $\mu = 10 \text{ cp}$

$\mu_e = \mu \left( 6.72 \times 10^4 \right) \frac{\text{R-sec}}{\text{cp}}$ $\mu_e = 0.007 \frac{\text{lb}}{\text{ft-sec}}$

Reynolds Number,

2 inch pipe $\text{Re}_{2\text{in}} = \frac{D_{2\text{in}} \cdot v_{2\text{in}} \cdot \rho}{\mu_e}$ $\text{Re}_{2\text{in}} = 32100$

3 inch pipe $\text{Re}_{3\text{in}} = \frac{D_{3\text{in}} \cdot v_{3\text{in}} \cdot \rho}{\mu_e}$ $\text{Re}_{3\text{in}} = 21626$

Friction Factor (Ref. Crane, Page A-25 and A-26),

2 inch pipe $f_{2\text{in}} = 0.026$ $f_{T2\text{in}} = 0.019$

3 inch pipe $f_{3\text{in}} = 0.027$ $f_{T3\text{in}} = 0.018$

Bernoulli's Theorem,

$$z_1 + \frac{144 \cdot P_1}{\rho_1} + \frac{v_1^2}{2g} = z_2 + \frac{144 \cdot P_2}{\rho_2} + \frac{v_2^2}{2g} + h_L$$
4.2 PROCESS PIT HEAD LOSSES

The HLW Alternative 3 transfer route from 241-AY-102 will pass through five process pits: The 241-AY-02A Pump Pit (PP), the 241-AY-02D Sluice Pit (SP), the 241-AX-B Valve Pit (VP), and the new SN-650 VP. The Alternative 4 transfer route will pass through five process pits: The 241-AY-02A PP, the 241-AY-02D SP, the 241-AX-B VP, the 241-AX-A VP, and the 241-A-A VP (See Attachment A).

4.2.1 AY-Farm Process Pits

The two AY-Farm process pits are assumed to have 2-inch jumpers that are 10 feet in length. In addition, each jumper is assumed to contain two 90 degree LR elbows, one three-way ball valve, and two Purex Connectors.

10.0 ft - 2" Pipe Length:  \[ L_1 = 10 \text{ ft} \]

\[
K_1 = \frac{f_{2\text{in}} L_1}{D_{2\text{in}}} \quad K_1 = 1.5
\]

2 - 2" Connectors (assumed 90 Mitre Bend):

\[ K_2 = (60 \cdot f_{2\text{in}})^2 \quad K_2 = 2.3 \]

2 - 2" Long Radius Elbow:

\[ K_3 = (14f_{2\text{in}})^2 \quad K_3 = 0.5 \]

1 - 2" 3-Way Ball Valve (assumed 90 Mitre Bend):

\[ K_4 = (60 \cdot f_{2\text{in}})^4 \quad K_4 = 1.1 \]

Head Loss for each pit:

\[
h_{\text{pit,2in}} = \frac{v_{2\text{in}}^2}{2g} \sum_{i=1}^{4} K_i
\]

\[
h_{\text{pit,2in}} = 15.2 \text{ ft}
\]

Head Loss for both AY-Farm pits:

\[
h_{\text{pump_pits}} = 2 \cdot h_{\text{pit,2in}}
\]

\[
h_{\text{pump_pits}} = 30.4 \text{ ft}
\]
4.2.2 Valve Pits

The three valve pits for Alternative 3 and Alternative 4 are assumed to have 3-inch jumpers that are 10 feet in length. In addition, each jumper is assumed to contain four 90 degree LR elbows, two three-way ball valves, and four Purex Connectors.

10.0 ft - 3" Pipe Length:

\[ L_1 = 10.0 \text{ ft} \]

\[ K_1 = \frac{L_1}{D_{3\text{in}}} \]

\[ K_1 = 1.1 \]

4 - 3" Connectors (assume 90 Mitre Bend):

\[ K_2 = (60 f_{T3\text{in}})^4 \]

\[ K_2 = 4.3 \]

4 - 3" Long Radius Elbow:

\[ K_3 = (14 f_{T3\text{in}})^4 \]

\[ K_3 = 1.0 \]

2 - 3" 3-Way Ball Valve (assume 90 Mitre Bend):

\[ K_4 = (60 f_{T3\text{in}})^2 \]

\[ K_4 = 2.2 \]

Head Loss for each pit:

\[ h_{pit_3\text{in}} = \frac{v^{2} g}{2} \sum_{i=1}^{4} K_i \]

\[ h_{pit_3\text{in}} = 4.9 \text{ ft} \]

Head Loss for all six remaining pits:

\[ h_{valve\_pits\_alt3} = 3 \cdot h_{pit_3\text{in}} \]

\[ h_{valve\_pits\_alt3} = 14.7 \text{ ft} \]

\[ h_{valve\_pits\_alt4} = 3 \cdot h_{pit_3\text{in}} \]

\[ h_{valve\_pits\_alt4} = 14.7 \text{ ft} \]
4.3 TRANSFER LINE HEAD LOSSES

The HLW Alternative 3 transfers from the 241-AY-102 will pass through five transfer lines: 2"SL-503, New 3"SL-502, 3"SN-200/213, 3"SN-560, and a new 3" SN line from the new VP to the Phase 1 vendor. The HLW Alternative 4 transfers will pass through five transfer lines: 2"SL-503, New 3"SL-502, 3"SN-210, 3"SN-201/214, and a new 3" SN line from the A-A VP to the Phase 1 vendor (See Attachment A).

4.3.1 2"SL-503 (AY-02A PP to AY-OZD SP)

11' - 2" Pipe Length:

\[ L_1 = 11 \text{ ft} \]

\[ K_1 = 2\text{ in} \frac{L_1}{D_{2\text{ in}}} \]

\[ K_1 = 1.7 \]

2 - 36" Radius Bends (r/d=18):

\[ K_2 = \left( \frac{46 f_{12\text{ in}}}{r} \right)^2 \]

\[ K_2 = 1.7 \]

Elevation at Start of Transfer (pit exit nozzle):

\[ z_{\text{start}} = 675.0 \text{ ft} \]

(See Assumption 2)

**Head Loss:**

\[ h_{\text{sl-503}} = \frac{v^2}{2g} \sum_{i=1}^{2} K_i \]

\[ h_{\text{sl-503}} = 9 \text{ ft} \]

4.3.2 NEW 3"SL-502 (AY-02D SP to AX-B VP)

235' - 3" Pipe Length:

\[ L_1 = 235 \text{ ft} \]

\[ K_1 = 3\text{ in} \frac{L_1}{D_{3\text{ in}}} \]

\[ K_1 = 24.8 \]

5 - 36" Radius Bends (r/d=12):

\[ K_2 = \left( \frac{34 f_{13\text{ in}}}{r} \right)^5 \]

\[ K_2 = 3.1 \]

**Head Loss:**

\[ h_{\text{new-sl-502}} = \frac{v^2}{2g} \sum_{i=1}^{2} K_i \]

\[ h_{\text{new-sl-502}} = 16 \text{ ft} \]
4.3.3 3" SN-200/213 (AX-B VP to A-B VP)

618' - 3" Pipe Length:

\[ L_1 = 618 \text{ ft} \]

\[ K_1 = \frac{f_{3 \text{in}} L_1}{D_{3 \text{in}}} \]

\[ K_1 = 65.3 \]

15 - 36" Radius Bends (r/d=12):

\[ K_2 = (34 \cdot f_{T3\text{in}}) \cdot 15 \]

\[ K_2 = 9.2 \]

2 - 36" Radius 45 Bends (r/d=12):

\[ K_3 = \left[ (0.5 - 1) \left( 0.25 \cdot f_{T3\text{in}} \cdot 12 + 0.5 \cdot (34 \cdot f_{T3\text{in}}) \right) + 34 \cdot f_{T3\text{in}} \right]^2 \]

\[ K_3 = 0.7 \]

Head Loss:

\[ h_{sn\_200\_213} = \frac{v^2}{2g} \sum_{i=1}^{3} K_i \]

\[ h_{sn\_200\_213} = 43 \text{ ft} \]

4.3.4 3" SN-650 MODIFIED (A-B VP to New VP)

It is assumed that the modified SN-650 to the new valve pit will be the same length and include the same number of bends as the existing SN-650.

1334' - 3" Pipe Length:

\[ L_1 = 1334 \text{ ft} \]

\[ K_1 = \frac{f_{3 \text{in}} L_1}{D_{3 \text{in}}} \]

\[ K_1 = 140.9 \]

25 - 36" Radius Bends (r/d=12):

\[ K_2 = (34 \cdot f_{T3\text{in}}) \cdot 25 \]

\[ K_2 = 15.3 \]

Head Loss:

\[ h_{sn\_650} = \frac{v^2}{2g} \sum_{i=1}^{2} K_i \]

\[ h_{sn\_650} = 90 \text{ ft} \]
4.3.5 NEW 3"SN Line (New VP to Vendor)

The length of this line is based on the location of the vendor’s facility provided in Ref. 3.

2820' - 3" Pipe Length:

\[ L_1 = 2820 \text{ ft} \]

\[ K_1 = \frac{L_1}{D_{3in}} \]

\[ K_1 = 297.8 \]

50 - 36" Radius Bends (r/d=12):

\[ K_2 = (34 \times f_{3in}) \times 50 \]

\[ K_2 = 30.6 \]

Elevation at End of Transfer:

\[ z_{end} = 670.0 \text{ ft} \]

(Assumption 6)

Head Loss:

\[ h_{sn\_vp\_vendor} = \frac{v^2}{2g} \sum_{i=1}^{2} K_i \]

\[ h_{sn\_vp\_vendor} = 188 \text{ ft} \]

4.4 TOTAL HEAD LOSS: 241-AY ALTERNATIVE 3

Process Pit Losses:

\[ h_1 = h_{pump\_pits} + h_{valve\_pits\_alt3} \]

\[ h_1 = 45 \text{ ft} \]

Transfer Path Losses:

\[ h_2 = h_{sl\_503} + h_{new\_sl\_502} + h_{sn\_200\_213} + h_{sn\_650} + h_{sn\_vp\_vendor} \]

\[ h_2 = 347 \text{ ft} \]

Elevation Change:

\[ h_3 = 50 \text{ ft} + z_{end} - z_{start} \]

\[ h_3 = 45 \text{ ft} \]

(Assumption 2)

Total Head Loss:

\[ i = 1, 2, 3 \]

\[ TDH_{140\_alt3} = \sum_{i} h_i \]

\[ TDH_{140\_alt3} = 437 \text{ ft} \]

Pressure Drop:

\[ \Delta P_{140\_alt3} = \frac{TDH_{140\_alt3} \rho}{144 \times \frac{\text{in}^2}{\text{ft}^2}} \]

\[ \Delta P_{140\_alt3} = 284 \frac{\text{lb}}{\text{in}^2} \]
4.5 TOTAL HEAD LOSS: 241-AV ALTERNATIVE 4

Alternative 4 requires a new 3-inch transfer line from the A-A VP to the vendor. If this new line is used instead of the SN-650 modifications the HLW transfer would have the following head requirements.

4.5.1 3" SN-210 (AX-B VP to AX-A VP)

6'-3" Pipe Length:

\[ L_1 = 6\text{-ft} \]

\[ K_1 = f_{3\text{in}} \frac{L_1}{D_{3\text{in}}} \]

4 - 36" Radius Bends (r/d=12):

\[ K_2 = \left(34f\frac{T_{3\text{in}}}{3\text{in}}\right)^4 \]

Head Loss:

\[ h_{sn_{-210}} = \frac{v^2}{2g} \sum_{i=1}^{2} K_i \]

\[ h_{sn_{-210}} = 2\text{-ft} \]

4.5.2 3" SN-201/214 (AX-A VP to A-A VP)

650'-3" Pipe Length:

\[ L_1 = 650\text{-ft} \]

\[ K_1 = f_{3\text{in}} \frac{L_1}{D_{3\text{in}}} \]

17 - 36" Radius Bends (r/d=12):

\[ K_2 = \left(34f\frac{T_{3\text{in}}}{3\text{in}}\right)^{17} \]

Head Loss:

\[ h_{sn_{-201\_214}} = \frac{v^2}{2g} \sum_{i=1}^{2} K_i \]

\[ h_{sn_{-201\_214}} = 45\text{-ft} \]
4.5.3 NEW 3" SN parallel to SN-650 (A-A PP to Vendor)

The length of this line is based on the location of the vendor's facility provided in Ref. 3.

4150' - 3" Pipe Length:
\[ L_1 = 4150 \text{ ft} \]
\[ K_1 = f \frac{L_1}{D_{3\text{in}}} \]
\[ K_1 = 438.3 \]

72 - 36" Radius Bends (r/d=12):
\[ K_2 = (34 f \frac{T_{3\text{in}}}{D_{3\text{in}}}) \cdot 72 \]
\[ K_2 = 44.1 \]

Head Loss:
\[ h_{sn\_aa\_vendor} = 277 \text{ ft} \]

4.5.4 TOTAL HEAD LOSS: 241-AY ALTERNATIVE 4

Process Pit Losses:
\[ h_1 = h_{pump\_pits} + h_{valve\_pits\_alt4} \]
\[ h_1 = 45 \text{ ft} \]

Transfer Path Losses:
\[ h_2 = h_{sl\_503} + h_{new\_sl\_502} + h_{sn\_210} + h_{sn\_201\_214} + h_{sn\_aa\_vendor} \]
\[ h_2 = 349 \text{ ft} \]

Elevation Change:
\[ h_3 = 50 \text{ ft} + z_{end} - z_{start} \]
\[ h_3 = 45 \text{ ft} \] (Assumption 2)

Total Head Loss:
\[ i = 1, 2 \ldots 3 \]
\[ TDH_{140\_alt4} = \sum_{i} h_i \]
\[ TDH_{140\_alt4} = 439 \text{ ft} \]

Pressure Drop:
\[ \Delta P_{140\_alt4} = \frac{TDH_{140\_alt4} \rho}{144 \text{ in}^2 \text{ ft}^2} \]
\[ \Delta P_{140\_alt4} = 285 \frac{\text{lb}}{\text{in}^2} \]
5.0 SYSTEM CURVE DEVELOPMENT

A system-head curve is a graphical representation of the relationship between flow and hydraulic losses in a given piping system. The system curve can be used with a pump characteristic curve to develop the operating point of the system. For this system, the friction losses at flow rates of 140 (previously calculated), 120, 100, 80, and 60 gpm will be used to develop the system-head curve.

