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3. From: (Originating Organization)  
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4. Related EDT No.:  
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5. Proj./Prog./Dept./Div.:  
   DST Annulus Pumping

6. Design Authority/Design Agent/Eng.:  
   Dan Reberger

7. Purchase Order No.:  
   NA

8. Equipment/Component No.:  
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9. System/Bldg./Facility:  
   DST Annulus

10. Major Asm. Dwg. No.:  
    NA

11. Receiver Remarks:  
    11A. Design Baseline Document?  
        ☑ Yes  ☐ No

12. Approval Designator (F)  
    Reason for Transmittal (G)  
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13. Permit/Permit Application No.:  
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14. Required Response Date:  
    8/2/00

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**SIGNATURE/DISTRIBUTION**

(See Approval Designator for required signatures)

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   Design Agent  
   Cog. Eng.  
   Cog. Mgr.  
   QA  
   Safety  
   Env.  
   Signature of EDT Originator  
   Authorized Representative for Receiving Organization  
   Design Authority Cognizant Manager |

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18. Signature of EDT Originator:  
   Date: 8/2/00

19. Authorized Representative for Receiving Organization:  
   Date:  

20. Design Authority Cognizant Manager:  
   Date: 8/3/00

21. DOE APPROVAL (if required)  
   Ctrl No.  
   ☐ Approved  
   ☐ Approved w/comments  
   ☐ Disapproved w/comments
September 8, 2000

Mr. G. S. Gustafson, President
Instrumentation Northwest, Inc.
14902 N. E. 31st Circle
Redmond, WA 98052

Dear Mr. Gustafson:

REQUEST FOR PERMISSION TO INCLUDE PROPRIETARY DRAWINGS INTO RPP-6485, "TECHNICAL INFORMATION TO SUPPORT DST EMERGENCY ANNULUS APUMPING"

CH2M-Hill Hanford Group, Inc. would like to include the following proprietary drawings in the "Publicly" release document RPP-6485, "Technical Document to Support DST Emergency Annulus Pumping":

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<td>Well Completion Assy. PVC/AL/PVC 2&quot;</td>
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<td>2D0025</td>
<td>Rod Assembly 1/4&quot; 1', 2', 3', 5', 10'</td>
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The equipment identified in these drawings was procured to support pumping of the annulus tank of a double shell tank if the primary tank were to leak. This equipment has been satisfactory tested will be stored until needed. The technical document referred to above will be included with the equipment to provide reference information if it is needed. CH2M-Hill Hanford Group, Inc. would like to obtain permission to include the aforementioned proprietary drawings into document RPP-6485.

If you have any questions or further assistance, please contact me at (509) 376-9886. The signatory below has provided their approval to include the above noted proprietary drawings into document RPP-6485.

Lisa Domnoske-Rauch, Cognizant Engineer
Double Shell Tank Cognizant Engineering

APPROVAL:

Lisa Domnoske-Rauch, Cognizant Engineer
Double Shell Tank Cognizant Engineering

Date: 9/18/00

G. S. Gustafson, President
Instrumentation Northwest, Inc.
## DISTRIBUTION SHEET

**To**  
DISTRIBUTION  

**From**  
DST ENGINEERING  

**Project Title/Work Order**  
RPP-6485, "Technical Information to Support DST Emergency Annulus Pumping"  

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Technical Information to Support DST Emergency Annulus Pumping

DW Reberger
CH2M Hill Hanford Group Inc.
Richland, WA 99352
U.S. Department of Energy Contract DE-AC06-76RL01837

Abstract: This document serves as a summarization of information relative to DST annulus emergency pumping.

*Flygt is a registered trademark of ITT Flygt Aktiebolag
*Hydrostar is a registered trademark of Kayaba Kogyo Kabushiki Kaisha

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Approved For Public Release
Technical Information to Support DST Emergency Annulus Pumping

Supporting Document prepared by: DW Reberger, DST Engineering
CH2M Hill Hanford Group Inc.
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Objective

This document provides the design calculations for the DST Annulus Emergency Pumping Project. This document also contains essential information relative to DST annulus emergency pumping that may not be found in other documents. This information consists of the following:

- Index drawing for annulus pumping
- References to the Acceptance Test Report, DST Emergency Pumping Guide, Time Deployment study, etc.
- Statements of work
- Reference CEIS and RMIS numbers

A Vendor Information document, VI-50121, is not included in this document, but a copy can be obtained by contacting Document Control Services. This document contains various information regarding the Hydrostar pumps, such as the air motor, cylinder size, pump installation and operation manual. It also contains information regarding the Flygt BS2060 submersible pump, such as parts list, pump handling, preventative maintenance, overhaul and repair. In addition, this document also has information on 3-way PM ball valves, electrical skid components and the alternate Gorman-Rupp stainless steel submersible pump.

Information in this document is organized into appendices, with a short discussion appearing below relative to each appendix. This document serves as a summarization of information.

APPENDIX A DST ANNULUS PUMPING PROCEDURE LIST

Provides listing of procedural document number and title for documents related to DST annulus pumping. This listing includes the Operational Test Procedure, OTP-001-001, which discusses the mandatory impeller rotation of the pump to prevent the seals from sticking if the pump is stored for more than a 6 month period.

APPENDIX B FLYGT BS-2060 PUMP PERFORMANCE CURVE & ELECTRICAL DIAGRAM

Manufacturers pump performance data for the BS-2060 pump and electrical diagram.

APPENDIX C FLAMMABLE GAS ISSUES

Flammable gas Report, FGEAB-00-002 Revision 1, approved Hydrostar and Flygt pumps. The electrical cable feed to the junction chamber was required, by the report, to be evaluated to meet Ignition Source Control Set 1 (ISC1) requirements (NEC Class 1, Division 1, Group B). Several cc-mails address this issue.
The Hydrostar pump was determined to provide equivalent safety to Ignition Source Control Set 1.

The Gorman-Rupp was also presented to the Flammable Gas Equipment Advisory Board (FGEAB), but was unacceptable because it did not have sufficient barriers to the electrical components. In general for pumps, the Flammable Gas Equipment Advisory Board required a double mechanical sealing barrier between potential flammable gas region and electrical components. A single metal housing provided an adequate barrier, but seals on shafts needed double isolation. All electrical components are required to be normally non-sparking or a modification to non-incendive or intrinsically safe.