5.1 120 GPM: 241-AY

5.1.1 Constant Data

Volumetric Flow Rate,

\[ Q_{120} = \frac{120 \text{ gal}}{\text{min}} \]

\[ q_{120} = \frac{120 \times 0.13368 \text{ ft}^3}{60 \text{ sec}} \]

\[ q = 0.27 \text{ ft}^3/\text{sec} \]

Velocity of Flow,

\[ v_{2\text{in}} = \frac{q}{A_{2\text{in}}} \]

\[ v_{2\text{in}} = 11.5 \text{ ft/ sec} \]

\[ v_{3\text{in}} = \frac{q}{A_{3\text{in}}} \]

\[ v_{3\text{in}} = 5.2 \text{ ft/ sec} \]

Reynolds Number,

\[ \text{Re}_{2\text{in}} = \frac{D_{2\text{in}} v_{2\text{in}} \rho}{\mu_e} \]

\[ \text{Re}_{2\text{in}} = 27514 \]

\[ \text{Re}_{3\text{in}} = \frac{D_{3\text{in}} v_{3\text{in}} \rho}{\mu_e} \]

\[ \text{Re}_{3\text{in}} = 18537 \]

Friction Factor (Ref. Crane, Page A-25 and A-26),

\[ f_{2\text{in}} = 0.026 \]

\[ f_{T2\text{in}} = 0.019 \]

\[ f_{3\text{in}} = 0.0275 \]

\[ f_{T3\text{in}} = 0.018 \]

Bernoulli's Theorem,

\[ z_1 + \frac{144P_1}{\rho_1} + \frac{v_1^2}{2g} = z_2 + \frac{144P_2}{\rho_2} + \frac{v_2^2}{2g} + h_L \]
5.1.2.1 AY-Farm Process Pits

10.0 ft - 2" Pipe Length: 
\[ h_{\text{pit,2in}} = \frac{2 \ln \left( \frac{L}{D_{\text{2in}}} \right)}{2g} \]
\[ K_1 = 1.5 \]

2 - 2" Connectors (assume 90 Mitre Bend):
\[ K_2 = \left( \frac{60 \ln T_{\text{2in}}}{2T_{\text{2in}}} \right)^2 \]
\[ K_2 = 2.3 \]

2 - 2" Long Radius Elbow:
\[ K_3 = \left( \frac{14 \ln T_{\text{2in}}}{2T_{\text{2in}}} \right)^2 \]
\[ K_3 = 0.5 \]

1 - 2" 3-Way Ball Valve (assume 90 Mitre Bend):
\[ K_4 = \left( \frac{60 \ln T_{\text{2in}}}{2T_{\text{2in}}} \right)^{1.1} \]
\[ K_4 = 1.1 \]

\[ h_{\text{pit,2in}} = \frac{v_{\text{2in}}^2}{2g} \sum_{i=1}^{4} K_i \]
\[ h_{\text{pit,2in}} = 11.2 \text{ ft} \]

Head Loss for both AY-Farm pits:
\[ h_{\text{pump,pits}} = 2 \cdot h_{\text{pit,2in}} \]
\[ h_{\text{pump,pits}} = 22.3 \text{ ft} \]
5.1.2.2 Valve Pits

10.0 ft - 3" Pipe Length: \( L_1 = 10 \) ft

\[
K_1 = f_{3in} \frac{L_1}{D_{3in}} \quad K_1 = 1.1
\]

4 - 3" Connectors (assume 90 Mitre Bend):

\[
K_2 = (60f_{T3in}) \cdot 4 \quad K_2 = 4.3
\]

4 - 3" Long Radius Elbow:

\[
K_3 = (14f_{T3in}) \cdot 4 \quad K_3 = 1.0
\]

2 - 3" 3-Way Ball Valve (assume 90 Mitre Bend):

\[
K_4 = (60f_{T3in}) \cdot 2 \quad K_4 = 2.2
\]

Head Loss for each pit:

\[
h_{pit\_3in} = \frac{v_{3in}^2}{2g} \sum_{i=1}^{4} K_i
\]

\[
h_{pit\_3in} = 3.6 \text{ ft}
\]

Head Loss for all six remaining pits:

\[
h_{valve\_pits\_alt3} = 3 \cdot h_{pit\_3in} \quad h_{valve\_pits\_alt3} = 10.8 \text{ ft}
\]

\[
h_{valve\_pits\_alt4} = 3 \cdot h_{pit\_3in} \quad h_{valve\_pits\_alt4} = 10.8 \text{ ft}
\]

5.1.3 TRANSFER LINE HEAD LOSSES

2" Pipe Length (Alternative 3 and 4):

\[
L_{2in} = 11 \text{ ft}
\]

\[
K_1 = f_{2in} \frac{L_{2in}}{D_{2in}} \quad K_1 = 1.7
\]

2" Pipe - 36" Radius Bends \((r/d=18)\) (Alternative 3 and 4):

\[
N_{2in\_bends} = 2
\]

\[
K_2 = (46f_{T2in}) \cdot N_{2in\_bends} \quad K_2 = 1.7
\]

3" Pipe Length (Alternative 3):

\[
L_{3in} = 235 \text{ ft} + 618 \text{ ft} + 1334 \text{ ft} + 2820 \text{ ft}
\]

\[
K_3 = f_{3in} \frac{L_{3in}}{D_{3in}} \quad K_3 = 538.6
\]
ICF Kaiser Hanford

DESIGN ANALYSIS

Client: WHC
Subject: Head Loss Calculations for HLW
        Feed from 241-AY Tanks (Alternative 3 and 4)
Location: 200 East

3" Pipe - 36" Radius Bends (r/d=12) (Alternative 3):

\[ N_{3\text{in.bends}} = 5 + 15 + 25 + 50 \]
\[ K_4 = (34 \cdot f_{T3\text{in}}) \cdot N_{3\text{in.bends}} \quad K_4 = 58.1 \]

3" Pipe - 36" Radius 45 Bends (r/d=12) (Alternative 3):

\[ N_{3\text{in.45s}} = 2 \]
\[ K_5 = \left( (0.5 - 1) \cdot \frac{2.25 \cdot \pi \cdot f_{T3\text{in}} \cdot 12 + 0.5 \cdot (34 \cdot f_{T3\text{in}})}{34 \cdot f_{T3\text{in}}} \right) \cdot N_{3\text{in.45s}} \quad K_5 = 0.7 \]

3" Pipe Length (Alternative 4):

\[ L_{3\text{in}} = 235\text{ ft} + 6\text{ ft} + 650\text{ ft} + 4150\text{ ft} \]
\[ K_6 = f_{3\text{in}} \cdot \frac{L_{3\text{in}}}{D_{3\text{in}}} \quad K_6 = 542.2 \]

3" Pipe - 36" Radius Bends (r/d=12) (Alternative 4):

\[ N_{3\text{in.bends}} = 5 + 4 + 17 + 72 \]
\[ K_7 = (34 \cdot f_{T3\text{in}}) \cdot N_{3\text{in.bends}} \quad K_7 = 60 \]

5.1.4 TOTAL HEAD LOSS: 241-AY ALTERNATIVE 3

Process Pit Losses:

\[ h_1 = h_{\text{pump.pits}} + h_{\text{valve.pits.alt3}} \quad h_1 = 33\text{ ft} \]

Transfer Path Losses:

\[ h_2 = \frac{v_{2\text{in}}^2}{2g} \cdot \sum_{i=1}^{2} K_i + \frac{v_{3\text{in}}^2}{2g} \cdot \sum_{i=3}^{5} K_i \quad h_2 = 259\text{ ft} \]

Elevation Change:

\[ h_3 = 50\text{ ft} + z_{\text{end}} - z_{\text{start}} \quad h_3 = 45\text{ ft} \quad \text{(Assumption 2)} \]

Total Head Loss:

\[ i = 1, 2, 3 \]
\[ \text{TDH}_{120\text{alt3}} = \sum_i h_i \quad \text{TDH}_{120\text{alt3}} = 337\text{ ft} \]

Pressure Drop:

\[ \Delta P_{120\text{alt3}} = \frac{\text{TDH}_{120\text{alt3}}}{144\text{ in}^2/\text{ft}^2} \quad \Delta P_{120\text{alt3}} = 219\text{ lb/in}^2 \]

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5.1.5 TOTAL HEAD LOSS: 241-AY ALTERNATIVE 4

**Process Pit Losses:**

\[ h_1 = h_{\text{pump \_ pits}} + h_{\text{valve \_ pits \_ alt4}} \]

\[ h_1 = 33 \text{-ft} \]

**Transfer Path Losses:**

\[ h_2 = \frac{v_{2\text{in}}^2}{2g} \sum_{i=1}^{2} K_i + \frac{v_{3\text{in}}^2}{2g} \sum_{i=6}^{7} K_i \]

\[ h_2 = 261 \text{-ft} \]

**Elevation Change:**

\[ h_3 = 50 \text{-ft} + z_{\text{end}} - z_{\text{start}} \]

\[ h_3 = 45 \text{-ft} \]  
(Assumption 2)

**Total Head Loss:**

\[ i : 1, 2, 3 \]

\[ \text{TDH}_{120_{\text{alt4}}} = \sum_{i} h_i \]

\[ \text{TDH}_{120_{\text{alt4}}} = 339 \text{-ft} \]

**Pressure Drop:**

\[ \Delta P_{120_{\text{alt4}}} = \frac{\text{TDH}_{120_{\text{alt4}}} \rho}{144 \text{-in}^2 / \text{ft}^2} \]

\[ \Delta P_{120_{\text{alt4}}} = 220 \text{-lb \_in}^2 \]

5.2 100 GPM: 241-AY

5.2.1 Constant Data

**Volumetric Flow Rate,**

\[ Q_{100} = 100 \text{ \_gal \_min} \]

\[ Q_{100} = 133.68 \text{ \_gal \_sec} \]

\[ q = \frac{Q_{100}}{60 \text{-min}} \]

\[ q = 0.22 \text{ \_ft}^3 \text{-sec}^{-1} \]

**Velocity of Flow,**

\[ \text{2 inch pipe} \quad v_{2\text{in}} = \frac{q}{A_{2\text{in}}} \]

\[ v_{2\text{in}} = 9.6 \text{ \_ft \_sec}^{-1} \]

\[ \text{3 inch pipe} \quad v_{3\text{in}} = \frac{q}{A_{3\text{in}}} \]

\[ v_{3\text{in}} = 4.3 \text{ \_ft \_sec}^{-1} \]
Reynolds Number,

\[ Re_{2\text{in}} = \frac{D_{2\text{in}} v_{2\text{in}} \rho}{\mu_c} \]
\[ Re_{2\text{in}} = 22928 \]
\[ Re_{3\text{in}} = \frac{D_{3\text{in}} v_{3\text{in}} \rho}{\mu_c} \]
\[ Re_{3\text{in}} = 15447 \]

Friction Factor (Ref. Crane, Page A-25 and A-26),

\[ f_{2\text{in}} = 0.027 \quad r_{2\text{in}} = 0.019 \]
\[ f_{3\text{in}} = 0.029 \quad r_{3\text{in}} = 0.018 \]

Bernoulli's Theorem,

\[ z_1 + \frac{144 \rho_1}{P_1} + \frac{v_1^2}{2g} = z_2 + \frac{144 \rho_2}{P_2} + \frac{v_2^2}{2g} + h_L \]

5.2.2 PROCESS PIT HEAD LOSSES

5.2.2.1 AY-Farm Process Pits

10.0 ft - 2" Pipe Length:
\[ L_1 = 10.0 \text{ ft} \]
\[ K_1 = f_{2\text{in}} \frac{L_1}{D_{2\text{in}}} \]
\[ K_1 = 1.6 \]

2 - 2" Connectors (assume 90 Mitre Bend):
\[ K_2 = (50 f_{2\text{in}} T_{2\text{in}})^2 \]
\[ K_2 = 2.3 \]

2 - 2" Long Radius Elbow:
\[ K_3 = (14 f_{2\text{in}} T_{2\text{in}})^2 \]
\[ K_3 = 0.5 \]

1 - 2" 3-Way Ball Valve (assume 90 Mitre Bend):
\[ K_4 = (60 f_{2\text{in}} T_{2\text{in}})^1 \]
\[ K_4 = 1.1 \]

Head Loss for each pit:
\[ h_{\text{pit,2in}} = \frac{v_{2\text{in}}^2}{2g} \sum_{i=1}^{4} K_i \]
\[ h_{\text{pit,2in}} = 7.8 \text{ ft} \]

Head Loss for both AY-Farm pits:
\[ h_{\text{pump, pits}} = 2 \cdot h_{\text{pit,2in}} \]
\[ h_{\text{pump, pits}} = 15.7 \text{ ft} \]
5.2.2.2 Valve Pits

10.0 ft - 3" Pipe Length:

\[ L_1 = 10 \text{ ft} \]

\[ K_1 = \frac{f_{3\text{in}}}{D_{3\text{in}}} \]

\[ K_1 = 1.1 \]

4 - 3" Connectors (assume 90 Mitre Bend):

\[ K_2 = (60 \cdot f_{T3\text{in}}) \cdot 4 \]

\[ K_2 = 4.3 \]

4 - 3" Long Radius Elbow:

\[ K_3 = (14 \cdot f_{T3\text{in}}) \cdot 4 \]

\[ K_3 = 1.0 \]

2 - 3" 3-Way Ball Valve (assume 90 Mitre Bend):

\[ K_4 = (60 \cdot f_{T3\text{in}}) \cdot 2 \]

\[ K_4 = 2.2 \]

Head Loss for each pit:

\[ h_{\text{pit\_3in}} = \frac{v_{3\text{in}}^2}{2g} \sum_{i=1}^{4} K_i \]

\[ h_{\text{pit\_3in}} = 2.5 \text{ ft} \]

Head Loss for all six remaining pits:

\[ h_{\text{valve\_pits\_alt3}} = 3 \cdot h_{\text{pit\_3in}} \]

\[ h_{\text{valve\_pits\_alt3}} = 7.6 \text{ ft} \]

\[ h_{\text{valve\_pits\_alt4}} = 3 \cdot h_{\text{pit\_3in}} \]

\[ h_{\text{valve\_pits\_alt4}} = 7.6 \text{ ft} \]

5.2.3 TRANSFER LINE HEAD LOSSES

2" Pipe Length (Alternative 3 and 4):

\[ L_{2\text{in}} = 11 \text{ ft} \]

\[ K_1 = \frac{f_{2\text{in}}}{D_{2\text{in}}} \]

\[ K_1 = 1.7 \]

2" Pipe - 36" Radius Bends (r/d=18) (Alternative 3 and 4):

\[ N_{2\text{in\_bends}} = 2 \]

\[ K_2 = (46 \cdot f_{T2\text{in}}) \cdot N_{2\text{in\_bends}} \]

\[ K_2 = 1.7 \]

3" Pipe Length (Alternative 3):

\[ L_{3\text{in}} = 235 \text{ ft} + 618 \text{ ft} + 1334 \text{ ft} + 2820 \text{ ft} \]

\[ K_3 = \frac{f_{3\text{in}}}{D_{3\text{in}}} \]

\[ K_3 = 567.9 \]
5.2.4 TOTAL HEAD LOSS: 241-AY ALTERNATIVE 3

Process Pit Losses:
\[ h_1 = h_{pump\ pits} + h_{valve\ pits\ alt3} \]
\[ h_1 = 23 \text{ ft} \]

Transfer Path Losses:
\[ h_2 = \sum_{i=1}^{2} \frac{V_{2\text{in}}}{2g} K_i + \sum_{i=3}^{5} \frac{V_{3\text{in}}}{2g} K_i \]
\[ h_2 = 188 \text{ ft} \]

Elevation Change:
\[ h_3 = 50 \text{ ft} + z_{\text{end}} - z_{\text{start}} \]
\[ h_3 = 45 \text{ ft} \] (Assumption 2)

Total Head Loss:
\[ i = 1, 2, 3 \]
\[ \text{TDH}_{100\_alt3} = \sum_{i} h_i \]
\[ \text{TDH}_{100\_alt3} = 257 \text{ ft} \]

Pressure Drop:
\[ \Delta P_{100\_alt3} = \frac{\text{TDH}_{100\_alt3}}{144 \text{ in}^2 / \text{ft}^2} \]
\[ \Delta P_{100\_alt3} = 167 \text{ lb/in}^2 \]
5.2.5 TOTAL HEAD LOSS: 241-AY ALTERNATIVE 4

**Process Pit Losses:**
\[ h_1 = h_{\text{pump pits}} + h_{\text{valve pits alt4}} \]
\[ h_1 = 23 \text{ ft} \]

**Transfer Path Losses:**
\[ h_2 = \frac{v_{2\text{in}}}{2g} \sum_{i=1}^{2} K_i + \frac{v_{3\text{in}}}{2g} \sum_{i=6}^{7} K_i \]
\[ h_2 = 190 \text{ ft} \]

**Elevation Change:**
\[ h_3 = 50 \text{ ft} + z_{\text{end}} - z_{\text{start}} \]
\[ h_3 = 45 \text{ ft} \] (Assumption 2)

**Total Head Loss:**
\[ i = 1, 2, 3 \]
\[ \text{TDH}_{100_{\text{alt4}}} = \sum h_i \]
\[ \text{TDH}_{100_{\text{alt4}}} = 258 \text{ ft} \]

**Pressure Drop:**
\[ \Delta P_{100_{\text{alt4}}} = \frac{\text{TDH}_{100_{\text{alt4}}^p}}{144 \text{ in}^2} \]
\[ \Delta P_{100_{\text{alt4}}} = 168 \text{ lb in}^2 \]

5.3 80 GPM: 241-AY

5.3.1 Constant Data

**Volumetric Flow Rate,**
\[ Q_{80} = 80 \frac{\text{gal}}{\text{min}} \]
\[ Q_{80} = 0.13368 \frac{\text{ft}^3}{\text{gal}} \]
\[ q = \frac{0.18 \frac{\text{ft}^3}{\text{sec}}}{60 \frac{\text{sec}}{\text{min}}} \]

**Velocity of Flow,**
\[ v_{2\text{in}} = \frac{q}{A_{2\text{in}}} \]
\[ v_{2\text{in}} = 7.6 \frac{\text{ft}}{\text{sec}} \]
\[ v_{3\text{in}} = \frac{q}{A_{3\text{in}}} \]
\[ v_{3\text{in}} = 3.5 \frac{\text{ft}}{\text{sec}} \]
Reynolds Number,

\[
2 \text{ inch pipe} \quad \frac{D_{2\text{in}} v_{2\text{in}} \rho}{\mu_e} = \frac{D_{2\text{in}}^2 v_{2\text{in}}^2 \rho}{\mu_e} = 18343
\]

\[
3 \text{ inch pipe} \quad \frac{D_{3\text{in}} v_{3\text{in}} \rho}{\mu_e} = \frac{D_{3\text{in}}^2 v_{3\text{in}}^2 \rho}{\mu_e} = 12358
\]

Friction Factor (Ref. Crane, Page A-25 and A-26),

\[
2 \text{ inch pipe} \quad f_{2\text{in}} = 0.028 \quad f_{T2\text{in}} = 0.019
\]

\[
3 \text{ inch pipe} \quad f_{3\text{in}} = 0.03 \quad f_{T3\text{in}} = 0.018
\]

Bernoulli's Theorem,

\[
z_1 + \frac{144 P_1}{\rho_1} + \frac{v_1^2}{2g} = z_2 + \frac{144 P_2}{\rho_2} + \frac{v_2^2}{2g} + h_L
\]

5.3.2 PROCESS PIT HEAD LOSSES

5.3.2.1 AY-Farm Process Pits

10.0 ft - 2" Pipe Length: \( L_1 = 10 \text{-ft} \)

\[
K_1 = f_{2\text{in}} D_{2\text{in}} \quad K_1 = 1.6
\]

2 - 2" Connectors (assume 90 Mitre Bend):

\[
K_2 = (60 f_{T2\text{in}})^2 \quad K_2 = 2.3
\]

2 - 2" Long Radius Elbow:

\[
K_3 = (14 f_{T2\text{in}})^2 \quad K_3 = 0.5
\]

1 - 2" 3-Way Ball Valve (assume 90 Mitre Bend):

\[
K_4 = (60 f_{T2\text{in}})^{-1} \quad K_4 = 1.1
\]

Head Loss for each pit: \( h_{\text{pit-2in}} = \frac{v_{2\text{in}}^2}{2g} \sum_{i=1}^{4} K_i \quad h_{\text{pit-2in}} = 5.1 \text{-ft} \)

Head Loss for both AY-Farm pits:

\[
h_{\text{pump-pits}} = 2 h_{\text{pit-2in}} \quad h_{\text{pump-pits}} = 10.1 \text{-ft}
\]
5.3.2.2 Valve Pits

**10.0 ft - 3" Pipe Length:**

\[ K_1 = f_{3in} \frac{L}{D_{3in}} \]

\[ K_1 = 1.2 \]

**4 - 3" Connectors (assume 90 Mitre Bend):**

\[ K_2 = (60f_{T3in})^4 \]

\[ K_2 = 4.3 \]

**4 - 3" Long Radius Elbow:**

\[ K_3 = (14f_{T3in})^4 \]

\[ K_3 = 1.0 \]

**2 - 3" 3-Way Ball Valve (assume 90 Mitre Bend):**

\[ K_4 = (60f_{T3in})^2 \]

\[ K_4 = 2.2 \]

**Head Loss for each pit:**

\[ h_{pit_{3in}} = \frac{v_{3in}^2}{2g} \sum_{i=1}^{4} K_i \]

\[ h_{pit_{3in}} = 1.6\text{ ft} \]

**Head Loss for all six remaining pits:**

\[ h_{valve_pits_{alt3}} = 3 \cdot h_{pit_{3in}} \]

\[ h_{valve_pits_{alt3}} = 4.9\text{ ft} \]

\[ h_{valve_pits_{alt4}} = 3 \cdot h_{pit_{3in}} \]

\[ h_{valve_pits_{alt4}} = 4.9\text{ ft} \]

5.3.3 TRANSFER LINE HEAD LOSSES

**2" Pipe Length (Alternative 3 and 4):**

\[ L_{2in} = 11\text{ ft} \]

\[ K_1 = f_{2in} \frac{L_{2in}}{D_{2in}} \]

\[ K_1 = 1.8 \]

**2" Pipe - 36" Radius Bends (r/d=18) (Alternative 3 and 4):**

\[ N_{2in\_bends} = 2 \]

\[ K_2 = (46f_{T2in})^2 \cdot N_{2in\_bends} \]

\[ K_2 = 1.7 \]

**3" Pipe Length (Alternative 3):**

\[ L_{3in} = 235\text{ ft} + 618\text{ ft} + 1334\text{ ft} + 2820\text{ ft} \]

\[ K_3 = f_{3in} \frac{L_{3in}}{D_{3in}} \]

\[ K_3 = 587.5 \]
Subject: Head Loss Calculations for HLW

Feed from 241-AY Tanks (Alternative 3 and 4)

**3" Pipe - 36" Radius Bends (r/d=12) (Alternative 3):**

\[ N_{3\text{in}_{\text{bends}}} = 5 + 15 + 25 + 50 \]
\[ K_4 = (34 f_{3\text{in}} \cdot N_{3\text{in}_{\text{bends}}}) \quad K_4 = 58.1 \]

**3" Pipe - 36" Radius 45 Bends (r/d=12) (Alternative 3):**

\[ N_{3\text{in}_{45\text{bends}}} = 2 \]
\[ K_5 = \left( \frac{0.25 f_{3\text{in}}}{12} \cdot (34 f_{3\text{in}}) \right) \cdot N_{3\text{in}_{45\text{bends}}} \quad K_5 = 0.7 \]

**3" Pipe Length (Alternative 4):**

\[ L_{3\text{in}} = 235\text{ft} + 6\text{ft} + 650\text{ft} + 4150\text{ft} \]
\[ K_6 = \frac{L_{3\text{in}}}{D_{3\text{in}}} \quad K_6 = 591.5 \]

**3" Pipe - 36" Radius Bends (r/d=12) (Alternative 4):**

\[ N_{3\text{in}_{\text{bends}}} = 5 + 4 + 17 + 72 \]
\[ K_7 = (34 f_{3\text{in}} \cdot N_{3\text{in}_{\text{bends}}}) \quad K_7 = 60 \]

### 5.3.4 TOTAL HEAD LOSS: 241-AY ALTERNATIVE 3

**Process Pit Losses:**

\[ h_1 = h_{\text{pump pits}} + h_{\text{valve pits alt3}} \quad h_1 = 15\text{ft} \]

**Transfer Path Losses:**

\[ h_2 = \sum_{i=1}^{2} \frac{v_{2\text{in}}^2}{2g} \sum_{i=1}^{2} K_i + \sum_{i=3}^{5} \frac{v_{3\text{in}}^2}{2g} K_i \quad h_2 = 124\text{ft} \]

**Elevation Change:**

\[ h_3 = 50\text{ft} + z_{\text{end}} - z_{\text{start}} \quad h_3 = 45\text{ft} \quad (\text{Assumption 2}) \]

**Total Head Loss:**

\[ i = 1, 2, 3 \]
\[ TDH_{80_{\text{alt3}}} = \sum_{i}^{} h_i \quad TDH_{80_{\text{alt3}}} = 184\text{ft} \]

**Pressure Drop:**

\[ \Delta P_{80_{\text{alt3}}} = \frac{TDH_{80_{\text{alt3}}}}{A_{\text{in}}^2 f} \quad \Delta P_{80_{\text{alt3}}} = \frac{120}{144} \text{lb/ft}^2 \]

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5.3.5 TOTAL HEAD LOSS: 241-AY ALTERNATIVE 4

Process Pit Losses:

\[ h_1 = h_{\text{pump pits}} + h_{\text{valve pits alt4}} \]

\[ h_1 = 15 \text{ ft} \]

Transfer Path Losses:

\[ h_2 = \frac{v_{2\text{in}}^2}{2g} \sum_{i=1}^{2} K_i + \frac{v_{3\text{in}}^2}{2g} \sum_{i=6}^{7} K_i \]

\[ h_2 = 125 \text{ ft} \]

Elevation Change:

\[ h_3 = 50 \text{ ft} + z_{\text{end}} - z_{\text{start}} \]

\[ h_3 = 45 \text{ ft} \quad \text{(Assumption 2)} \]

Total Head Loss:

\[ TDH_{80,\text{alt4}} = \sum h_i \]

\[ TDH_{80,\text{alt4}} = 185 \text{ ft} \]

Pressure Drop:

\[ \Delta P_{80,\text{alt4}} = \frac{TDH_{80,\text{alt4}}}{144 \frac{\text{in}^2}{\text{ft}^2}} \]

\[ \Delta P_{80,\text{alt4}} = 120 \frac{\text{lb}}{\text{in}^2} \]

5.4 60 GPM: 241-AY

5.4.1 Constant Data

Volumetric Flow Rate, \( Q_{60} = 60 \frac{\text{gal}}{\text{min}} \)

\[ Q_{60} = 0.13368 \frac{\text{ft}^3}{\text{gal}} \quad q = \frac{0.13}{\frac{\text{sec}}{\text{min}}} \]

Velocity of Flow,

\[ \text{2 inch pipe} \quad v_{2\text{in}} = \frac{q}{A_{2\text{in}}} \quad v_{2\text{in}} = 5.7 \frac{\text{ft}}{\text{sec}} \]

\[ \text{3 inch pipe} \quad v_{3\text{in}} = \frac{q}{A_{3\text{in}}} \quad v_{3\text{in}} = 2.6 \frac{\text{ft}}{\text{sec}} \]
Reynolds Number,

\[
\text{2 inch pipe} \quad \text{Re}_{2\text{in}} = \frac{D_{2\text{in}} v_{2\text{in}} \rho}{\mu_e} \quad \text{Re}_{2\text{in}} = 13757
\]

\[
\text{3 inch pipe} \quad \text{Re}_{3\text{in}} = \frac{D_{3\text{in}} v_{3\text{in}} \rho}{\mu_e} \quad \text{Re}_{3\text{in}} = 9268
\]

Friction Factor (Ref. Crane, Page A-25 and A-26),

\[
\text{2 inch pipe} \quad f_{2\text{in}} = 0.03 \quad f_{2\text{in}} = 0.019
\]

\[
\text{3 inch pipe} \quad f_{3\text{in}} = 0.032 \quad f_{3\text{in}} = 0.018
\]

Bernoulli's Theorem,

\[
z_1 + \frac{144 P_1}{\rho_1} + \frac{v_1^2}{2g} = z_2 + \frac{144 P_2}{\rho_2} + \frac{v_2^2}{2g} + h_L
\]

5.4.2 PROCESS PIT HEAD LOSSES

5.4.2.1 AY-Farm Process Pits

10.0 ft - 2" Pipe Length:

\[
L_1 = 10 \text{ ft} \quad K_1 = f_{2\text{in}} \frac{L_1}{D_{2\text{in}}} \quad K_1 = 1.7
\]

2 - 2" Connectors (assume 90 Mitre Bend):

\[
K_2 = (60 f_{2\text{in}})^2 \quad K_2 = 2.3
\]

2 - 2" Long Radius Elbow:

\[
K_3 = (14 f_{2\text{in}})^2 \quad K_3 = 0.5
\]

1 - 2" 3-Way Ball Valve (assume 90 Mitre Bend):

\[
K_4 = (60 f_{2\text{in}})^{-1} \quad K_4 = 1.1
\]

Head Loss for each pit:

\[
h_{\text{pit,2in}} = \frac{v_{2\text{in}}^2}{2g} \sum_{i=1}^{4} K_i \quad h_{\text{pit,2in}} = 2.9 \text{ ft}
\]

Head Loss for both AY-Farm pits:

\[
h_{\text{pump_pits}} = 2 \cdot h_{\text{pit,2in}} \quad h_{\text{pump_pits}} = 5.8 \text{ ft}
\]
5.4.2.2 Valve Pits

10.0 ft - 3" Pipe Length:

\[ L_1 = 10 \text{ ft} \]

\[ K_1 = 1.3 \]

4 - 3" Connectors (assume 90 Mitre Bend):

\[ K_2 = (60 \cdot f \cdot T_{3in})^{0.4} \]

\[ K_2 = 4.3 \]

4 - 3" Long Radius Elbow:

\[ K_3 = (14 \cdot f \cdot T_{3in})^{0.4} \]

\[ K_3 = 1.0 \]

2 - 3" 3-Way Ball Valve (assume 90 Mitre Bend):

\[ K_4 = (60 \cdot f \cdot T_{3in})^{2} \]

\[ K_4 = 2.2 \]

Head Loss for each pit:

\[ h_{pit,3in} = \frac{v_{3in}^2}{2g} \sum_{i=1}^{4} K_i \]

\[ h_{pit,3in} = 0.9 \cdot \text{ft} \]

Head Loss for all six remaining pits:

\[ h_{valve, pits, alt3} = 3 \cdot h_{pit,3in} \]

\[ h_{valve, pits, alt3} = 2.8 \cdot \text{ft} \]

\[ h_{valve, pits, alt4} = 3 \cdot h_{pit,3in} \]

\[ h_{valve, pits, alt4} = 2.8 \cdot \text{ft} \]

5.4.3 TRANSFER LINE HEAD LOSSES

2" Pipe Length (Alternative 3 and 4):

\[ L_{2in} = 11 \cdot \text{ft} \]

\[ K_1 = f_{2in} \cdot L_{2in} \frac{1}{D_{2in}} \]

\[ K_1 = 1.9 \]

2" Pipe - 36" Radius Bends \((r/d=18)\) (Alternative 3 and 4):

\[ N_{2in, bends} = 2 \]

\[ K_2 = (46 \cdot f \cdot T_{2in})^{0.8} \cdot N_{2in, bends} \]

\[ K_2 = 1.7 \]

3" Pipe Length (Alternative 3):

\[ L_{3in} = 235 \cdot \text{ft} + 618 \cdot \text{ft} + 1334 \cdot \text{ft} + 2820 \cdot \text{ft} \]

\[ K_3 = f_{3in} \cdot L_{3in} \frac{1}{D_{3in}} \]

\[ K_3 = 626.7 \]

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ICF Kaiser Hanford

DESIGN ANALYSIS

Client: WHC
Subject: Head Loss Calculations for HLW
Feed from 241-AY Tanks (Alternative 1 and 2)
Location: 200 East

Calc. No. E44810-2703
Revision 0
Page No. 26 of 30

Client: WHC
WO/Job No. E44810
Date: 5/1/96

Subject: Head Loss Calculations for HLW
Job No. E44810
Date: 5/1/96

Location: 200 East

By: T.B. Salzano
By:

3" Pipe - 36" Radius Bends (r/d=12) (Alternative 3):

\[ N_{3\text{in\_bends}} = 5 + 15 + 25 + 50 \]
\[ K_4 = \left(34.5 \cdot T_{3\text{in}}\right) \cdot N_{3\text{in\_bends}} \]
\[ K_4 = 58.1 \]

3" Pipe - 36" Radius 45 Bends (r/d=12) (Alternative 3):

\[ N_{3\text{in\_45s}} = 2 \]
\[ K_5 = \left[\left(0.5 - 1\right) \right] \cdot 25 \cdot \left(34.5 \cdot T_{3\text{in}}\right) + 1 \cdot 34.5 \cdot T_{3\text{in}} \]
\[ K_5 = 8.1 \]

3" Pipe Length (Alternative 4):

\[ L_{3\text{in}} = 235 \text{ ft} + 6 \text{ ft} + 650 \text{ ft} + 4150 \text{ ft} \]
\[ K_6 = f_{3\text{in}} \cdot \frac{L_{3\text{in}}}{D_{3\text{in}}} \]
\[ K_6 = 630.9 \]

3" Pipe - 36" Radius Bends (r/d=12) (Alternative 4):

\[ N_{3\text{in\_bends}} = 5 + 4 + 17 + 72 \]
\[ K_7 = \left(34.5 \cdot T_{3\text{in}}\right) \cdot N_{3\text{in\_bends}} \]
\[ K_7 = 60 \]

5.4.4 TOTAL HEAD LOSS: 241-AY ALTERNATIVE 3

Process Pit Losses:

\[ h_1 = h_{\text{pump\_pits}} + h_{\text{valve\_pits\_alt3}} \]
\[ h_1 = 9 \text{ ft} \]

Transfer Path Losses:

\[ h_2 = \frac{v_{2\text{in}}^2}{2g} \sum_{i=1}^{2} K_i + \frac{v_{3\text{in}}^2}{2g} \sum_{i=3}^{5} K_i \]
\[ h_2 = 74 \text{ ft} \]

Elevation Change:

\[ h_3 = 50 \text{ ft} + z_{\text{end}} - z_{\text{start}} \]
\[ h_3 = 45 \text{ ft} \]

(Assumption 2)

Total Head Loss:

\[ i = 1, 2, 3 \]

\[ TDH_{60\_alt3} = \sum_{i=1}^{3} h_i \]
\[ TDH_{60\_alt3} = 128 \text{ ft} \]

Pressure Drop:

\[ \Delta P_{60\_alt3} = \frac{TDH_{60\_alt3} \cdot p}{144 \cdot \text{in}^2} \]
\[ \Delta P_{60\_alt3} = 83 \text{ lb} \in \text{in}^2 \]

A-79
5.4.5 TOTAL HEAD LOSS: 241-AY ALTERNATIVE 4

Process Pit Losses:

\[ h_1 = h_{pump_{pit}} + h_{valve_{pit_{alt4}}} \]

\( h_1 = 9 \text{ ft} \)

Transfer Path Losses:

\[ h_2 = \frac{v^2}{2g} \sum_{i=1}^{2} K_i + \frac{v^2}{2g} \sum_{i=6}^{7} K_i \]

\( h_2 = 75 \text{ ft} \)

Elevation Change:

\( h_3 = 50 \text{ ft} + z_{\text{end}} - z_{\text{start}} \)

\( h_3 = 45 \text{ ft} \) (Assumption 2)

Total Head Loss:

\[ i = 1, 2, 3 \]

\[ TDH_{60_{alt4}} = \sum_i h_i \]

\( TDH_{60_{alt4}} = 128 \text{ ft} \)

Pressure Drop:

\[ \Delta P_{60_{alt4}} = \frac{TDH_{60_{alt4}} \cdot \rho}{144 \text{ in}^2 \text{ ft}^2} \]

\( \Delta P_{60_{alt4}} = \frac{83 \text{ lb}}{\text{in}^2} \)

6.0 SYSTEM CURVE

The system curve can now be generated. The curve will be used to determine different possible operating points for the system. A pump could then be selected to meet the needed operating requirements. The main operating points to be considered are at a Reynolds number of 20,000 and at the design pressure limit of the system.