APPENDIX D PROCUREMENT DOCUMENTATION

Statement of work, #39121, Statement of Work for Annulus Pumping Time Deployment Study
Statement of work, #39142, Statement of Work for Annulus Pumping
Statement of work, #39151, Statement of Work for Annulus Pumping

Interoffice memo 74100-00-029, upgraded the existing spare Flygt pumps from Quality Level 0 to 3. The catch tank pumps are spared under #6111-5514-5670 catalog ID# 552920. Bill of material (BOM)

Procurement Specification, 4975-59-P1 Rev. 0, Annulus Submersible Transfer Pump, provides the minimum requirements for a submersible transfer pump and any special handling equipment required for pump shipping and installation.

Procurement Specification 4975-59-P2 Rev. 0, Annulus Heel Pump, provides the minimum requirements for an air driven heel pump and any special handling equipment required for pump shipping and installation.

A significant number of pumps (>20) were investigated. Twelve vendors were checked more thoroughly. Refer to the listing for reasons why each was eliminated from consideration.

The Flygt BS-2060 has been used on-site since the early 1980's for catch tank pumping (i.e.241-A-302A, 241-ER-311, etc.). The "B" in the model number stands for Multi-vane, open or semi-shrouded impellers for dirty water containing abrasive particles. The "S" stands for Slim Design.
APPENDIX E   DRAWINGS

Drawings included are:

- H-14-104118, Drawing List for Annulus Pumping
- 2A0001, HS-8001-1 Series Hydrostar Sampling Pump
- 2A0004, Air Motor Assembly
- 2A0020, Well Completion Assembly
- 2A0025, Rod Assembly

APPENDIX F   SPARE PARTS

Itemized listing of parts needed to support central pump pit jumper fabrication for annulus pumping. The remaining loose parts stored in the trailer for the pump assembly and annulus jumper have parts lists on the appropriate drawing. Seven Flygt BS-2060 pumps are stored in spare parts under Stock Number 6111-5514-5670 and a modified spare pump in convenient storage under 9900-4865-8002.

APPENDIX G   JUMPERS

To expedite the deployment, pre-fabricated jumpers were considered. The best case assumed a flex could be incorporated into the design near the connector to overcome minor as-built dimensional differences in similar pits. Jumper and pump assemblies are similar for AY and AZ tank farms and AN, AP, AW and SY tank farms.

APPENDIX H   CALCULATIONS

Calculation, DSTAP-P-001 Rev 0, DST Annulus Pump Line Losses provided by Fluor Federal Services Inc.

The objective of this calculation was to determine the line losses of a piping route that transfers waste from the annulus in tank AN-106 to tank AP-104, via existing lines. The line losses are used to select an annulus pump that will satisfy the pressure requirements of the route.

Design Criteria*/Input:

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<td>Temperature</td>
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Safety Class General Service

* Found in Appendix I: Annulus Pump Criteria Letters, 74100-00-005):

It was concluded that the total line loss, at a fluid discharge of 40 gpm, was 175 ft. A pump should be selected that will satisfy this operating condition. Multiple pumps operating in tandem are acceptable, if necessary, to achieve the appropriate discharge head required based on the transfer route distance.

The Flygt pump was the only pump that met the size, flow, and flammable gas criteria.

Calculation, DSTAP-P-002 Rev 0, DST Annulus Jumper Orifice Design provided by Fluor Federal Services Inc.

The purpose of the calculation is to size an orifice, which will be used to reduce the flow rate in the annulus pump pit transfer piping. The transfer line connecting the annulus pump pit to the central pump pit in the AY-101, AY-102 and AZ-102 tanks are direct buried pipe. A flow restriction of 50 gpm is placed on these lines based on the following. Administrative Control (AC) 5.12 states, "Perform ground level radiation surveys of any single-walled, direct buried/bermed lines that are part of the WASTE transfer route... every 30 minutes during submersible pumping (maximum of 50 gpm)."

It was concluded that a centrally located orifice with a diameter of 0.9 inches should be used in an annulus jumper which required a 50 gpm flow restriction. This number assumes that only one submersible pump is used (as opposed to a tandem arrangement)

Calculation, DSTAP-P-003 Rev 0, DST Annulus Pump Transfer Line Pressure provided by Fluor Federal Services Inc.

The objective of this calculation was to determine if the Hydrostar air pump could pressurize a transfer line above its design pressure.

Calculation DSTAP-P-004 Rev 0, Annulus Jumper Piping Stress Analysis provided by Fluor Federal Services Inc.

The objective of this calculation was to perform static and seismic analysis for jumper piping. It was determined that the piping stresses meets acceptance criteria Code B31.3a.

Calculation DSTAP-P-005 Rev 0, DST Annulus Pump Test Piping Line Loss provided by Fluor Federal Services Inc.
Calculation Misc rev 0, DST Annulus Pump Miscellaneous Calculations provided by Fluor Federal Services Inc.

This includes calculations for air compressor sizing, desiccant filler replacement, Test Tank modification analysis, Test Tank sizing, radiation resistance of the Flygt submersible pump elastomers, weep hole sizing and annulus pump assembly

Calculation, DST-C-001 Rev 0, Portable DST Tank Skid provided by Fluor Federal Services Inc.

The objective of this calculation was to check the portable skid structure.

Calculation, DST-C-002 Rev 0, Fused Disconnect Skid provided by Fluor Federal Services Inc.

The objective of this calculation was to check the fused disconnect skid structure.

APPENDIX I ANNULUS PUMP CRITERIA LETTERS

This appendix includes letter 74100-00-005, Annulus Pump Design Criteria which discusses the criteria required to support the design of a new style of Annulus Pumps for the DST system and CO-00-RPP-237, Contract No. 4975, release No. 59, DST Annulus Pumping (L-02), which discusses the design of the Hydrostar and Flygt pumps.

APPENDIX J SKETCHES FOR PUMP TEST TANK

Sketches in this appendix include:

- Drawings of the Test Skid for the submersible pump arrangement
- Air pump in tank test arrangement
- Mock annulus riser and lower pump arrangement
- Air driven pump adapter arrangements and assembly
- Jumper assembly

APPENDIX K FABRICATION

The following Fabrication Requests are located in this appendix. Copies of the work packages can be found in the Annulus Pumping Trailer.

2H-0004706/F 2H-0004768/F
2H-0004769/F 2H-0004777/F
2H-0004824/F
APPENDIX A
DST ANNULUS PUMPING PROCEDURE LIST
# DST ANNULUS PUMPING PROJECT

**WEEKLY PROCEDURE STATUS: 7/6/00  5:16 PM**

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REPLACES 6-TF-509.
APPENDIX B
FLYGT BS-2060 PUMP PERFORMANCE CURVE & ELECTRICAL DIAGRAM
Y / 9-lead stator

230V/YII

U1 U5 V5 V1 W2 U2 V2 W1 W6

connection, see inside of junction box cover.