6.1 SYSTEM CURVE DATA: 241-AY

The system curve for the 241-AY-102 Tank transfers to the vendor's processing facility can now be generated.

Flow Rate:

\[
Q = \begin{bmatrix}
Q_{60} \\
Q_{80} \\
Q_{100} \\
Q_{120} \\
Q_{140}
\end{bmatrix}
\]

Total Head:

\[
TDH_{ay_{alt3}} = \begin{bmatrix}
TDH_{60_{alt3}} \\
TDH_{80_{alt3}} \\
TDH_{100_{alt3}} \\
TDH_{120_{alt3}} \\
TDH_{140_{alt3}}
\end{bmatrix}
\]

\[
TDH_{ay_{alt4}} = \begin{bmatrix}
TDH_{60_{alt4}} \\
TDH_{80_{alt4}} \\
TDH_{100_{alt4}} \\
TDH_{120_{alt4}} \\
TDH_{140_{alt4}}
\end{bmatrix}
\]
6.2 SYSTEM CURVE

\[ i = 0.4 \]

HLW Transfers from 241-AY-102 to the Vendor (Alternative 3 and 4)

Reynolds No. = 20,000

System Design Pressure

Head (ft)

241-AY (Alternative 4)

241-AY (Alternative 3)

Flow (gpm)
6.3 SPECIFIC OPERATING POINTS

6.3.1 Operating Point at Reynolds Number > 20,000: 241-AY ALTERNATIVE 3

This operating point occurs at a flow rate of 130 gpm. From the above graph,

\[ Q_{Re} = 130 \text{ gpm} \]

\[ TDH_{Re} = 385 \text{ ft} \]

Therefore, the pressure drop and velocity in the 3 inch lines are as follows.

Velocity:

\[ v_{Re-3in} = \frac{Q_{Re}}{A_{3in}} \]

\[ v_{Re-3in} = 5.6 \text{ ft/sec} \]

Pressure Drop:

\[ \Delta P_{Re} = \frac{TDH_{Re} \rho}{144 \text{ in}^2 \text{ ft}^2} \]

\[ \Delta P_{Re} = 250 \text{ lb/in}^2 \]

6.3.2 Operating Point at Lowest Pipeline Design Pressure: 241-AY ALTERNATIVE 3

The lowest design pressure is 230 psi (See Attachment A). This is equivalent to the following Head:

\[ \Delta P_{DP} = 230 \text{ lb/in}^2 \]

\[ TDH_{DP} = \frac{144 \text{ in}^2}{\rho} \]

\[ TDH_{DP} = 354 \text{ ft} \]

From the above graph,

\[ Q_{DP} = 123 \text{ gpm} \]

Therefore, the velocity in the 3 inch lines is as follows.

Velocity:

\[ v_{DP-3in} = \frac{Q_{DP}}{A_{3in}} \]

\[ v_{DP-3in} = 5.3 \text{ ft/sec} \]
6.3.3 Operating Point at Reynolds Number > 20,000: 241-AY ALTERNATIVE 4

This operating point occurs at a flow rate of 130 gpm. From the above graph,

\[ Q_{Re} = 130 \text{ gpm} \quad \text{TDH}_{Re} = 390 \text{ ft} \]

Therefore, the pressure drop and velocity in the 3 inch lines are as follows.

**Velocity:**

\[ q_{Re} = \frac{Q_{Re} \cdot 0.13368 \cdot \frac{ft^3}{gal}}{60 \frac{sec}{min}} \quad q_{Re} = 0.29 \cdot \frac{ft^3}{sec} \]

\[ v_{Re,3in} = \frac{q_{Re}}{A_{3in}} \quad v_{Re,3in} = 5.6 \cdot \frac{ft}{sec} \]

**Pressure Drop:**

\[ \Delta P_{Re} = \frac{TDH_{Re} \rho}{144 \frac{in^2}{ft^2}} \quad \Delta P_{Re} = 253 \cdot \frac{lb}{in^2} \]

6.3.4 Operating Point at Lowest Pipeline Design Pressure: 241-AY ALTERNATIVE 4

The lowest design pressure is 230 psi (See Attachment A). This is equivalent to the following Head:

\[ \Delta P_{DP} = 230 \frac{lb}{in^2} \]

\[ \Delta P_{DP} \cdot 144 \frac{in^2}{ft^2} \]

\[ TDH_{DP} = \frac{\Delta P_{DP}}{\rho} \quad TDH_{DP} = 354 \cdot ft \]

From the above graph,

\[ Q_{DP} = 122 \text{ gpm} \]

Therefore, the velocity in the 3 inch lines is as follows.

**Velocity:**

\[ q_{DP} = \frac{Q_{DP} \cdot 0.13368 \cdot \frac{ft^3}{gal}}{60 \frac{sec}{min}} \quad q_{DP} = 0.27 \cdot \frac{ft^3}{sec} \]

\[ v_{DP,3in} = \frac{q_{DP}}{A_{3in}} \quad v_{DP,3in} = 5.3 \cdot \frac{ft}{sec} \]
HLW ALTERNATIVE 3
"NEW 3" LINES TO AX-B AND NEW SN-650 VALVE PIT"
HLW ALTERNATIVE 4
"NEW 3" LINES TO AX VALVE PITS AND A-A TO VENDOR"
2" SL-503,504,505
(AY-FARM)

241-AY-01A
PUMP PIT

U12
5.5' 7'

SL-505

U2
5.5'

U3

241-AY-01D
SLUICE PIT

241-AY-02A
PUMP PIT

SL-505

73.4'

SL-504

7'

EL 675.3

14.5'

SL-503

2.1'

U3

U8
4.5'

16.6'

241-AY-02D
SLUICE PIT

4'

4.9'

NOTE: ALL NOZZLES AT EL 675 UNLESS OTHERWISE NOTED

REFERENCES:
H-2-70764
H-2-64313
H-2-64314
B-131-C1

SUMMARY:

SL-503
SL-504
SL-505

LENGTH
11 FT
116 FT
18 FT

3' R BENDS
2
4
2

DESIGN:

PRESSURE
400 PSIG

TEMP
200 'F

PREPARED BY: T.R. SALZANO 4/5/96

CHECKED BY: [Signature] 4/5/96
2" SL-502

VALVE PIT REFERENCES:
- EL 682.1
- H-2-69245
- H-2-70763
- H-2-70764
- H-2-70780
- B-131-C1

SUMMARY:
- LENGTH 234.7 FT
- 3'R BENDS 5
- COBs 1
- REDUCERS 1

DESIGN:
- PRESSURE 400 PSIG
- TEMP 200 °F

PREPARED BY: T.B. SALZANO 4/5/96
CHECKED BY: [Signature] 4/5/96
REFERENCES:

H-2-69244
H-2-69241
H-2-69240
H-2-69184
H-2-70397
H-2-69188
B-102-C1

SUMMARY:

LENGTH 617.8 FT
3'R BENDS 15
45 3'R 2

DESIGN:

PRESSURE 230 PSIG
TEMP 330 °F

PREPARED BY: T.B. SALZANO 1/5/96
CHECKED BY: [Signature] 4/5/96
3" SN-201/214

REFERENCES:
H-2-69244
H-2-69241
H-2-69240
H-2-69184
H-2-70397
H-2-69188
B-102-C1

SUMMARY:
LENGTH 648.1 FT
3'R BENDS 17

DESIGN:
PRESSURE 230 PSIG
TEMP 330 °F

PREPARED BY: T.B. SALZANO 4/5/96
CHECKED BY: J.B. MCCLURE 4/5/96
3" SN-650

REFERENCES:
H-2-76984
H-2-76985
H-2-90545
H-2-90546
H-2-90554
B-340-C7

SUMMARY:
LENGTH 1333.7 FT
3'R BENDS 25

DESIGN:
PRESSURE 400 PSIG
TEMP 340 'F

PREPARED BY: T.B. SALZANO 4/5/96
CHECKED BY: JACOB WILKINSON 4/5/96
5.1.4 TOTAL HEAD LOSS: 241-AN ALTERNATIVE 3

**Process Pit Losses:**

\[ h_1 = h_{\text{pump\_pit}} + h_{\text{valve\_pits}} \]

**Transfer Path Losses:**

\[ h_2 = \frac{v^2}{2g} \sum_{i=1}^{3} K_i + \frac{v^2}{2g} \sum_{i=4}^{6} K_i \]

**Elevation Change:**

\[ h_3 = 50 \text{ ft} + z_{\text{end}} - z_{\text{start}} \]

**Total Head Loss:**

\[ TDH_{120\_alt3} = \sum_i h_i \]

\[ TDH_{120\_alt3} = 542 \text{ ft} \]

**Pressure Drop:**

\[ \Delta P_{120\_alt3} = \frac{TDH_{120\_alt3} \rho}{144 \frac{\text{in}^2}{\text{ft}^2}} \]

\[ \Delta P_{120\_alt3} = 352 \frac{\text{lb}}{\text{in}^2} \]

5.1.5 TOTAL HEAD LOSS: 241-AN ALTERNATIVE 4

**Process Pit Losses:**

\[ h_1 = h_{\text{pump\_pit}} + h_{\text{valve\_pits}} \]

**Transfer Path Losses:**

\[ h_2 = \frac{v^2}{2g} \sum_{i=1}^{8} K_i \]

**Elevation Change:**

\[ h_3 = 50 \text{ ft} + z_{\text{end}} - z_{\text{start}} \]

**Total Head Loss:**

\[ TDH_{120\_alt4} = \sum_i h_i \]

\[ TDH_{120\_alt4} = 259 \text{ ft} \]

**Pressure Drop:**

\[ \Delta P_{120\_alt4} = \frac{TDH_{120\_alt4} \rho}{144 \frac{\text{in}^2}{\text{ft}^2}} \]

\[ \Delta P_{120\_alt4} = 168 \frac{\text{lb}}{\text{in}^2} \]
5.2 100 GPM: 241-AN

5.2.1 Constant Data

Volumetric Flow Rate,

\[ Q_{100} = \frac{100 \text{gal}}{\text{min}} \]

\[ Q_{100} = 0.13368 \text{ft}^3/\text{gal} \]

\[ q = \frac{Q_{100} \times 0.13368 \text{ft}^3}{60 \text{sec/min}} \]

\[ q = 0.22 \text{ft}^3/\text{sec} \]

Velocity of Flow,

\[ v_{2\text{in}} = \frac{q}{A_{2\text{in}}} \]

\[ v_{2\text{in}} = 9.6 \text{ft/sec} \]

\[ v_{3\text{in}} = \frac{q}{A_{3\text{in}}} \]

\[ v_{3\text{in}} = 4.3 \text{ft/sec} \]

Reynolds Number,

\[ Re_{2\text{in}} = \frac{D_{2\text{in}} v_{2\text{in}}}{\mu_e} \]

\[ Re_{2\text{in}} = 22928 \]

\[ Re_{3\text{in}} = \frac{D_{3\text{in}} v_{3\text{in}}}{\mu_e} \]

\[ Re_{3\text{in}} = 15447 \]

Friction Factor (Ref. Crane, Page A-25 and A-26),

\[ f_{2\text{in}} = 0.027 \]

\[ f_{2\text{in}} = 0.019 \]

\[ f_{3\text{in}} = 0.029 \]

\[ f_{3\text{in}} = 0.018 \]

Bernoulli's Theorem,

\[ z_1 + \frac{144 P_1}{\rho_1} + \frac{v_1^2}{2g} = z_2 + \frac{144 P_2}{\rho_2} + \frac{v_2^2}{2g} + h_L \]
5.2.2 PROCESS PIT HEAD LOSSES

5.2.2.1 AN-Farm Pump Pit

10.0 ft - 3" Pipe Length: \( L_1 = 10 \text{ ft} \)

\[ K_1 = \frac{f_{3\text{in}} \cdot \frac{L_1}{D_{3\text{in}}}} {K_{3\text{in}}} \]

\( K_1 = 1.1 \)

2 - 3" Connectors (assume 90 Mitre Bend):

\( K_2 = \frac{(60 f_{T3\text{in}})}{2} \)

\( K_2 = 2.2 \)

2 - 3" Long Radius Elbow:

\( K_3 = \frac{(14 f_{T3\text{in}})}{2} \)

\( K_3 = 0.5 \)

1 - 3" 3-Way Ball Valve (assume 90 Mitre Bend):

\( K_4 = \frac{(60 f_{T3\text{in}})}{1} \)

\( K_4 = 1.1 \)

Head Loss for Pump Pit:

\[ h_{\text{pump pit}} = \frac{v_{3\text{in}}^2}{2g} \sum_{i=1}^{4} K_i \]

\[ h_{\text{pump pit}} = 1.4 \text{ ft} \]

5.2.2.2 Valve Pits

10.0 ft - 3" Pipe Length: \( L_1 = 10 \text{ ft} \)

\[ K_1 = \frac{f_{3\text{in}} \cdot \frac{L_1}{D_{3\text{in}}}} {K_{3\text{in}}} \]

\( K_1 = 1.1 \)

4 - 3" Connectors (assume 90 Mitre Bend):

\[ K_2 = \frac{(60 f_{T3\text{in}})}{4} \]

\( K_2 = 4.3 \)

4 - 3" Long Radius Elbow:

\[ K_3 = \frac{(14 f_{T3\text{in}})}{4} \]

\( K_3 = 1 \)

2 - 3" 3-Way Ball Valve (assume 90 Mitre Bend):

\[ K_4 = \frac{(60 f_{T3\text{in}})}{2} \]

\( K_4 = 2.2 \)

Head Loss for each Pit:

\[ h_{\text{pits}} = \frac{v_{3\text{in}}^2}{2g} \sum_{i=1}^{4} K_i \]

\( h_{\text{pits}} = 2.5 \text{ ft} \)

Head Loss for all seven valve pits:

\[ h_{\text{valve pits}} = 7 \cdot h_{\text{pits}} \]

\[ h_{\text{valve pits}} = 17.7 \text{ ft} \]
5.2.3 TRANSFER LINE HEAD LOSSES

2" Pipe Length (Alternative 3):

\[ L_{2\text{in}} = 389.4 \text{ ft} + 530 \text{ ft} \]

\[ K_1 = \frac{f_{2\text{in}} L_{2\text{in}}}{D_{2\text{in}}} \]

\[ K_1 = 144.1 \]

2" Pipe - 36" Radius Bends (r/d=18) (Alternative 3):

\[ N_{2\text{in\_bends}} = 9 + 14 \]

\[ K_2 = \left(46 f_{2\text{in}} T_{2\text{in}}\right) N_{2\text{in\_bends}} \]

\[ K_2 = 20.1 \]

Clean-Out Boxes (COB) (assume Tee - thru) (Alternative 3):

\[ N_{\text{COB}} = 3 + 5 \]

\[ K_3 = \left(20 f_{2\text{in}} T_{2\text{in}}\right) N_{\text{COB}} \]

\[ K_3 = 3 \]

3" Pipe Length (Alternative 3):

\[ L_{3\text{in}} = 222.4 \text{ ft} + 7 \text{ ft} + 6 \text{ ft} + 618 \text{ ft} + 1334 \text{ ft} + 235 \text{ ft} \]

\[ K_4 = \frac{f_{3\text{in}} L_{3\text{in}}}{D_{3\text{in}}} \]

\[ K_4 = 274.7 \]

3" Pipe - 36" Radius Bends (r/d=12) (Alternative 3):

\[ N_{3\text{in\_bends}} = 5 + 4 + 4 + 15 + 25 + 5 \]

\[ K_5 = \left(34 f_{3\text{in}} T_{3\text{in}}\right) N_{3\text{in\_bends}} \]

\[ K_5 = 35.5 \]

3" Pipe - 36" Radius 45 Bends (r/d=12):

\[ K_6 = \left[0.5 - 1 \right] \left[0.25 f_{3\text{in}} T_{3\text{in}}^{12} + 0.5 \left(34 f_{3\text{in}} T_{3\text{in}}\right) \right]^{2} \]

\[ K_6 = 0.7 \]

3" Pipe Length (Alternative 4):

\[ L_{3\text{in}} = 222.4 \text{ ft} + 7 \text{ ft} + 389.4 \text{ ft} + 530 \text{ ft} + 6 \text{ ft} + 618 \text{ ft} + 1334 \text{ ft} + 235 \text{ ft} \]

\[ K_7 = \frac{f_{3\text{in}} L_{3\text{in}}}{D_{3\text{in}}} \]

\[ K_7 = 379 \]

3" Pipe - 36" Radius Bends (r/d=12) (Alternative 4):

\[ N_{3\text{in\_bends}} = 5 + 4 + 9 + 14 + 4 + 15 + 25 + 5 \]

\[ K_8 = \left(34 f_{3\text{in}} T_{3\text{in}}\right) N_{3\text{in\_bends}} \]

\[ K_8 = 49.6 \]
5.2.4 TOTAL HEAD LOSS: 241-AN ALTERNATIVE 3

**Process Pit Losses:**

\[ h_1 = h_{\text{pump pit}} + h_{\text{valve pits}} \]

\[ h_1 = 19 \text{ ft} \]

**Transfer Path Losses:**

\[ h_2 = \frac{v^2}{2g} \left( \sum_i h_i \right) + \frac{v^2}{2g} \left( \sum_i K_i \right) \]

\[ h_2 = 329 \text{ ft} \]

**Elevation Change:**

\[ h_3 = 50 \text{ ft} + z_{\text{end}} - z_{\text{start}} \]

\[ h_3 = 58.9 \text{ ft} \] (Assumption 2)

**Total Head Loss:**

\[ TDH_{100_{\text{alt3}}} = \sum_i h_i \]

\[ TDH_{100_{\text{alt3}}} = 407 \text{ ft} \]

**Pressure Drop:**

\[ \Delta P_{100_{\text{alt3}}} = \frac{TDH_{100_{\text{alt3}}}}{144 \text{ in}^2/\text{ft}^2} \]

\[ \Delta P_{100_{\text{alt3}}} = 264 \text{ lb/in}^2 \]

5.2.5 TOTAL HEAD LOSS: 241-AN ALTERNATIVE 4

**Process Pit Losses:**

\[ h_1 = h_{\text{pump pit}} + h_{\text{valve pits}} \]

\[ h_1 = 19 \text{ ft} \]

**Transfer Path Losses:**

\[ h_2 = \frac{v^2}{2g} \left( \sum_i h_i \right) \]

\[ h_2 = 126 \text{ ft} \]

**Elevation Change:**

\[ h_3 = 50 \text{ ft} + z_{\text{end}} - z_{\text{start}} \]

\[ h_3 = 58.9 \text{ ft} \] (Assumption 2)

**Total Head Loss:**

\[ TDH_{100_{\text{alt4}}} = \sum_i h_i \]

\[ TDH_{100_{\text{alt4}}} = 206 \text{ ft} \]

**Pressure Drop:**

\[ \Delta P_{100_{\text{alt4}}} = \frac{TDH_{100_{\text{alt4}}}}{144 \text{ in}^2/\text{ft}^2} \]

\[ \Delta P_{100_{\text{alt4}}} = 132 \text{ lb/in}^2 \]

A-230
5.3 80 GPM: 241-AN

5.3.1 Constant Data

Volumetric Flow Rate,

\[ Q_{80} = 80 \text{ gal/min} \]

\[ Q_{80} = 0.13368 \text{ ft}^3/\text{min} \]

\[ q = \frac{Q_{80}}{60 \text{ sec/min}} \]

\[ q = 0.18 \text{ ft}^3/\text{sec} \]

Velocity of Flow,

\[ v_{2\text{in}} = \frac{q}{A_{2\text{in}}} \]

\[ v_{2\text{in}} = 7.6 \text{ ft/sec} \]

\[ v_{3\text{in}} = \frac{q}{A_{3\text{in}}} \]

\[ v_{3\text{in}} = 3.5 \text{ ft/sec} \]

Reynolds Number,

\[ Re_{2\text{in}} = \frac{D_{2\text{in}} \cdot v_{2\text{in}} \cdot \rho}{\mu_e} \]

\[ Re_{2\text{in}} = 18343 \]

\[ Re_{3\text{in}} = \frac{D_{3\text{in}} \cdot v_{3\text{in}} \cdot \rho}{\mu_e} \]

\[ Re_{3\text{in}} = 12358 \]

Friction Factor (Ref. Crane, Page A-25 and A-26),

\[ f_{2\text{in}} = 0.028 \]

\[ f_{2\text{in}} = 0.019 \]

\[ f_{3\text{in}} = 0.03 \]

\[ f_{3\text{in}} = 0.018 \]

Bernoulli's Theorem,

\[ z_1 + \frac{144 \cdot P_1}{\rho_1} + \frac{v_1^2}{2g} + z_2 + \frac{144 \cdot P_2}{\rho_2} + \frac{v_2^2}{2g} + h_L \]
5.3.2 PROCESS PIT HEAD LOSSES

5.3.2.1 AN-Farm Pump Pit

10.0 ft - 3" Pipe Length: $L_1 = 10 \text{ ft}$

$$K_1 = f_{3in} \frac{L_1}{D_{3in}}$$

$K_1 = 1.2$

2 - 3" Connectors (assume 90 Mitre Bend):

$$K_2 = (60 - f_{T3in})^{-2}$$

$K_2 = 2.2$

2 - 3" Long Radius Elbow:

$$K_3 = \left(14 - f_{T3in}\right)^{-2}$$

$K_3 = 0.5$

1 - 3" 3-Way Ball Valve (assume 90 Mitre Bend):

$$K_4 = (60 - f_{T3in})^{-1}$$

$K_4 = 1.1$

Head Loss for pump pit:

$$h_{pump\_pit} = \frac{v_{3in}^2}{2g} \sum_{i=1}^{4} K_i$$

$$h_{pump\_pit} = 0.9 \text{ ft}$$

5.3.2.2 Valve Pits

10.0 ft - 3" Pipe Length: $L_1 = 10 \text{ ft}$

$$K_1 = f_{3in} \frac{L_1}{D_{3in}}$$

$K_1 = 1.2$

4 - 3" Connectors (assume 90 Mitre Bend):

$$K_2 = (60 - f_{T3in})^{-4}$$

$K_2 = 4.3$

4 - 3" Long Radius Elbow:

$$K_3 = \left(14 - f_{T3in}\right)^{-4}$$

$K_3 = 1$

2 - 3" 3-Way Ball Valve (assume 90 Mitre Bend):

$$K_4 = (60 - f_{T3in})^{-2}$$

$K_4 = 2.2$

Head Loss for each pit: $h_{pits} = \frac{v_{3in}^2}{2g} \sum_{i=1}^{4} K_i$

$$h_{pits} = 1.6 \text{ ft}$$

Head Loss for all seven valve pits:

$$h_{valve\_pits} = 7 \times h_{pits}$$

$$h_{valve\_pits} = 11.4 \text{ ft}$$
ICF Kaiser Hanford

DESIGN ANALYSIS

Client: WHC
Subject: Head Loss Calculations for LLW Feed from 241-AN Tanks (Alternative 3 and 4)
Location: 200 East

5.3.3 TRANSFER LINE HEAD LOSSES

2" Pipe Length (Alternative 3):

\[ L_{2in} = 389 \text{ ft} + 530 \text{ ft} \]

\[ K_1 = \frac{f_{2in} L_{2in}}{D_{2in}} \quad K_1 = 149.4 \]

2" Pipe - 36" Radius Bends (r/d=18) (Alternative 3):

\[ N_{2in\text{bends}} = 9 + 14 \]

\[ K_2 = (46 \cdot f_{T2in}) \cdot N_{2in\text{bends}} \quad K_2 = 20.1 \]

Clean-Out Boxes (COB) (assume Tee - thru) (Alternative 3):

\[ N_{COB} = 3 + 5 \]

\[ K_3 = (20 \cdot f_{T2in}) \cdot N_{COB} \quad K_3 = 3 \]

3" Pipe Length (Alternative 3):

\[ L_{3in} = 222 \text{ ft} + 7 \text{ ft} + 6 \text{ ft} + 618 \text{ ft} + 1334 \text{ ft} + 235 \text{ ft} \]

\[ K_4 = \frac{f_{3in} L_{3in}}{D_{3in}} \quad K_4 = 284.2 \]

3" Pipe - 36" Radius Bends (r/d=12) (Alternative 3):

\[ N_{3in\text{bends}} = 5 + 4 + 4 + 15 - 25 + 5 \]

\[ K_5 = (34 \cdot f_{T3in}) \cdot N_{3in\text{bends}} \quad K_5 = 35.5 \]

3" Pipe - 36" Radius 45 Bends (r/d=12):

\[ K_6 = \left( \frac{1}{2} \right) \left( 0.25 \cdot \frac{f_{T3in}}{L_{3in}} \right)^{1/2} + 34 \cdot f_{T3in} \]

\[ K_6 = 0.7 \]

3" Pipe Length (Alternative 4):

\[ L_{3in} = 222 \text{ ft} + 7 \text{ ft} + 389 \text{ ft} + 530 \text{ ft} + 6 \text{ ft} + 618 \text{ ft} + 1334 \text{ ft} + 235 \text{ ft} \]

\[ K_7 = \frac{f_{3in} L_{3in}}{D_{3in}} \quad K_7 = 392 \]

3" Pipe - 36" Radius Bends (r/d=12) (Alternative 4):

\[ N_{3in\text{bends}} = 5 + 4 + 9 + 14 + 4 + 15 + 25 + 5 \]

\[ K_8 = (34 \cdot f_{T3in}) \cdot N_{3in\text{bends}} \quad K_8 = 49.6 \]
5.3.4 TOTAL HEAD LOSS: 241-AN ALTERNATIVE 3

Process Pit Losses:
\[ h_1 = h_{\text{pump pit}} + h_{\text{valve pits}} \]

\( h_1 = 12 \text{-ft} \)

Transfer Path Losses:
\[ h_2 = \frac{v^2}{2g} \sum_{i=1}^{3} K_i + \frac{v^3}{2g} \sum_{i=4}^{6} K_i \]

\( h_2 = 217 \text{-ft} \)

Elevation Change:
\[ h_3 = 50 \text{ ft} + z_{\text{end}} - z_{\text{start}} \]

\( h_3 = 58.9 \text{-ft} \) (Assumption 2)

Total Head Loss:
\( \sum_{i=1}^{3} h_i \)

\[ \text{TDH}_{80\_alt3} = 288 \text{-ft} \]

Pressure Drop:
\[ \Delta P_{80\_alt3} = \frac{\text{TDH}_{80\_alt3} \cdot \rho}{144 \text{ in}^2 / \text{ft}^2} \]

\( \Delta P_{80\_alt3} = 187 \frac{\text{lb}}{\text{in}^2} \)

5.3.5 TOTAL HEAD LOSS: 241-AN ALTERNATIVE 4

Process Pit Losses:
\[ h_1 = h_{\text{pump pit}} + h_{\text{valve pits}} \]

\( h_1 = 12 \text{-ft} \)

Transfer Path Losses:
\[ h_2 = \frac{v^2}{2g} \sum_{i=1}^{8} K_i \]

\( h_2 = 83 \text{-ft} \)

Elevation Change:
\[ h_3 = 50 \text{ ft} + z_{\text{end}} - z_{\text{start}} \]

\( h_3 = 58.9 \text{-ft} \) (Assumption 2)

Total Head Loss:
\( \sum_{i=1}^{3} h_i \)

\[ \text{TDH}_{80\_alt4} = 154 \text{-ft} \]

Pressure Drop:
\[ \Delta P_{80\_alt4} = \frac{\text{TDH}_{80\_alt4} \cdot \rho}{144 \text{ in}^2 / \text{ft}^2} \]

\( \Delta P_{80\_alt4} = 100 \frac{\text{lb}}{\text{in}^2} \)
5.4 60 GPM: 241-AN

5.4.1 Constant Data

Volumetric Flow Rate,

\[ Q_{60} = 60 \frac{\text{gal}}{\text{min}} \]

\[ q = 60 \cdot 0.13368 \frac{\text{ft}^3}{\text{gal}} \]

Velocity of Flow,

\[ v_{2\text{in}} = \frac{q}{A_{2\text{in}}} \]

\[ v_{2\text{in}} = 5.7 \frac{\text{ft}}{\text{sec}} \]

\[ v_{3\text{in}} = 2.6 \frac{\text{ft}}{\text{sec}} \]

Reynolds Number,

\[ \text{Re}_{2\text{in}} = \frac{D_{2\text{in}} v_{2\text{in}} \rho}{\mu_c} \]

\[ \text{Re}_{2\text{in}} = 13757 \]

\[ \text{Re}_{3\text{in}} = \frac{D_{3\text{in}} v_{3\text{in}} \rho}{\mu_c} \]

\[ \text{Re}_{3\text{in}} = 9268 \]

Friction Factor (Ref. Crane, Page A-25 and A-26),

\[ f_{2\text{in}} = 0.03 \]

\[ f_{2\text{in}} = 0.019 \]

\[ f_{3\text{in}} = 0.032 \]

\[ f_{3\text{in}} = 0.018 \]

Bernoulli's Theorem,

\[ z_1 + \frac{144 P_1}{\rho_1} + \frac{v_1^2}{2g} = z_2 + \frac{144 P_2}{\rho_2} + \frac{v_2^2}{2g} + h_L \]
5.4.2 PROCESS PIT HEAD LOSSES

5.4.2.1 AN-Farm Pump Pit

10.0 ft - 3" Pipe Length: \( L_1 = 10 \text{ ft} \)
\[ K_1 = f_{3\text{in}} \frac{L_1}{D_{3\text{in}}} \]
\[ K_1 = 1.3 \]

2 - 3" Connectors (assume 90 Mitre Bend):
\[ K_2 = \left( \frac{60 \text{ ft}}{3\text{in}} \right)^2 \]
\[ K_2 = 2.2 \]

2 - 3" Long Radius Elbow:
\[ K_3 = \left( \frac{14 \text{ ft}}{3\text{in}} \right)^2 \]
\[ K_3 = 0.5 \]

1 - 3" 3-Way Ball Valve (assume 90 Mitre Bend):
\[ K_4 = \left( \frac{60 \text{ ft}}{3\text{in}} \right)^2 \]
\[ K_4 = 4.3 \]

Head Loss for pump pit:
\[ h_{\text{pump pit}} = \frac{v_{3\text{in}}^2}{2g} \sum_{i=1}^{4} K_i \]
\[ h_{\text{pump pit}} = 0.5 \text{ ft} \]

5.4.2.2 Valve Pits

10.0 ft - 3" Pipe Length: \( L_1 = 10 \text{ ft} \)
\[ K_1 = f_{3\text{in}} \frac{L_1}{D_{3\text{in}}} \]
\[ K_1 = 1.3 \]

4 - 3" Connectors (assume 90 Mitre Bend):
\[ K_2 = \left( \frac{60 \text{ ft}}{3\text{in}} \right)^4 \]
\[ K_2 = 4.3 \]

4 - 3" Long Radius Elbow:
\[ K_3 = \left( \frac{14 \text{ ft}}{3\text{in}} \right)^4 \]
\[ K_3 = 1 \]

2 - 3" 3-Way Ball Valve (assume 90 Mitre Bend):
\[ K_4 = \left( \frac{60 \text{ ft}}{3\text{in}} \right)^2 \]
\[ K_4 = 2.2 \]

Head Loss for each pit:
\[ h_{\text{pits}} = \frac{v_{3\text{in}}^2}{2g} \sum_{i=1}^{4} K_i \]
\[ h_{\text{pits}} = 0.9 \text{ ft} \]