460V/Y Ser.

Motor Jct. Box

U1 - RED
U2 - GREEN
U5 - RED

V1 - (TAN) BROWN
V2 - BLUE
V5 - (TAN) BROWN

W1 - YELLOW
W2 - BLACK
W5 - YELLOW

Motor Internal Leads

Power Cable

U1 - RED
V1 - BLACK
W1 - WHITE
GND - YELLOW
-YELLOW/GREEN STRIKE

*NOTE! When connecting pumps which have 1 9-lead stator for 460V Y Ser. 60 Hz, no closing links should be used. For correct connection, see inside of junction box cover.

Thermal Switch -
-ORANGE
- BLUE
7-#12 wires

REM 6/19/77.
APPENDIX C
FLAMMABLE GAS ISSUES
Reberger, Dan W

From: Merriman, Raymond E  
Sent: Wednesday, March 22, 2000 12:50 PM  
To: Schlosser, Richard L; Al-Wazani, Mazen G; Huckfeidt, Rick A; Scaief, C C III (Chuck)  
Cc: Merriman, Raymond E; Reberger, Dan W; Rang, Bradley K  
Subject: Flygt Pump - Power Cable

All:

I Faxed the cable specification for the Flygt Pump to all of you, except Chuck, yesterday. I made an incorrect notation on the bottom of the front page that the cable was "Not Class 1, Div.1, Gp B". It has been pointed out to me that the cable does meet the requirement of NEC 501-11 and as such it does meet the above requirements for Class 1, Div. 1, Gp B.

I have also checked out the cable specification with the chairperson and secretary the Hanford Electrical Contractor Safety Board, and they agree that the cable meets the requirements of NEC 501-11.

As such, the cable is acceptable to be used in a Class 1, Div. 1, Gp B situation such as the DSTs.

Please review this information and let me know if you concur or if I have overlooked something.

Thank You

Ray
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<tr>
<td>8</td>
<td>10</td>
<td>1/0</td>
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</tbody>
</table>

Metric wire sizes are expressed as millimeters squared. This is the cross-sectional area of the copper conductor.

---

### SUBCAB-AWG Sales Specification

**SUBCAB-AWG** are those **SUBCAB** cables that are designed specifically to the U.S. and Canadian standards in the size range #14 AWG through #1 AWG.

The power cable shall be designed specifically for use with submersible pumps and shall be type **SUBCAB** (SUBmersible CABle). The cable shall be rated and applied in accordance with the National Electrical Code (NEC), and constructed according to the standards of the Insulated Cable Engineers Association (ICEA). The outer jacket shall be oil resistant chloroprene rubber, and the tinned copper conductors shall be insulated with ethylene-propylene rubber (EPR). The filler and conductor separator materials shall be of non-wicking vulcanized rubber. One of the conductors shall include marking on its insulation so that the cable may be identified in the event the external marking becomes unreadable. The outer jacket of the cable shall be marked "Water Resistant". The cable shall be rated for 600 volts and 90° C with a 40° C ambient temperature and shall be approved by Factory Mutual (FM) and the Mining Safety and Health Administration (MSHA). The cable length shall be adequate to reach the junction box without the need for splices.

---

### SUBCAB-Metric Sales Specification

**SUBCAB-IEC** are those **SUBCAB** cables that are designed to the international electrical standard IEC. They are usually used on large pump drive units as power and pilot cables.

The power cable shall be designed specifically for use with submersible pumps and shall be type **SUBCAB** (SUBmersible CABle). The cable shall be rated and applied in accordance with the National Electrical Code (NEC). The outer jacket shall be oil resistant chloroprene rubber, and the copper conductors shall be insulated with ethylene-propylene rubber (EPR). The filler and conductor separator materials shall be of...
non-wicking vulcanized rubber. All jacket and insulation materials shall be lead free. The cable outer jacket shall be marked "Water Resistant." The cable shall be rated for 750 volts and 90°C with a 40°C ambient temperature and shall be approved by Factory Mutual (FM). The cable length shall be adequate to reach the junction box without the need for splices.

**SUBCAB-AWG Technical Data**

<table>
<thead>
<tr>
<th>CABLE</th>
<th>PART NUMBER</th>
<th>PWR (3) (AWG)</th>
<th>GND (1) (AWG)</th>
<th>CNTL (2) (AWG)</th>
<th>GC (1) (AWG)</th>
<th>DIAMETER (INCHES) (MM)</th>
<th>WEIGHT LBS/FT</th>
<th>RATING AMPS* (@ 30°C)</th>
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<tr>
<td>#14/4</td>
<td>94 21 01</td>
<td>15</td>
<td>14</td>
<td>N/A</td>
<td>N/A</td>
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<td>14</td>
<td>14</td>
<td>14</td>
<td>0.71 - 0.79 (18.0 - 20.0)</td>
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<td>0.80 - 0.88 (20.3 - 22.3)</td>
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<td>1.60 - 1.68 (40.7 - 42.7)</td>
<td>2.4</td>
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</tbody>
</table>

*For ampacity @ 70°C, multiply 30°C ampacity by 0.58

**GENERAL**

**SUBCAB** is manufactured to **ITT Flygt** specifications and in accordance with the following standards:

- Insulated Cable Engineers Association (ICEA No. S-68-516).
- National Electrical Manufacturers Association (NEMA No. WC 8).
- Canadian Standards Association (CSA C 22.2, No. 49).
**RATINGS**
- Voltage - 600 Volts;
- Current - Determined by size of conductors;
- Temperature - 90° C total, based on a 40° C ambient.

**CODING**
- Power conductors - Black, White, Red;
- Ground Conductors - Green/Yellow or Green;
- Control Conductors* - Blue and Orange;
- Ground check* - Yellow.

*7-conductor cables only.