Head Loss for all seven valve pits:
\[ h_{\text{valve pits}} = 7 \cdot h_{\text{pits}} \]
\[ h_{\text{valve pits}} = 6.4 \text{ ft} \]
5.4.3 TRANSFER LINE HEAD LOSSES

2" Pipe Length (Alternative 3):
\[ L_{2\text{in}} = 389 \text{ ft} + 530 \text{ ft} \]
\[ K_1 = f_{2\text{in}} \frac{L_{2\text{in}}}{D_{2\text{in}}} \]
\[ K_1 = 160.1 \]

2" Pipe - 36" Radius Bends (r/d=18) (Alternative 3):
\[ N_{2\text{in}_\text{bends}} = 9 + 14 \]
\[ K_2 = \left( 46 \cdot f_{T2\text{in}} \right) \frac{N_{2\text{in}_\text{bends}}}{N_{2\text{in}_\text{bends}}} \]
\[ K_2 = 20.1 \]

Clean-Out Boxes (COB) (assume Tee - thru) (Alternative 3):
\[ N_{COB} = 3 + 5 \]
\[ K_3 = \left( 20 \cdot f_{T2\text{in}} \right) N_{COB} \]
\[ K_3 = 3 \]

3" Pipe Length (Alternative 3):
\[ L_{3\text{in}} = 222 \text{ ft} + 7 \text{ ft} + 6 \text{ ft} + 618 \text{ ft} + 1334 \text{ ft} + 235 \text{ ft} \]
\[ K_4 = f_{3\text{in}} \frac{L_{3\text{in}}}{D_{3\text{in}}} \]
\[ K_4 = 303.1 \]

3" Pipe - 36" Radius Bends (r/d=12) (Alternative 3):
\[ N_{3\text{in}_\text{bends}} = 5 + 4 + 4 + 15 + 25 + 5 \]
\[ K_5 = \left( 34 \cdot f_{T3\text{in}} \right) N_{3\text{in}_\text{bends}} \]
\[ K_5 = 35.5 \]

3" Pipe - 36" Radius 45 Bends (r/d=12):
\[ K_6 = \left( 0.5 - 1 \right) \left[ 0.25 \cdot \pi f_{T3\text{in}} \cdot 12 - 0.5 \cdot \left( 34 \cdot f_{T3\text{in}} \right) + 34 \cdot f_{T3\text{in}} \right]^2 \]
\[ K_6 = 0.7 \]

3" Pipe Length (Alternative 4):
\[ L_{3\text{in}} = 222 \text{ ft} + 7 \text{ ft} + 389 \text{ ft} + 530 \text{ ft} + 6 \text{ ft} + 618 \text{ ft} + 1334 \text{ ft} + 235 \text{ ft} \]
\[ K_7 = f_{3\text{in}} \frac{L_{3\text{in}}}{D_{3\text{in}}} \]
\[ K_7 = 418.2 \]

3" Pipe - 36" Radius Bends (r/d=12) (Alternative 4):
\[ N_{3\text{in}_\text{bends}} = 5 + 4 + 9 + 14 + 4 + 15 + 25 + 5 \]
\[ K_8 = \left( 34 \cdot f_{T3\text{in}} \right) N_{3\text{in}_\text{bends}} \]
\[ K_8 = 49.6 \]
5.4.4 TOTAL HEAD LOSS: 241-AN ALTERNATIVE 3

Process Pit Losses:
\[ h_1 = h_{pump\_pit} + h_{valve\_pits} \]
\[ h_1 = 7 \text{ ft} \]

Transfer Path Losses:
\[ h_2 = \frac{v^2}{2g} \sum_{i=1}^{3} K_i + \frac{v'^2}{2g} \sum_{i=4}^{6} K_i \]
\[ h_2 = 129 \text{ ft} \]

Elevation Change:
\[ h_3 = 50 \text{ ft} + z_{end} - z_{start} \]
\[ h_3 = 58.9 \text{ ft} \] (Assumption 2)

Total Head Loss:
\[ i = 1, 2..3 \]
\[ \text{TDH}_{60\_alt3} = \sum_i h_i \]
\[ \text{TDH}_{60\_alt3} = 195 \text{ ft} \]

Pressure Drop:
\[ \Delta P_{60\_alt3} = \frac{\text{TDH}_{60\_alt3} \rho}{144 \text{ in}^2 \text{ ft}^2} \]
\[ \Delta P_{60\_alt3} = 127 \text{ lb in}^2 \]

5.4.5 TOTAL HEAD LOSS: 241-AN ALTERNATIVE 4

Process Pit Losses:
\[ h_1 = h_{pump\_pit} + h_{valve\_pits} \]
\[ h_1 = 7 \text{ ft} \]

Transfer Path Losses:
\[ h_2 = \frac{v^2}{2g} \sum_{i=6}^{8} K_i \]
\[ h_2 = 49 \text{ ft} \]

Elevation Change:
\[ h_3 = 50 \text{ ft} + z_{end} - z_{start} \]
\[ h_3 = 58.9 \text{ ft} \] (Assumption 2)

Total Head Loss:
\[ i = 1, 2..3 \]
\[ \text{TDH}_{60\_alt4} = \sum_i h_i \]
\[ \text{TDH}_{60\_alt4} = 115 \text{ ft} \]

Pressure Drop:
\[ \Delta P_{60\_alt4} = \frac{\text{TDH}_{60\_alt4} \rho}{144 \text{ in}^2 \text{ ft}^2} \]
\[ \Delta P_{60\_alt4} = 75 \text{ lb in}^2 \]
ICF Kaiser Hanford

DESIGN ANALYSIS

Client: WHC
Subject: Head Loss Calculations for LLW
Feed from 241-AN Tanks (Alternative 3 and 4)
Location: 200 East

6.0 SYSTEM CURVE

The system curve can now be generated. The curve will be used to determine different possible operating points for the system. A pump could than be selected to meet the needed operating requirements. The main operating points to be considered are at a Reynolds number of 20,000 and at the design pressure limit of the system.

6.1 SYSTEM CURVE DATA: 241-AN

The system curve for the 241-AN-104 Tank transfers to the 241-AP-102 Feed Staging Tank can now be generated.

Flow Rate:

\[ Q = \begin{bmatrix} Q_{60} \\ Q_{80} \\ Q_{100} \\ Q_{120} \\ Q_{140} \end{bmatrix} \]

Total Head:

\[ TDH_{an\_alt3} = \begin{bmatrix} TDH_{60\_alt3} \\ TDH_{80\_alt3} \\ TDH_{100\_alt3} \\ TDH_{120\_alt3} \\ TDH_{140\_alt3} \end{bmatrix} \quad TDH_{an\_alt4} = \begin{bmatrix} TDH_{60\_alt4} \\ TDH_{80\_alt4} \\ TDH_{100\_alt4} \\ TDH_{120\_alt4} \\ TDH_{140\_alt4} \end{bmatrix} \]
6.2 SYSTEM CURVE

\[ i = 0.4 \]

LLW Transfers from 241-AN-104 to 241-AP-104 (Alternative 3 and 4)

![Diagram showing system curve with flow (gpm) vs. head (ft) for LLW transfers from 241-AN-104 to 241-AP-104. The curves represent different alternatives, with 241-AN (Alternative 3) and 241-AN (Alternative 4). The system design pressure is indicated.]
6.3 SPECIFIC POINTS

6.3.1 Operating Point at Reynolds Number > 20,000: 241-AN ALTERNATIVE 3

This operating point occurs at a flow rate of 130 gpm. From the above graph,
\[ Q_{Re} = 130 \text{ gpm} \]
\[ TDH_{Re} = 630 \text{ ft} \]

Therefore, the pressure drop and velocity in the 3 inch lines are as follows.

**Velocity:**
\[ q_{Re} = \frac{Q_{Re}}{60 \text{ sec/min}} \]
\[ q_{Re} = 0.29 \left( \frac{\text{ft}^3}{\text{sec}} \right) \]
\[ v_{Re\_3in} = \frac{q_{Re}}{A_{3in}} \]
\[ v_{Re\_3in} = 5.6 \left( \frac{\text{ft}}{\text{sec}} \right) \]

**Pressure Drop:**
\[ \Delta P_{Re} = \frac{TDH_{Re} \rho}{144 \left( \frac{\text{in}^2}{\text{ft}^2} \right)} \]
\[ \Delta P_{Re} = 409 \left( \frac{\text{lb}}{\text{in}^2} \right) \]

6.3.2 Operating Point at Lowest Pipeline Design Pressure: 241-AN ALTERNATIVE 3

The lowest design pressure is 230 psi (See Attachment A). This is equivalent to the following head:
\[ \Delta P_{DP} = 230 \left( \frac{\text{lb}}{\text{in}^2} \right) \]
\[ \Delta P_{DP} \cdot 144 \left( \frac{\text{in}^2}{\text{ft}^2} \right) \]
\[ TDH_{DP} = \frac{\Delta P_{DP}}{\rho} \]
\[ TDH_{DP} = 354 \text{ ft} \]

From the above graph,
\[ Q_{DP} = 91 \text{ gpm} \]

Therefore, the velocity in the 3 inch lines is as follows.

**Velocity:**
\[ q_{DP} = \frac{Q_{DP}}{60 \text{ sec/min}} \]
\[ q_{DP} = 0.2 \left( \frac{\text{ft}^3}{\text{sec}} \right) \]
\[ v_{DP\_3in} = \frac{q_{DP}}{A_{3in}} \]
\[ v_{DP\_3in} = 3.9 \left( \frac{\text{ft}}{\text{sec}} \right) \]
6.3.3 Operating Point at Reynolds Number > 20,000: 241-AN ALTERNATIVE 4

This operating point occurs at a flow rate of 130 gpm. From the above graph,

\[ Q_{Re} = 130 \text{ gpm} \]

\[ \text{TDH}_{Re} \approx 295 \text{ ft} \]

Therefore, the pressure drop and velocity in the 3 inch lines are as follows.

**Velocity:**

\[ \frac{Q_{Re}}{A_{3\text{in}}} \cdot \frac{0.13368 \text{ ft}^3}{60 \text{ min}} = q_{Re} \]

\[ q_{Re} = 0.29 \cdot \frac{\text{ft}^3}{\text{sec}} \]

\[ v_{Re_{3\text{in}}} = \frac{q_{Re}}{A_{3\text{in}}} \]

\[ v_{Re_{3\text{in}}} = 5.6 \cdot \frac{\text{ft}}{\text{sec}} \]

**Pressure Drop:**

\[ \Delta P_{Re} = \frac{\text{TDH}_{Re} \cdot p}{144 \cdot \text{in}^2} \]

\[ \Delta P_{Re} = 192 \cdot \frac{\text{lb}}{\text{in}^2} \]

6.3.4 Operating Point at Lowest Pipeline Design Pressure: 241-AN ALTERNATIVE 4

The lowest design pressure is 230 psi (See Attachment A). The operating point of this system at the minimum Reynolds of 20,000 is below this design pressure requirement.
LLW ALTERNATIVE 3
"NEW SN-650 VALVE PIT"

LEGEND
- EXISTING ROUTE
- NEW VALVE PIT AND TRANSFER LINES

Attachment A
Page A1 of A7
LLW ALTERNATIVE 4
"NEW 3" LINE AND VALVE PIT"
REFERENCES:

H-2-69244
H-2-69241
H-2-69240
H-2-69184
H-2-70397
H-2-69188
B-102-C1

SUMMARY:

LENGTH
3' R BENDS
45 3' R

DESIGN:

PRESSURE 230 PSIG
TEMP 330 °F

PREPARED BY: T.B. SALZANO 4/5/96
CHECKED BY: [Signature] 4/5/96
3" SN-650

REFERENCES:

- H-2-76984
- H-2-76985
- H-2-90545
- H-2-90546
- H-2-90554
- B-340-C7

SUMMARY:

- LENGTH 1333.7 FT
- 3'R BENDS 25
- PRESSURE 400 PSIG
- TEMP 340 °F

DESIGN:

- PRESSURE 400 PSIG
- TEMP 340 °F

PREPARED BY: T.B. SALZANO 4/5/96

CHECKED BY: J.K. WILSON 4/5/96
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APPENDIX B

JUMPER MANIFOLD DESIGN
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APPENDIX B
JUMPER MANIFOLD DESIGN

B1.0 INTRODUCTION

The increase in the number of transfers to support Phase I privatization, 242-A Evaporator campaigns, and tank farm operations will require the elimination of the jumper changes to configure a new transfer route. Under the current operational mode, each time a different waste transfer route is required, valve pit cover blocks are removed, an individual jumper is physically disconnected, a different jumper is installed and the desired waste transfer piping configuration is obtained. The cover blocks are then reinstalled and operations proceed. This method of aligning waste transfer piping requires entry into the valve pits exposing workers to high radiation levels and is very expensive.

To support the schedule and flexibility requirements needed for the Phase I privatization transfer system, valve manifolds designs have been provided. These designs support the recommended low-level waste and high-level waste options. Installation of jumper manifolds will benefit regular double-shell tanks (DSTs) waste transfer operations, current and future evaporator campaigns and future waste management and retrieval operations.

B2.0 JUMPER MANIFOLDS

Jumper manifold designs are provided to support waste transfer operations in the following process pits: The 241-AN-A Valve Pit (VP), the 241-AN-B VP, the 241-AZ-02A Pump Pit, the 241-AX-A VP, the 241-AX-B VP, the 241-A-A VP, and the 241-A-B VP. Project W-454 is currently responsible for providing jumper manifolds for the 241-AW-A VP and 241-AW-B VP. The manifolds are constructed of stainless steel valves and piping to facilitate decontamination and to ensure long-term reliability. The manifolds provide all necessary waste routing configurations by manual operation of valve handles that would extend through the pit cover blocks. The seven jumper manifold designs are shown in Figures B2-1 through B2-7. Figure B2-8 shows an isometric of the 241-AN-A VP manifold.

The jumper manifold designs provide the following:

- Two-valve isolation from piping outside the desired flow path.
- Avoid trapping of liquids.
- The ability to cross-connect the slurry and supernate transfer piping lines.
- The ability to flush all flow paths.
New cover blocks would be required on each of the process pits. The new cover blocks will accept the valve operating extension handles.

**B3.0 COST**

The cost estimate for each of the jumper manifold designs include the cost for decontamination, removal and disposal of the existing pit jumpers, and new cover blocks. The total estimated cost for the seven jumper manifolds is $6.8 million. The detail cost estimate is provided in Appendix C. Table B3-1 shows the cost of the jumper manifolds per process pit.

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Figure B2-2. 241-AN-B Valve Pit Arrangement.
Figure B2-4. 241-AX-A Valve Pit Arrangement.
Figure B2-5. 241-AX-B Valve Pit Arrangement.
Figure B2-8. 241-AN-A Valve Pit Isometric.
### General Requirements

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** IEST - INTERACTIVE ESTIMATING **  
** PHASE I PRIVATIZATION ALTERNATIVES STUDY - OPTION 6 **

** DOE_401 - PROJECT COST SUMMARY **

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** DATE 04/21/96 14:41:24 **

** REMARKS: **

CHaEK

(Rounded/Adjusted to the Nearest * 10,000 / 100,000 * - Percentages Not Recalculated to Reflect Rounding)
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1. DOCUMENTS AND DRAWINGS

**DOCUMENTS:** DSI FROM T. SALZANO REQUESTING ESTIMATES FOR PHASE I PRIVATIZATION ALTERNATIVES DATED 5/20/96.

**DRAWINGS:** ATTACHMENT A, B & C TO DSI.

2. LABOR RATES


B.) BASE CRAFT RATES ARE AS ISSUED BY KEH FINANCE (EFFECTIVE 10-01-95). RATES INCLUDE FRINGE BENEFITS, LABOR INSURANCE, TAXES, TRAVEL, DEPARTMENTAL OVERHEADS AND G&A/US.

C.) SEE HANFORD SOFT REPORTING, FDS BUDGET GUIDELINE HANDBOOK, SECTION 2 - COMPANY INFORMATION, FY 1996 PLANNING RATES.

3. GENERAL REQUIREMENTS/TECHNICAL SERVICES/OVERHEADS

A.) ONSITE CONSTRUCTION FORCES GENERAL REQUIREMENTS AND TECHNICAL SERVICES COSTS ARE INCLUDED AS A COMPOSITE PERCENTAGE BASED ON THE ICF-KH ESTIMATING FACTORS FOUND IN SECTION 2 OF THE BUDGET GUIDELINE HANDBOOK (CGM) LOCATED ON HANFORD SOFT REPORTING, FDS BUDGET GUIDELINE HANDBOOK. THE PERCENTAGE APPLIED TO ONSITE CONSTRUCTION FORCES LABOR, FOR THIS PROJECT, IS 52% FOR SHOP WORK AND FIELD WORK, WHICH IS REFLECTED IN THE "OH&P/B&I" COLUMN OF THE ESTIMATE DETAIL.

B.) ONSITE CONTRACT ADMINISTRATION AND CONSTRUCTION MANAGEMENT COSTS, ASSOCIATED WITH THE OVERALL MANAGEMENT OF THE FIXED PRICE CONTRACTS, ARE INCLUDED AS A COMPOSITE PERCENTAGE AND LUMP SUM ALLOWANCE (FOR ROD PACKAGE PREP) BASED ON THE ESTIMATING FACTOR/BILLING SCHEDULE. THE TOTAL COMPOSITE PERCENTAGE AND LUMP SUM ALLOWANCE ARE APPLIED AGAINST THE TOTAL FIXED PRICE CONTRACT AMOUNT WHICH IS REFLECTED ON THE KG SUMMARY REPORT DOE 507, INCLUDED WITH THIS ESTIMATE. (FINAL ESTIMATES MAY BE PARTIALLY MANLOADED AND INCLUDED WITHIN THE ESTIMATE DETAIL).

C.) FIXED PRICE CONTRACTOR OVERHEAD, PROFIT, BOND AND INSURANCE COSTS HAVE BEEN APPLIED AT THE FOLLOWING PERCENTAGES AND ARE REFLECTED IN THE "OH&P/B&I" COLUMN OF THE ESTIMATE DETAIL: LABOR - 30% MATERIAL - 30% EQUIPMENT USAGE - 0% EQUIPMENT - 0% SUBCONTRACTS - 10%

4. ESCALATION


5. ROUNDING

U.S. DEPARTMENT OF ENERGY - DOE ORDER 5100.4 PAGE 1-32 SUBPARAGRAPH (M), REQUIRES ROUNDING OF ALL GENERAL PLANT PROJECTS (GPP'S) AND LINE ITEM (LI) COST ESTIMATES, REFERENCE: DOE 5100.4, FIGURE 1-11, DATED 10-31-84.

6. REMARKS

A.) ESTIMATE IS IN FY 96 DOLLARS. NO ESCALATION WAS APPLIED AS A SCHEDULE FOR THIS WORK IS UNKNOWN.

B.) WORK IS ASSUMED TO BE ALL VALVE PIT TIE INS PER DESIGN AND NO EXPERIMENT WAS APPLIED AS RADIATION CONDITIONS WERE UNKNOWN.

C.) 150 FEET OF LINE WAS INSTALLED BY THE ONSITE E/C AND REMAINING 2850 FEET BY FIXED PRICE CONTRACTOR.

D.) THE FIXED PRICE CONTRACTOR WILL SUPPLY ONSITE E/C FOR COMPLETE PIPE RUN INSIDE THE FARM.

E.) ASSUME THAT LAST 1000 FEET OF PIPE RUN IS TO BE BERNIED AND REMAINING 1850 FEET (TOWARDS FARM) TO BE EXCAVATED.

F.) NO CY OF EXCAVATED EARTH IN FARM WILL BE SPREAD ABOUT THE FARM.

G.) INSTALL 3" PVC ENCAUCE LINE FROM 241-A-8 VALVE PIT TO THE VENDOR.
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**NOTE:** Costs are in dollars. The project total is $3,524,118.
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C-29
**EST - INTERACTIVE ESTIMATING**

**FILE NO. Z394SAA6**

**JOB NO. Z394SAA6**

**DATE 04/19/96**

**PAGE 6 OF 7**

REFERENCE: ESTIMATE BASIS SHEET

COST CODE ACCOUNT SUMMARY

THE U.S. DEPARTMENT OF ENERGY - RICHLAND ORDER 5700.3 "COST ESTIMATING, ANALYSIS AND STANDARDIZATION" DATED 3-27-85, PROVIDES GUIDELINES FOR ESTIMATE CONTINGENCIES. THE GUIDELINE FOR A STUDY ESTIMATE SHOULD HAVE AN OVERALL RANGE OF 20 TO 30%.

CONTINGENCY IS EVALUATED AT THE THIRD COST CODE LEVEL AND SUMMARIZED AT THE PRIMARY AND SECONDARY COST CODE LEVEL OF THE DETAILED COST ESTIMATE.

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<td>310100 GENERAL REQUIREMENTS</td>
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<tr>
<td>310101 HAND EXCAV TRENCH</td>
<td>310301 PIPE INSTALL</td>
</tr>
<tr>
<td>310302 VALVE PKT TIE-IN</td>
<td>320101 MACH EXCAV TRENCH</td>
</tr>
<tr>
<td>320102 HAND EXCAV TRENCH</td>
<td>3220301 FAB &amp; INSTALL PIPE</td>
</tr>
<tr>
<td>700 SPECIAL EQUIP/PROCESS SYSTEMS</td>
<td>310401 CATHODIC PROTECTION</td>
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<tr>
<td>980 OTHER PROJECT COSTS</td>
<td>501000 OPC ACTIVITIES</td>
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</table>

A 35% CONTINGENCY WAS APPLIED AS A PERCENTAGE OF DIRECT CONSTRUCTION AS LIMITED DESIGN MEDIA WAS SUPPLIED TO ESTIMATING AND DUE TO UNKNOW/UNFORESEEN CONDITIONS IN TANK FARMS THAT COULD IMPACT THE COST OF CONSTRUCTION.

A 35% CONTINGENCY WAS APPLIED TO CONSTRUCTION AS LIMITED DESIGN MEDIA WAS SUPPLIED TO ESTIMATING AND DUE TO UNKNOW/UNFORESEEN CONDITIONS IN TANK FARMS THAT COULD IMPACT THE COST OF CONSTRUCTION.

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** IEST - INTERACTIVE ESTIMATING **

** PHASE I PRIVATIZATION ALTERNATIVES **

** STUDY - OPTION 6 **

DOE_R07 - ONSITE INDIRECT COSTS BY WBS

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<th>WBS DESCRIPTION</th>
<th>ESTIMATE SUBTOTAL</th>
<th>CONTRACT ADMINISTRATION %</th>
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<th>BID PACK PREP.</th>
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**IEST - INTERACTIVE ESTIMATING**

**PHASE I - PRIVATIZATION STUDY**

**STUDY**

**DOE_R01 - PROJECT COST SUMMARY**

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<tr>
<th>COST CODE</th>
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**TYPE OF ESTIMATE**

ARCHITECT

ENGINEER

CONTRACTOR

**REMARKS:**

**CHECK**

(ROUNDED/ADJUSTED TO THE NEAREST = 10,000 / 100,000 = PERCENTAGES NOT RECALCULATED TO REFLECT ROUNDING)
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<th>SUB TOTAL %</th>
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1. DOCUMENTS AND DRAWINGS

2. MATERIAL PRICES
   UNIT COSTS REPRESENT CURRENT PRICES FOR SPECIFIED MATERIAL. VENDOR INFORMATION WAS OBTAINED FOR THE FOLLOWING ITEMS:
   - NERION PRODUCTS - PIT COATING AIR CONTROL, INC. - OHEPA FILTER HOUSINGS
   - QOS - TYPE A BURIAL BOXES
   - UNIT PROCESS CO. - ISOLATION BUTTERFLY VALVES
   - BEECHTEL, WOODED BURIAL BOXES
   - ELECTRICAL RESOURCES - DATA BASE

3. LABOR RATES
   B.) BASE CRAFT RATES ARE AS ISSUED BY KEN FINANCE (EFFECTIVE 10-01-95). RATES INCLUDE FRINGE BENEFITS, LABOR INSURANCE, TAXES, DEPARTMENTAL OVERHEADS, G&A, AND GWS, AND TRAVEL. SEE HANFORD SOFT REPORTING, BDS BUDGET GUIDELINE HANDBOOK, SECTION 2 - COMPANY INFORMATION, FY 1996 PLANNING RATES.

4. GENERAL REQUIREMENTS/TECHNICAL SERVICES/OVERHEADS
   A.) ON SITE CONSTRUCTION FORCES GENERAL REQUIREMENTS AND TECHNICAL SERVICES COSTS ARE INCLUDED AS A COMPOSITE PERCENTAGE BASED ON THE ICF-HER ESTIMATING FACTORS FOUND IN SECTION 2 OF THE BUDGET GUIDELINE HANDBOOK (BGGH) LOCATED ON HANFORD SOFT REPORTING, BDS BUDGET GUIDELINE HANDBOOK, THE PERCENTAGE APPLIED TO ON SITE CONSTRUCTION FORCES LABOR. FOR THIS PROJECT, IS 52% FOR SHOP WORK AND FIELD WORK, WHICH IS REFLECTED IN THE "OH6P61" COLUMN OF THE ESTIMATE DETAIL.
   B.) ON SITE CONTRACT ADMINISTRATION AND CONSTRUCTION MANAGEMENT COSTS, ASSOCIATED WITH THE OVERALL MANAGEMENT OF THE FIXED PRICE CONTRACTS, ARE INCLUDED AS A COMPOSITE PERCENTAGE AND LUMP SUM ALLOWANCE APPLIED AGAINST THE TOTAL FIXED PRICE CONTRACT AMOUNT WHICH IS REFLECTED ON THE KEN SUMMARY REPORT DOE-RO7, INCLUDED WITH THIS ESTIMATE, (FINAL ESTIMATES MAY BE PARTIALLY MANLOADED AND INCLUDED WITHIN THE ESTIMATE DETAIL).

5. ESCALATION
   ESCALATION IS NOT INCLUDED IN THIS COST ESTIMATE.

6. ROUNDING
   U.S. DEPARTMENT OF ENERGY - DOE ORDER 5100.4 PAGE 1-32 SUBPARAGRAPH (M), REQUIRES ROUNDING OF ALL GENERAL PLANT PROJECT (GPP'S) AND LINE ITEM (LI) COST ESTIMATES. REFERENCE: DOE 5100.4, FIGURE 1-11, DATED 10-31-84.
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**EST - INTERACTIVE ESTIMATING**

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APPENDIX D

DESIGN PRESSURE RATING UPGRADE
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DON'T SAY IT --- Write It!

DATE: 9/9/96

TO: John Koberg  G3-12  FROM: J.R. Nicholson  G3-12

cc: J. Galbraith  H5-49

SUBJECT: DESIGN PRESSURE RATING UP-GRADE FOR SN-213/200

The existing 3" SN-213/200 transfer line has been investigated to determine if a methodology is available to re-rate the design pressure of 230 psig to 400 psig to enhance the transfer systems hydraulic performance.

The 3" SN-213/200 is approximately 620 feet long with 15-90° 3 ft radius bends and 2-45° 3 ft radius bends. This line along with SN-216 are potential candidates for increasing their design pressure to 400 psig.

The pipe lines referenced above have been subjected to transfers from B Plant to the 241-AY-101 double shell tank and piping failures have occurred from 1980 to 1995, refer to Figure 1 for route failure locations and SD-RE-TI-148 (Metallurgical Analysis of Leak Failure of 241-A-B Valve Pit Jumper.1985) for documented analysis of jumper failure.

Two methods have been researched and are available to examine the 3"-SN-213/200 pipe line to investigate corrosion/erosion to aid in determining the remaining strength of these areas and what is the pressure containing capability of the remaining pipe metal in terms of its ability to operate safely at the maximum allowable operating pressure of the transfer system.

**CCTV EXAMINATION SYSTEM**

The CCTV examination consists of a laser-ring followed by a camera pushed into the transfer pipe for approximately 100 feet using a push pole. Entry is through the wall nozzle in the valve pit at either end of the line. The laser-ring illuminates a circumferential circle on the internal surface of the pipe. These circles, which take the form of the pipe contour are compared with a standard pipe contour to measure corrosion or scaling of the pipe material. While the laser-ring paints a contour, the camera provides a direct view of the internal surface condition. The product of the exam is the information gained by direct viewing of the laser-ring and the internal surface of the pipe wall through the monitor in the field. Video tape of both the direct viewing and the laser-ring information is available for further examination and evaluation to determine the probability of significant piping material degradation. The evaluation is qualitative and the system is currently available on site. The estimated cost for the CCTV examination is $61,000 (see attachment) for an examination of 100 feet from one end of the line. If entry from both ends of the transfer pipe is performed, the cost is estimated to be $110,000.

**EDDY CURRENT SYSTEM**

A-3000-723 (01/95) GEF013
The Eddy Current instrument with remote field option is used for a broad range of tubing and piping applications on the petroleum, chemical and power generation industries. The probe is hand feed and pushed through a wall nozzle in the valve pits at either end of the transfer line and power and signal data connected to equipment adjacent to the point of entry of the probe. A vector analysis of the data is used to estimate pitting depth, length and general wall thinning. A local vendor representing ZETEL estimated 50 - 100 feet entry maximum from each end of the 620 feet line. The estimated costs for the Eddy Current examination will be very similar to the CCTV system and are assumed the same.

Cleanliness of the line to be examined is also a critical factor for both methods. The CCTV examination may mask the pitting corrosion if sludge exists in the bottom of the pipe. If sludge buildup is present, the Eddy Current system will not function properly and therefore the sludge will have to be removed. Present knowledge of the transfer lines does not quantify the amount of sludge that is present. Past experience during performance of transfer line "hot tie-ins", has identified sludge being present in some of the lines.

Considering the transfer systems continuing failure from 1980, only a 100% examination of the pipeline to verify existing wall thickness would be acceptable to validate re-rating. The risk would not be acceptable to only perform a partial examination (approximately 33% of SN-213/200 based on 100 foot entry from each end of line). At the current time no system has been found that can traverse 100% of the lines length to determine remaining pipe wall thickness and attempting to re-rate the system is not recommended. If 100% of the transfer system were to be examined, the probability of increasing the design pressure is very low due to expected corrosion to be detected given past history on pipeline failures.

Attachments: Figure 1-Recent Failure Locations In B-Plant/200 East Area Lines Estimated Cost For CCTV Pipeline Examination
FIGURE 1
RECENT FAILURE LOCATIONS IN B-PLANT/200 EAST AREA LINES

D-5
# ESTIMATED COST FOR CCTV PIPELINE EXAMINATION

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38 days or $19,000
**DISTRIBUTION SHEET**

**To**

Distribution

**From**

Process Design 73520

**Page 1 of 1**

**Date** 9/10/96

**Project Title/Work Order**

Decision Document for Phase I Privatization Transfer System Needs, WHC-SD-WM-TI-750, Revision 0

**EDT No.** 608745

**ECN No.**

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*These employees will receive the main document plus Appendix B, C, and D only. Appendix A consists of 250 pages of calculations.*

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A-6000-135 (01/93) WEP067
APPENDIX C

COST ESTIMATES

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**NOTE:** ROUNDED/ADJUSTED TO THE NEAREST $10,000 / $100,000 = PERCENTAGES NOT RECALCULATED TO REFLECT ROUNDING.
** ICF Kaiser Hanford **  
WESTINGHOUSE HANFORD COMPANY  
JOB NO. 23944AA3/P4WOOD  
FILE NO. 23944AA3  

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1. DOCUMENTS AND DRAWINGS

DOCUMENTS: DSJ FROM T. SALZANO REQUESTING ESTIMATES FOR PHASE I PRIVATIZATION ALTERNATIVES DATED 3/20/96.

DRAWINGS: ATTACHMENT B TO DSJ.

2. LABOR RATES

A.) ICF-KH HOURLY RATES ARE BASED ON THE 1996 Fiscal Year Budget Liquidation Rates as Issued by KEH Finance (Effective 3-08-96). See also the FY 1996 Planning Rates* (Report BCRB7021).

B.) BASE CRAFT RATES ARE AS ISSUED BY KEH Finance (Effective 10-01-95). Rates include fringe benefits, labor insurance, taxes, travel, departmental overheads and G&A/SGS.


3. GENERAL REQUIREMENTS/TECHNICAL SERVICES/OVERHEADS

A.) Onsite construction forces general requirements and technical services costs are included as a composite percentage based on the ICF-KH estimating factors found in Section 2 of the Budget Guideline Handbook (BGHB) located on Hanford Soft Reporting, FDS Budget Guideline Handbook. The percentage applied to onsite construction forces labor, for this project, is 52% for shop work and field work, which is reflected in the "OHLP/BLI" column of the estimate detail.

B.) Onsite contract administration and construction management costs, associated with the overall management of the fixed price contracts, are included as a composite percentage and lump sum allowance (for bid package prep) based on the estimating factors billling schedule. The total composite percentage and lump sum allowance are applied against the total fixed price contract amount which is reflected on the KEH Summary Report Doe Not, included with this estimate. (Final estimates may be partially renumbered and included within the estimate detail).