**MATERIALS**
- Jacket - Chloroprene rubber
- Conductor insulation - Ethylene Propylene Rubber (EPR)

**APPROvals**
- Factory Mutual;
- Mine Safety and Health Administration (MSHA);
- Canadian Standards Association (CSA).

---

**SUBCAB-Metric Technical Data**

<table>
<thead>
<tr>
<th>CABLE</th>
<th>PART NUMBER</th>
<th>DIAMETER INCHES (MM)</th>
<th>WEIGHT LBS/FT</th>
<th>RATING AMPS* (0°30°)</th>
<th>AWG EQUIV.</th>
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<tbody>
<tr>
<td>7X1.5</td>
<td>94 19 22</td>
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<td>0.26</td>
<td>20</td>
<td>#16</td>
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<tr>
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<td>0.72 - 0.83 (18.2 - 21.2)</td>
<td>0.36</td>
<td>20</td>
<td>#16</td>
</tr>
<tr>
<td>24X1.5</td>
<td>94 19 21</td>
<td>0.88 - 1.14 (24.5 - 28.9)</td>
<td>0.66</td>
<td>20</td>
<td>#16</td>
</tr>
<tr>
<td>7G1.5</td>
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<td>0.59 - 0.67 (15 - 17)</td>
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<td>20</td>
<td>#16</td>
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<tr>
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<td>94 20 46</td>
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<td>0.61</td>
<td>99</td>
<td>#3</td>
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<tr>
<td>4G25</td>
<td>94 20 47</td>
<td>1.28 - 1.36 (32.5 - 34.5)</td>
<td>1.28</td>
<td>131</td>
<td>#4</td>
</tr>
<tr>
<td>4G50</td>
<td>94 20 66</td>
<td>1.61 - 1.77 (41 - 45)</td>
<td>2.29</td>
<td>162</td>
<td>#1</td>
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<tr>
<td>4G70</td>
<td>94 20 67</td>
<td>1.77 - 1.93 (45 - 49)</td>
<td>3.02</td>
<td>237</td>
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<td>4G120</td>
<td>94 20 69</td>
<td>2.20 - 2.38 (56 - 65)</td>
<td>4.0</td>
<td>334</td>
<td>#10</td>
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</table>
Preparations are underway to be ready to pump the annulus of any Double-Shell Tank in the event of a primary tank waste leak. The method for pumping an annulus is to have a submersible pump staged in a mobile trailer ready to deploy when a leak is identified. The DST’s are either a Facility Group 1 or 2 and the pump column is considered Waste Intruding Equipment and must meet ISC Set 1 per Table 5.10-1 of the TSR.

The candidate pump (Gorman-Rupp Model SM2E) is an electric, submersible, centrifugal type pump. It will be part of a rigid supported column assembly that will be installed through the annulus pump pit 12” riser and extend down to a depth of approximately 50-feet.

Key information regarding the Gorman-Rupp SM2E Submersible pump is summarized below:

- The pump is approved by the Mine Safety and Health Administration (MSHA), and has an explosion-proof motor.

- The pump has an air-filled motor isolated from the waste by upper and lower (2) mechanical shaft seals, which are, operate in oil, as shown

- Motor temperatures are monitored by two thermal switches, embedded in the end coils of the stator windings. The switches have normally closed contacts, activation of either switch will shutdown the pump motor. In order to minimize arcing they are of the snap-action type. The thermal switch opens at a temperature of 145°C (293°F) and closes at 90°C (194°F). The electrical signal from the thermal switches will be modified to intrinsically safe or disconnected. Any thermal protection will be provided in the pump start/stop station located adjacent to the pit.

The following documentation is attached:

- Gorman-Rupp SM2E two page cutsheet (includes basic specifications, figures and performance data)
- Figure cutaway of pump internals and sketch of a representative tandem seal
- Descriptive Pages from a Gorman-Rupp Brochure
- Pages from the Gorman-Rupp Technical Manual
- Chemical resistance data on hypalon cable

03/14/00
I. I

Type 2: Rotating and Stationary Faces are Buna-N.
Type 22: Rotating Face is Carbon; Stationary Face is Cast Iron.

Two®, Operate in Off.
A complete line of American-made, MSHA approved submersible mine pumps.

Gorman-Rupp manufactures a complete line of submersible pumps designed for safe operation in gassy mines and tunnels.

Twenty-two different models are available in four basic discharge sizes: 2-inch, 3-inch, 4-inch and 6-inch. They are available from 1 to 60 horsepower, with capacities to 2175 gpm, heads to 380 feet.

These pumps are specifically designed for efficient mine dewatering operations. From the compact slimline design, which aids in portability and installation in the mine, to the superior hydraulic design, which reduces operating costs by delivering more gpm at less horsepower, the Gorman-Rupp submersible pump is the most efficient, dependable mine pump you can buy.

American-Made.
Standard parts. Easy Service.

Gorman-Rupp submersibles are manufactured in the U.S. with standard parts. No waiting for days or weeks for special cables or parts to arrive.

And if service is required, it can be completed quickly and easily with common hand tools. The easy-to-service design permits removal of impeller and suction head without loss of oil in the seal cavity.

MSHA Approved.

Gorman-Rupp submersibles are approved by the Mine Safety and Health Administration (MSHA) for use in gassy mines or tunnels. The approval is given for complete assemblies which include pump, control and cable. The components that make up this design cannot be changed or substituted without obtaining a new approval. All components must be restored to original condition after service.

These MSHA approved pumps should not be considered for use in hazardous environments other than mining without approval.

Most Gorman-Rupp pump models are also approved by the Commonwealth of Pennsylvania.

Special metal construction for corrosive/abrasive applications

Gorman-Rupp submersibles are designed for continuous, unattended operation in the most hostile mine environments.

The rotor shaft and all internal nuts and bolts coming in contact with the liquid are made of stainless steel to resist corrosion and pitting and extend the operational life of the pump.

In addition, stainless steel fitted pump models are available for corrosive applications. The suction head, impeller, and diffuser are constructed of CD4MCu.

For severely corrosive/abrasive applications, pump models constructed entirely of CD4MCu and 316 SST are available.

Round-the-clock unattended operation.

Gorman-Rupp submersibles are electric motor driven, so they operate unattended for long periods of time with no need for service personnel or fuel checks.

They operate totally or partially submerged, so there's no need to move the pump as the water level changes. The pumps are non-overloading, so they’ll run even in the worst conditions. And the pumps are designed to run dry for reasonable periods of time without seal damage.

Compact, slimline design for easy installation and handling.

The slimline design of Gorman-Rupp submersibles allows them to operate in hard-to-reach places where other pumps can't go. And they're light in weight for easy portability in the mine. For instance, the SM2F1 2" pump will deliver up to 110 gpm, yet weighs only 44 lbs. The easy-carry handles make handling and installation simple, even on the larger two-man units.

Tandem, in-line design.