C.) Fixed price contractor overhead, profit, bond and insurance costs have been applied at the following percentages and are reflected in the "OHLP/BLI" column of the estimate detail: labor - 0%, material - 0%, equipment usage - 0%, equipment - 0%, subcontract - 0%

4. ESCALATION

Escalation percentages were calculated from the January 1996 update of the Economic Escalation Price Change Indices for DOE construction projects as published by the "Office of Infrastructure Acquisition" FN-50.

5. ROUNDING


6. REMARKS

A.) Estimate is for construction only. Does not include design costs.

B.) Estimate is in FY 96 dollars. No escalation was applied as a schedule for this work is unknown.

C.) Work is assumed to be all valve pit 715-150-726 per design. Some weldout was applied as radiological conditions were unknown.

D.) All work was assumed to be done by the onsite E/C.

E.) Estimate for SL-500 was derived using the existing estimate from project V-214.

### PHASE I PRIVATIZATION ALTERNATIVES

#### STUDY - OPTION 3

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**EST - INTERACTIVE ESTIMATING**

**PHASE I PRIVATIZATION ALTERNATIVES**

**STUDY - OPTION 3**

DOE_R04 - CONTINGENCY ANALYSIS BASIS SHEET

---

### Reference: Estimate Basis Sheet

#### Cost Code Account Summary

---


Contingency is evaluated at the third cost code level and summarized at the primary and secondary cost code level of the detailed cost estimate.

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** ICF KAISER HANFORD **
WESTINGHOUSE HANFORD COMPANY
JOB NO. 2394SA1/PAWUDD
FILE NO. 2394SA1/P

** PHASE I PRIVATIZATION ALTERNATIVES **
STUDY - OPTION 1

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1. DOCUMENTS AND DRAWINGS

DOCUMENTS: DSI FROM T. SALZANO REQUESTING ESTIMATES FOR PHASE I PRIVATIZATION ALTERNATIVES DATED 3/20/96.

DRAWINGS: ATTACHMENT A, B & C TO DSI.

2. MATERIAL PRICES

UNIT COSTS REPRESENT CURRENT PRICES FOR SPECIFIED MATERIAL. VENDOR INFORMATION WAS OBTAINED FOR THE FOLLOWING ITEMS:

3. LABOR RATES

B. WHC HOURLY RATES ARE BASED UPON THE FY 1996 PLANNING RATES * (REPORT BGB82001).
C. IRH HOURLY RATES ARE BASED UPON THE FY 1996 PLANNING RATES * (REPORT BGB87008).
D. BASE CRAFT RATES ARE AS ISSUED BY KEH FINANCE (EFFECTIVE 10-01-95). RATES INCLUDE FRINGE BENEFITS, LABOR INSURANCE, TAXES, TRAVEL, DEPARTMENTAL OVERHEADS AND G&A/SWS.

* SEE HANFORD SOFT REPORTING, FDS BUDGET GUIDELINE HANDBOOK, SECTION 2 - COMPANY INFORMATION, FY 1996 PLANNING RATES.

4. GENERAL REQUIREMENTS/TECHNICAL SERVICES/OVERHEADS

A. ONSITE CONSTRUCTION FORCES GENERAL REQUIREMENTS AND TECHNICAL SERVICES COSTS ARE INCLUDED AS A COMPOSITE PERCENTAGE BASED ON THE ICF-KH ESTIMATING FACTORS FOUND IN SECTION 2 OF THE BUDGET GUIDELINE HANDBOOK (BGHB) LOCATED ON HANFORD SOFT REPORTING. FDS BUDGET GUIDELINE HANDBOOK. THE PERCENTAGE APPLIED TO ONSITE CONSTRUCTION FORCES LABOR FOR THIS PROJECT, IS 5%/ FOR SHOP WORK AND FIELD WORK, WHICH IS REFLECTED IN THE "OHsP/OAI" COLUMN OF THE ESTIMATE DETAIL.

5. ESCALATION


6. ROUNDING

U.S. DEPARTMENT OF ENERGY - DOE ORDER 5100.4 PAGE 1-32 SUPPAGRAPH (M). REQUIRES ROUNDING OF ALL GENERAL PLANT PROJECTS (6P-5) AND LINE ITEM (LI) COST ESTIMATES. REFERENCE: DOE 5100.4, FIGURE 1-11. DATED 10-31-84.

7. REMARKS

A. ESTIMATE IS IN FY 96 DOLLARS. NO ESCALATION WAS APPLIED AS A SCHEDULE FOR THIS WORK IS UNKNOWN.
B. TIE-INS TO THE TANKS WERE ASSUMED TO BE HOT TIE-INS PER DESIGN HOWEVER NO BURNOUT WAS APPLIED AS RADIOLOGICAL CONDITIONS WERE UNKNOWN.
C. ALL WORK WAS ASSUMED TO BE DONE BY THE ONSITE E/C.
D. THIS WORK IS FOR TIE IN TO SW 600, PROVIDE NEW VALVE PIT, NEW 2.75" ENCASED piping TO TANKS AP-102 AND AP-104 AND VALVE PIT DRAIN TO TANK AP-102.
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**Phase I Privatization Alternatives Study - Option I**

**DDE-R06 - Contingency Analysis Basis Sheet**

**Reference:** Estimate Basis Sheet

**Cost Code Account Summary**

The U.S. Department of Energy - Richland Order 5700.3 "Cost Estimating, Analysis and Standardization" dated 3-27-85 provides guidelines for estimate contingencies. The guideline for a study estimate should have an overall range of 20 to 50%.

Contingency is evaluated at the third cost code level and summarized at the primary and secondary cost code level of the detailed cost estimate.

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<td>3/8&quot; Encased Pipe</td>
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A 35% contingency was applied as a percentage of direct construction was used to generate the cost for design and a detailed planning effort has not been performed to identify all discipline involved.

A 35% contingency was applied as a percentage of direct construction was used to generate the cost for WHC project management and a detailed planning effort needs to be performed to determine the number of support personnel.

A 35% contingency was applied to construction as limited design media was supplied to estimating and due to unknown/unforeseen conditions in tank farms that could impact the cost of construction.

A 35% contingency was applied to construction as limited design media was supplied to estimating and due to unknown/unforeseen conditions in tank farms that could impact the cost of construction.

A 35% contingency was applied as a percentage of direct construction was used to generate the cost for WHC OPC activities and a detailed planning effort needs to be performed to determine the number of support personnel.
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<th>BID PACK PREP</th>
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## DOE-RO1 - PROJECT COST SUMMARY

**General Information**
- **File No.**: Z394SAA5
- **Company**: ICF Kaiser Hanford
- **Study Name**: DOE-RO1 - PROJECT COST SUMMARY
- **Date**: April 21, 1996

### Cost Breakdown

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### Remarks

**Summary**
- The project cost summary includes detailed cost breakdowns for various categories such as engineering, project management, and other project costs.
- The total project cost is $2,800,000.

**Calculation Details**
- Escalated costs are adjusted to reflect current market conditions.
- Contingencies are included to account for unexpected expenses.

**Notes**
- The project cost summary is reviewed and updated as of April 21, 1996.

**Language and Formatting**
- The document is formatted in a table with clear headers and subheaders for easy reading.
- The project cost summary includes both numeric and textual data for better understanding.

**References**
- The study is conducted by ICF Kaiser Hanford, and the file number is Z394SAA5.
- The project is a part of the DOE-RO1 study.

---

**CHECK**

(Rounded/Adjusted to the nearest = 10,000 / 100,000 = - Percentages not recalculated to reflect rounding)
** ICF KAISER HANFORD **

** WESTINGHOUSE HANFORD COMPANY **

** JOB NO. 23945A65/P4W000 **

** FILE NO. 13946A95 **

---

### Study - Option 5

** DOE-102 - YORK BREAKDOWN STRUCTURE SUMMARY **

---

** PM-1002 - WORK BREAKDOWN STRUCTURE SUMMARY **

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** PROJECT TOTAL **

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1. DOCUMENTS AND DRAWINGS

DOCUMENTS: DSI FROM T. SALZANO REQUESTING ESTIMATES FOR PHASE I PRIVATIZATION ALTERNATIVES DATED 3/20/96.

DRAWINGS: ATTACHMENT A, B & C TO DSI.

2. LABOR RATES

A.) ICF-KH HOURLY RATES ARE BASED ON THE 1996 FISCAL YEAR BUDGET LIQUIDATION RATES AS ISSUED BY KER FINANCE (REPORT BQHB7012).

B.) BASE CRAFT RATES ARE AS ISSUED BY KER FINANCE (EFFECTIVE 10-01-95). RATES INCLUDE FRINGE BENEFITS, LABOR INSURANCE, TAXES, TRAVEL, DEPARTMENTAL OVERHEADS AND G&A.

C.) SEE HANFORO SOFT REPORTING, FDS BUDGET GUIDELINE HANDBOOK, SECTION 2 - COMPANY INFORMATION, FY 1996 PLANNING RATES.

3. GENERAL REQUIREMENTS/TECHNICAL SERVICES/OVERHEADS

A.) ONSITE CONSTRUCTION FORCES GENERAL REQUIREMENTS AND TECHNICAL SERVICES COSTS ARE INCLUDED AS A COMPOSITE PERCENTAGE BASED ON THE ICF-KH ESTIMATING FACTORS FOUND IN SECTION 2 OF THE BUDGET GUIDELINE HANDBOOK (BGHB) LOCATED ON HANFORO SOFT REPORTING. THE PERCENTAGE APPLIED TO ONSITE CONSTRUCTION FORCES LABOR, FOR THIS PROJECT, IS 52% FOR SHOP WORK AND FIELD WORK, WHICH IS REFLECTED IN THE "OHLP/BPI" COLUMN OF THE ESTIMATE DETAIL.

B.) ONSITE CONTRACT ADMINISTRATION AND CONSTRUCTION MANAGEMENT COSTS, ASSOCIATED WITH THE OVERALL MANAGEMENT OF THE FIXED PRICE CONTRACTS, ARE INCLUDED AS A COMPOSITE PERCENTAGE AND LUMP SUM ALLOWANCE (FOR BID PACKAGE PREP) BASED ON THE ESTIMATING FACTORS/BILLING SCHEDULE. THE TOTAL COMPOSITE PERCENTAGE AND LUMP SUM ALLOWANCE ARE APPLIED AGAINST THE TOTAL FIXED PRICE CONTRACT AMOUNT WHICH IS REFLECTED ON THE KER SUMMARY REPORT DATA, INCLUDED WITH THIS ESTIMATE. (FINAL ESTIMATES MAY BE PARTIALLY MANLOADED AND INCLUDED WITHIN THE ESTIMATE DETAIL)

C.) FIXED PRICE CONTRACTOR OVERHEAD, PROFIT, BOND AND INSURANCE COSTS HAVE BEEN APPLIED AT THE FOLLOWING PERCENTAGES AND ARE REFLECTED IN THE "OHLP/BPI" COLUMN OF THE ESTIMATE DETAIL:

LABOR - 0% MATERIAL - 0% EQUIPMENT USAGE - 0% EQUIPMENT - 0% SUBCONTRACTS - 0%

4. ESCALATION


5. ROUNDBING

U.S. DEPARTMENT OF ENERGY - DOE ORDER 5100.4 PAGE 1-32 SUBPARAGRAPH (M), REQUIRES ROUNDBING OF ALL GENERAL PLANT PROJECTS (GPP'S) AND LINE ITEM (LI) COST ESTIMATES. REFERENCE: DOE 5100.4, FIGURE 1-11, DATED 10-31-94.

6. REMARKS

A.) ESTIMATE IS FOR CONSTRUCTION ONLY. DOES NOT INCLUDE DESIGN COSTS.

B.) ESTIMATE IS IN FY 96 DOLLARS. NO ESCALATION WAS APPLIED AS A SCHEDULE FOR THIS WORK IS UNKNOWN.

C.) WORK IS ASSUMED TO BE ALL VALVE PIT TIE-INS PER DESIGN AND NO BURNOUT WAS IMPLIED AS RADIOLOGICAL CONDITIONS WERE UNKNOWN. ALL WORK WAS ASSUMED TO BE DONE DURING THE ON-SITE STAGE.

D.) ESTIMATE FOR SL-S02 WAS DERIVED USING THE EXISTING ESTIMATE FROM PROJECT W-314.

E.) MODIFY THE W-314 ESTIMATE FOR REPLACEMENT OF 2" SL-S04 AND 2" SL-S02 AND INCREASE TO 3"/6" ENCASED PIPE.
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PROJECT TOTAL: 2,086,996, 0.00, 2,086,996, 35, 730,449, 2,817,445
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THE U.S. DEPARTMENT OF ENERGY - RICHLAND ORDER 5700.3 "COST ESTIMATING, ANALYSIS AND STANDARDIZATION" DATED 3-27-85, PROVIDES GUIDELINES FOR ESTIMATE CONTINGENCIES. THE GUIDELINE FOR A STUDY ESTIMATE SHOULD HAVE AN OVERALL RANGE OF 20 TO 50%.

CONTINGENCY IS EVALUATED AT THE THIRD COST CODE LEVEL AND SUMMARIZED AT THE PRIMARY AND SECONDARY COST CODE LEVEL OF THE DETAILED COST ESTIMATE.

A 35% CONTINGENCY WAS APPLIED AS A PERCENTAGE OF DIRECT CONSTRUCTION AS USED TO GENERATE THE COST FOR DESIGN AND A DETAILED PLANNING EFFORT HAS NOT BEEN PERFORMED TO IDENTIFY ALL DISCIPLINE INVOLVED.

A 35% CONTINGENCY WAS APPLIED AS A PERCENTAGE OF DIRECT CONSTRUCTION AS USED TO GENERATE THE COST FOR WEC PROJECT MANAGEMENT AND A DETAILED PLANNING EFFORT NEEDS TO BE PERFORMED TO DETERMINE THE NUMBER OF SUPPORT PERSONNEL.

A 35% CONTINGENCY WAS APPLIED TO CONSTRUCTION AS LIMITED DESIGN MEDIA WAS SUPPLIED TO ESTIMATING AND DUE TO UNKNOWN/UNFORESEEN CONDITIONS IN TANK FARMS THAT COULD IMPACT THE COST OF CONSTRUCTION.

A 35% CONTINGENCY WAS APPLIED TO CONSTRUCTION AS LIMITED DESIGN MEDIA WAS SUPPLIED TO ESTIMATING AND DUE TO UNKNOWN/UNFORESEEN CONDITIONS IN TANK FARMS THAT COULD IMPACT THE COST OF CONSTRUCTION.

A 35% CONTINGENCY WAS APPLIED AS A PERCENTAGE OF DIRECT CONSTRUCTION AS USED TO GENERATE THE COST FOR WEC OPC ACTIVITIES AND A DETAILED PLANNING EFFORT NEEDS TO BE PERFORMED TO DETERMINE THE NUMBER OF SUPPORT PERSONNEL.
5.2.5 TOTAL HEAD LOSS: 241-AN ALTERNATIVE 2

Process Pit Losses:

\[ h_1 = h_{\text{pump_pits}} + h_{\text{valve_pits}} \]

Transfer Path Losses:

\[ h_2 = \sum_{i=1}^{8} \frac{v_{3i}}{2g} K_i \]

Elevation Change:

\[ h_3 = z_{\text{end}} - z_{\text{start}} \]

Total Head Loss:

\[ i = 1, 2, 3 \]

\[ \text{TDH}_{100.\text{alt2}} = \sum_{i} h_i \]

Pressure Drop:

\[ \Delta P_{100.\text{alt2}} = \frac{\text{TDH}_{100.\text{alt2}} \rho}{144 \text{ in}^2 \text{ ft}^2} \]

5.3 80 GPM: 241-AN

5.3.1 Constant Data

Volumetric Flow Rate,

\[ Q_{80} = 80 \text{ gal min}^{-1} \]

\[ Q_{80} = 0.13368 \text{ ft}^3 \text{ min}^{-1} \]

\[ q = \frac{Q_{80}}{60 \text{ sec min}^{-1}} = 0.18 \text{ ft}^3 \text{ sec}^{-1} \]

Velocity of Flow,

\[ v_{2\text{in}} = \frac{q}{A_{2\text{in}}} \]

\[ v_{3\text{in}} = \frac{q}{A_{3\text{in}}} \]

\[ v_{2\text{in}} = 7.6 \text{ ft sec}^{-1} \]

\[ v_{3\text{in}} = 3.5 \text{ ft sec}^{-1} \]