The discharge of one pump can be connected through hose and couplings to the suction of another for in-line series operation which effectively doubles the head at a given flow, eliminating the need for a variety of different size pumps. The narrow slimline design doesn't take up space, so the pumps stay clear of machinery and conveyors.

Reduced operating costs.

Gorman-Rupp submersibles are designed to provide maximum output with minimal power consumption. The improved hydraulic design allows them to deliver more gpm at less horsepower than other submersible mine pumps.
Corrosion-resistant stainless steel shaft and hardware.

Rotor shaft and all internal nuts and bolts coming in contact with the liquid are made of stainless steel to resist corrosion and pitting and extend the operational life of the pump. For severely corrosive applications, stainless steel fitted and all-stainless pump models are available.

Rugged impeller handles tough abrasives.

Abrasion-resistant impellers stand up to coal fines, slurries, and other abrasive mining materials. The fully-shrouded impeller back reduces seal pressure and helps prevent foreign materials from entering the seal cavity. Seal life is extended and operational life of the pump is increased.

Dual seals. Double protection.

Primary seal keeps dirty water in the pump end and prevents contamination of the oil cavity. A second "fail safe" seal provides extra protection against the possibility of damage to the motor. Positive oil lubrication enables the pump to run dry without seal damage.

Gorman-Rupp explosion-proof motors

Three phase 460- or 575-volt explosion-proof motors specifically designed for vertical submersible pumps, and meet all MSHA requirements for use in hazardous mine locations (30 CFR, Part 18).

Pictured above are several motor stators which will undergo rigorous quality control checks before becoming part of a Gorman-Rupp explosion-proof motor. Manufacturing of pumps and controls at Gorman-Rupp provides single source responsibility and ensures fast parts service when necessary.

Motor cavity keeps motor cool.

When Gorman-Rupp submersibles start pumping, a flow of water is established between the inner and outer walls of the motor housing which cools the motor and prevents overheating.
Model SM2E
MSHA Approval No. 2G-3015A-2
Commonwealth of Pennsylvania No. BFE-637-77
Discharge ............................................ 2-inch
Solids Handled ..................................... 5/16-inch
Horsepower ............................................ 3.5
Hertz ..................................................... 60
RPM ................................................... 3450
Voltage ................................................. 460 or 575 volt, 3 phase, 6.8 Kw
Cable ................................................... # 14 gauge, 50' length
Weight ........................................... 57 lbs.

Model SM3B and SM3C
MSHA Approval No. 2G-3481A-0
Commonwealth of Pennsylvania No. BFE-637-77
Discharge ............................................. 3-inch
Solids Handled ..................................... 3/8-inch
Horsepower ........................................... 6
Hertz .................................................. 60
RPM ................................................... 3450
Voltage ............................................... 460 or 575 volt, 3 phase, 6.8 Kw
Cable ................................................... # 10 gauge, 50' length
Weight ........................................ 106 lbs.
Figure 3. Pump Model SM2E65-X3.5 480/3 & 575/3
## PARTS LIST

Pump Model SM2E65-X3.5 460/3 & 575/3

(From S/N 915775 up)

If your pump serial number is followed by an "N", your pump is NOT a standard production model. Contact the Gorman-Rupp Company to verify part numbers.

<table>
<thead>
<tr>
<th>ITEM NO.</th>
<th>PART NAME</th>
<th>PART NUMBER</th>
<th>MAT'L CODE</th>
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<td>SUCTION CASING</td>
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<td>3 *</td>
<td>SEAL ASSEMBLY</td>
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**NOT SHOWN:**
- QUART SUBMERSIBLE PUMP OIL
- VOLTAGE TAG (430V)
- VOLTAGE TAG (575V)
- CONTROL BOX (460V)
- CONTROL BOX (575V)

* INDICATES PARTS RECOMMENDED FOR STOCK

Above Serial Numbers Do Not Apply To Pumps Made In Canada.

CANADIAN SERIAL NO. .................................................. AND UP
Figure 6. Pump Motor (SM2E65-X3.5 460/3 & 575/3)
# PARTS LIST

Pump Motor 47111-058 (SM2E65-X3.5 460/3)  
and  
Pump Motor 47111-069 (SM2E65-X3.5 575/3)

<table>
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<tr>
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<th>PART NAME</th>
<th>PART NUMBER</th>
<th>MAT'L CODE</th>
<th>QTY</th>
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<td>36</td>
<td>SNAP RING</td>
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**OPTIONAL:**  
- HOT-MELT ADHESIVE (1/2 IN. STICK)  
  18661-044  

* INDICATES PARTS RECOMMENDED FOR STOCK
PUMP POWER CABLE CONNECTION INSTRUCTIONS

1. Run the pump cable through the packing gland nuts and washers (the concave side of the washer should toward the packing) at the bottom of the control.

2. Connect the white, black, and red power leads to terminals "T1", "T2", and "T3", respectively.

3. Connect the green ground lead to terminal "GRD".

4. Connect the yellow ground check lead to terminal "GC".

5. Connect the blue control lead to terminal "P1".

6. Connect the orange control lead to terminal "P2".

7. Install the packing in the gland with the washers on each side, and tighten the packing gland nut. With the nuts tight and the packing fully compressed, there must be a minimum space of 1/8 inch between the bottom of the nut and the enclosure.

8. Use the seal wire (P/N 31311-004) and lead seal (P/N 21188-002) to secure the packing gland nut to the enclosure. Use the hole in the hex nut and the hole at the top left of the enclosure to prevent loosening of the nut. See Terminal Housing And Power Cable Reassembly And Installation in Section E for details.
Record of Telephone Conversation

To:       Bruce Pfieffer of Gorman-Rupp
From:    Paul Dorsh
Date:     March 07, 2000
Subject: Stainless Steel Submersible Pump Model SM2E65-X3.5

The following bits of information were discussed:

1. The upper and lower single groove ball bearings used in the pump are both SKF Model 6303-2RS. The maximum operating temperature of the seal (taken at the seal housing) is 220° F.

2. The material used for the cable jacket on the MSHA approved pump is Hypalon. This is very similar to Neoprene, which is used on the standard (non-MSHA approved) pump.

3. The air filled motor is not completely surrounded by the pumped fluid. As seen in the Specification Data sheet, only half of the motor is surrounded and cooled by the pumped fluid.
# DuPont Products Database Search Results

## Hypalon(R) vs. Chlorosulfonated Polyethylene

**Description:**
Chlorosulfonated polyethylene, in white chips, used for a wide range of industrial and consumer products that require high performance characteristics.

<table>
<thead>
<tr>
<th>Uses:</th>
<th>Industries:</th>
</tr>
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<tbody>
<tr>
<td>- Jacketing and insulation for wire and cable</td>
<td>- Adhesives</td>
</tr>
<tr>
<td>- Automotive components</td>
<td>- Aerospace and Aircraft</td>
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<tr>
<td>including:</td>
<td>- Apparel and Footwear</td>
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<tr>
<td>- High-temperature timing belts</td>
<td>- Appliances</td>
</tr>
<tr>
<td>- Power steering pressure hose</td>
<td>- Architecture and Design</td>
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<td>- Gaskets</td>
<td>- Automotive</td>
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<td>- Coated fabrics</td>
<td>- Computers and Electronics</td>
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<td>- Sheet roofing</td>
<td>- Construction</td>
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<tr>
<td>- Liners and covers for:</td>
<td>- Consumer Goods</td>
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<tr>
<td>- Waste-containment ponds</td>
<td>- Containment</td>
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<tr>
<td>- Variety of protective and decorative coatings</td>
<td>- Control Systems</td>
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<td>- Industrial products such as:</td>
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<tr>
<td>- Hose</td>
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<td>- Rolls</td>
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<td>- Linings for chemical processing equipment</td>
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<td>- Toys and Leisure Products</td>
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<td>- Waste Disposal</td>
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http://www.dupont-dow.com/

Business: DuPont Dow Elastomers
Product Contacts
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<td>HARD RUBBER</td>
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<th>SODIUM HYDROXIDE, 50%</th>
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Double-Shell Tank Annulus Auxiliary Transfer Pump
Hydrostar Air Driven Piston Pump
Submitted For FGEAB Evaluation

Preparations are underway to be ready to pump the annulus of any Double-Shell Tank in the event of a primary tank waste leak. The method for pumping an annulus is to have a submersible pump staged in a mobile trailer ready to deploy when a leak is identified. The DST’s are either a Facility Group 1 or 2 and the pump column is considered Waste Intruding Equipment and must meet ISC Set 1 per Table 5.10-1 of the TSR.

The candidate pump (Hydrostar “Ground Water Sampling Pump”) is an air driven, double-check valve, positive displacement piston pump. It will be part of a rigidly supported column assembly, alongside an electric submersible pump, that will be installed through the annulus pump pit 12” riser and extend down to a depth of approximately 50 feet. The Hydrostar pump is adept at removing fluid down to the minimum possible level. It’s purpose is to augment the centrifugal type, electric submersible pump which will lose its suction at a level above what the Hydrostar pump can pump down to.

Key information regarding the Hydrostar pump is summarized below:

- **The pump has no electrical components.** The pump is driven by an air motor cylinder using minimal CFM of compressed air. Air exhaust will be in the annulus pump pit; no air is forced “downhole”.

- **The pump is less than 2” in diameter.** Flow rates are between 3 and 5 gpm. Manual operation through the use of a portable manual handle is possible to a depth of 100’ (ie. the force to lift and lower the piston is not great).

- **The piston assembly has a teflon seal on each end which seals against the stainless steel pump housing** (see attached vendor sheets). This seal provides the vacuum which sucks fluid into the pump during the upstroke cycle. On the downstroke, a spring assembly pulls the piston back towards the stationary lower ball check assembly and fluid exits the pumping chamber. The process fluid provides lubrication between the seal and the pump housing.

The following documentation is attached:

- Hydrostar vendor data sheets (10), from Instrumentation Northwest Inc.
- Detailed description of Hydrostar pump components and principle of operation
DEEP PERFORMANCE UNMATCHED BY ANY OTHER SAMPLING DEVICE

The HydroStar is a unique ground water monitoring device for dedicated applications. It is unsurpassed in its ability to deliver high-quality ground water samples from extreme depths in 2" or larger wells. Commonly used ground water sampling pumps, such as bladder pumps and small-diameter electric submersible pumps are limited to depths of 300 feet. The HydroStar can pump from depths of 500 feet! This performance is achieved without electricity and without the use of compressed air inside the well.

The HydroStar is just 1.62 inches O.D. It can be installed in 2-inch and larger monitoring wells. It can achieve a range of flow rates from 3 to 5 GPM for purge pumping, and adjusts easily to produce low flow rates suitable for sampling.

ONE PUMP, TWO JOBS

Variable flow rates mean the HydroStar can efficiently perform two required operations for ground water monitoring - purge pumping and sampling. Teflon™, 300-series stainless steel and viton components ensure sample quality. The dedicated system design virtually eliminates the possibility of cross-contamination. Sample quality has been analyzed and found to be statistically indistinguishable from that obtained with bladder pumps.*

PROVEN PERFORMANCE WHERE IT MATTERS - IN THE FIELD

Hundreds of HydroStar systems have been installed since 1986. At nuclear facilities, landfills, mining operations and other severe environments, HydroStar systems have performed where no other sampling device could do the job.

Instrumentation Northwest, Inc.
(800) PRO-WELL
APPLICATION NOTE:
Hydrostar System Air Motors
May 5, 1992

Introduction

When sizing an air-driven system one must consider the air motor cylinder size being used, the stroke rate desired to produce a certain production rate (GPM) and the air consumption of the air motor.

Air Cylinder Size

Without going through the formulas, outlined below is a general guideline table for selecting the proper size air motor depending on the installation depth of the HydroStar. For each motor size a range of values is given: the Maximum Full Speed Depth (MFSD) and the Maximum Recommended Depth (MRD). The Maximum Full Speed Depth is the installation depth where some loss in air motor performance will begin to occur. The Maximum Recommended Depth is the deepest installation depth we would recommend using this size air motor.

<table>
<thead>
<tr>
<th>Cylinder size (in)</th>
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<th>2.5</th>
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<tr>
<td>MFSD (ft)</td>
<td>76</td>
<td>146</td>
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<td>392</td>
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<tr>
<td>MRD (ft)</td>
<td>106</td>
<td>205</td>
<td>337</td>
<td>549</td>
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Production Due to Stroke Rate

The HS-8000 and HS-8001 pumps are 1.5” diameter pump cylinders with a stroke rate of 12 inches. If we assume that the pumps operate at 90% efficiency the production factor of the pumps is .082 gallons per stroke. Note: Actual field studies rate the efficiency of the HydroStar pumps better than 90% at their rated operating depth capacity (see pump curves).

Example: If your pump is operating at 40 strokes per minute your production rate would be 40 * .082 = 3.29 gallons per minute.

Air Consumption (at 80 PSI operation)

Air consumption is a factor of the cylinder size you use and the stroke rate of the cylinder. The HydroStar system can operate up to 60 strokes per minute down to less than 1 stroke per minute so naturally the air consumption will vary depending on the desired operating speed.

Below is a table of factors one can use to determine the air consumption of your system in Standard Cubic Feet (SCF). (These factors are just guidelines since a number of additional variables can effect air consumption).

<table>
<thead>
<tr>
<th>Cylinder Size (in)</th>
<th>1.5</th>
<th>2.0</th>
<th>2.5</th>
<th>3.25</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air consumption (SCF per stroke)</td>
<td>.10</td>
<td>.18</td>
<td>.30</td>
<td>.49</td>
<td>.76</td>
</tr>
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</table>

Example: A HydroStar system operating at 40 strokes per minute using a 1.5 inch cylinder would need .1 * 40 = 4 SCFM of air.
Freeze-up Considerations

The air cylinders used by INW employ a 4-way valve to switch cylinder direction. Under moist, cold conditions the 4 way valve can be frozen due to air expanding through the valve. The freeze up is due to moisture in the air lines.

The best way to minimize or eliminate freeze up problems is to use dry air. However, air dryers are expensive and not always practical.

What we have found to be the most practical solution is to install a pre-filter, a secondary oil/water removal filter and a lubricator. When installing, they should be put as close to the air cylinder as possible. The lubricator should then be filled with an anti-freeze lubricant such as Kil Frost. However, for sampling applications no lubricant should be used because of potential exhaust contamination.

Comments:
Instrumentation Northwest appreciates any comments you may have regarding this application note. Please call or write to:
MEETING THE HIGH STANDARDS WITHOUT THE HIGH COST

HYDROSTAR™
GROUND WATER SAMPLING SYSTEM
TOP PERFORMANCE, LOW COST,
UNCOMPROMISING RESULTS

Ground water monitoring is a high-stakes industry. Whether sampling ground water at industrial sites, landfills, or Superfund sites, you demand equipment that will produce a highly accurate sample. Any compromise could cost you thousands—or millions—of dollars in repeat testing or re-evaluation.

There are a variety of ground water monitoring systems available, and many obtain accurate samples. But now there's a sampling system that meets the high standards without the high costs. Instrumentation Northwest, Inc. has developed a system that gives you more than accuracy.

INW's HydroStar™ Ground Water Sampling System produces consistently reliable samples, faster and more economically than conventional methods. You can purge a monitoring well at the high rate of 3 to 5 gallons per minute, then reduce the flow to obtain your sample—with a single dedicated pump and a portable motor.

Because it is a dedicated system, and it is constructed of the most chemically inert materials available, the HydroStar™ ensures virtually no risk of cross-contamination or sample alteration. You can obtain an accurate sample the first time, every time.

And the HydroStar™ is versatile. It can be used in 2-inch or larger monitoring wells, ranging in depth from 5 feet to 500 feet. It can be operated by either manual or automatic motors, allowing you to tailor the HydroStar™ to your specific monitoring needs.

What's more, the HydroStar™ is easy to install and simple to operate. Both training and field time are low, and the chance for operator inconsistency is near zero.

SPEED. ACCURACY. RELIABILITY. INTEGRITY.

The HydroStar™ offers the most cost-effective solution in ground water monitoring today. If you want to meet the high standards without the high costs, turn to the HydroStar™ for your next monitoring program.

THE MAJOR BENEFITS ENJOYED BY HYDROSTAR™ USERS.

"Our experience with the HydroStar™ has been very positive. We conducted our own VOA sample integrity study and were pleased to find the sample integrity to be better than that of a bailer. The simplicity, overall and sample sample handling, allowed us to save a great deal of time in the field."

Warren Perkins
Woodward Clyde Consultants
Seattle, Washington.

"The HydroStar™ has allowed us to purge and sample with a single pump, from a depth of 690 feet—something that no other sampling system can accomplish. I have recommended the HydroStar to others who are looking for a more cost-effective dedicated sampling system and I will continue to do so in the future."

Glenn AbduNur
Bermite Division of Whittaker
Saugus, California.
FEATURES THAT ENSURE TOP PERFORMANCE

QUALITY CONSTRUCTION
Made of stainless steel virgin fiber, the two materials combine the greatest chemical resistance and strength.

SMALL-DIAMETER DESIGN
Designed for use in existing and new monitoring wells. With an outside diameter of just 1.625 inches, the HydroStar™ can be installed in wells as small as 1.75 inches inside diameter.

OPTIMUM SAMPLE INTEGRITY
With a dedicated HydroStar™ Sampling System, there’s no risk of cross-contamination between wells. Plus, there’s no downhole air that can introduce contaminants to the well. The chemically inert materials used in its construction ensure the most unbiased samples.

HIGH PURGING RATES
By constant cycling of the HydroStar™ in the 40-to-60 stroke per-minute range, purge rates of 3 to 5 gallons per minute may be obtained with minimal submergence.

CONTROLLED SAMPLING RAILS
The pumping rate for sampling can be reduced to less than 2.5 gallons per minute by simply reducing the stroke rate of the pump.

FLEXIBLE POWER OPTIONS
Interchangeable manual or automatic motors can be used at multiple pump installations.

IMPRESSIVE DEPTH CAPACITIES
Consistently high discharge rates of at least 4 gpm can be achieved against pumping heads of 5 to 500 ft.

NO DOWNSHIFT MOTORS
A pressure motor is in the system. There’s no risk of costly downhole motor failure or leakage.

QUICK INSTALLATION
Installation to 400 feet is accomplished in approximately 20 minutes.

EASY OPERATION
Operators require very little training to master the simple principles of operation.

EXTENDED WARRANTY
Limited two-year warranty on all parts, except seals, is standard.

BENEFITS ONLY A SMALL-DIAMETER PUMP CAN OFFER

The overall cost of a ground water monitoring program includes more than sampling equipment and the associated labor expenses. The cost of drilling the wells and treating or disposing of water pumped prior to sampling can effect a dramatic increase in the bottom line.

- The HydroStar™ unique narrow design allows you to work a 2 inch well, which can reduce your sampling costs in a number of ways. Two 1 inch wells:
  - Can be installed by smaller, less expensive drilling equipment.
  - Require less costly well completion materials.
  - Can accommodate required characteristics such as pump and slug testing where 25 to 500 gpm pump rates are acceptable.
  - Contain only one-quarter the casing volume of 4 inch wells.
  - Can achieve a 35% reduction in pump water and purge time.

In addition, dewatering and recovery operations may be accomplished in the same less costly 2 inch monitoring well.
PRINCIPLES OF OPERATION

The HydroStar™ is a double check valve, positive displacement piston pump. It employs a simple, single action design. The upper piston is actuated with a rod from the surface. Patterned after the slacker rod technology used in the oil industry, the pump motor remains at the surface so that only the pump, rod and discharge pipe are downhole in contact with the water.

The pump body is divided into an upper and lower chamber by the upper check valve, or piston. This piston is connected to the rod and is actuated from the surface by the motor. When the piston is raised, the check valve closes and moves the water column upward. Simultaneously, the lower check valve is opened due to head pressure in the well. This head pressure fills the lower chamber with water.

When the piston is lowered, the lower check valve closes and the check valve in the piston opens, allowing the water to pass from the lower chamber into the upper chamber. Continuous raising and lowering of the piston pumps the water to the surface.
The performance curves shown below represent the calculated purge rates when operating the various systems at an optimum rate of 60 strokes per minute with an efficiency factor of 88%.

**HYDROSTAR™ SAMPLING MOTORS**

The Portable Automatic Motor incorporated in the HydroStar™ Sampling System offers the following features:

**OPERATES ON INDUSTRIAL COMPRESSOR AIR**
Since no air is used downhole there is no need for expensive oil-less compressors or inert gasses.

**PORTABLE**
Easily moved from well to well to operate an array of HydroStar™ sampling pumps.

**SIMPLE OPERATION**
Pump is set up with two clevis pins and operated by connecting an air supply with a quick coupler. Start, stop, and speed are activated by controls mounted on the motor.

Manual operation is possible through the use of the portable manual handle. System operation with manual handle is possible to a depth of 100' and allows shallow wells to be sampled without compressor-driven equipment.

**WARRANTED**
One-year unlimited usage warranty.
WELL COMPLETION ASSEMBLIES

<table>
<thead>
<tr>
<th>CASING SIZE</th>
<th>STAINLESS STEEL PART NO.</th>
<th>PVC PART NO.</th>
<th>REQUIRED CLEARANCES</th>
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</thead>
<tbody>
<tr>
<td>2</td>
<td>QE-20-V001</td>
<td>QE-20-V001</td>
<td>P/N</td>
</tr>
<tr>
<td>4</td>
<td>QE-40-V001</td>
<td>QE-40-V001</td>
<td>11&quot;</td>
</tr>
<tr>
<td>6</td>
<td>QE-60-V001</td>
<td>QE-60-V001</td>
<td>11&quot;</td>
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</tbody>
</table>

DISCHARGE COLUMN (WITH ROD)

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>MAXIMUM DEPTH</th>
<th>O.D.</th>
<th>PART NUMBER</th>
<th>LENGTH</th>
</tr>
</thead>
<tbody>
<tr>
<td>PVC</td>
<td>150'</td>
<td>1.03&quot;</td>
<td>OB-50</td>
<td>10'</td>
</tr>
<tr>
<td>Stainless Steel</td>
<td>500'</td>
<td>1.03&quot;</td>
<td>OB-40</td>
<td>10'</td>
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<tr>
<td>PVC, FTJ Adapters</td>
<td>1.03&quot;</td>
<td></td>
<td>CM-13-D1</td>
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</table>

HYDROSTAR PUMPS

<table>
<thead>
<tr>
<th>MAXIMUM DEPTH</th>
<th>O.D.</th>
<th>LENGTH</th>
<th>PART NUMBER</th>
<th>GALLONS PER STROKE</th>
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</thead>
<tbody>
<tr>
<td>HS8000-1</td>
<td>150'</td>
<td>1.625</td>
<td>QA-10-V001</td>
<td>50</td>
</tr>
<tr>
<td>HS8001-1</td>
<td>500'</td>
<td>1.625</td>
<td>QA-11-V003</td>
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OPERATING MOTORS

<table>
<thead>
<tr>
<th>MAXIMUM DEPTH</th>
<th>STROKE</th>
<th>WEIGHT</th>
<th>PART NUMBER</th>
<th>AIR CONSUMPTION</th>
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</thead>
<tbody>
<tr>
<td>2.5&quot; Air Motor</td>
<td>300'</td>
<td>12'</td>
<td>QD-20-V001</td>
<td>15 CFM</td>
</tr>
<tr>
<td>3.25&quot; Air Motor</td>
<td>500'</td>
<td>12'</td>
<td>QD-20-V005</td>
<td>22 CFM</td>
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<tr>
<td>Manual Handle</td>
<td>100'</td>
<td>10'</td>
<td>QD-10-V001</td>
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SAMPLE AND PURGE HOSES

<table>
<thead>
<tr>
<th>PART NUMBER</th>
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<tr>
<td>QG-01-V001</td>
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<tr>
<td>QG-01-V002</td>
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OPTIONAL ACCESSORIES

<table>
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<tr>
<th>PART NUMBER</th>
</tr>
</thead>
<tbody>
<tr>
<td>QE-30</td>
</tr>
<tr>
<td>QE-20-V001</td>
</tr>
</tbody>
</table>

PACKAGING AND SHIPPING INFORMATION

Hydrostar Systems are sealed in a 6 mil polyethylene plastic and packaged in cardboard tubes for shipping to ensure that the system arrives ready to install. All components may be shipped UPS, except 10' lengths of discharge column which must be shipped by truck or air cargo. All systems are F.O.B. Redmond, Washington.
COMPARE THE COSTS

With faster set-up, purging, and sampling times, the HydroStar™ can cut your sampling costs by as much as 90%.

The following table compares equipment and operating costs of the four leading types of sampling systems: a Bailer (B); a Bladder Pump (BP); a Bladder Pump with a Submersible Purge Pump (BP/SP); and the HydroStar™ piston pump (HS).

WELL CHARACTERISTICS

Five monitoring wells, each 150 feet deep with 4-inch Schedule 40 casing. Casing volume for each well is 25 gallons, which requires the purging of approximately 375 gallons for all 5 wells.

<table>
<thead>
<tr>
<th></th>
<th>B</th>
<th>BP</th>
<th>BP/SP</th>
<th>HS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Equipment Cost</td>
<td>$934</td>
<td>$8,088</td>
<td>$18,220</td>
<td>$12,071</td>
</tr>
<tr>
<td>Purge Rate (gpm)</td>
<td>.15</td>
<td>.15</td>
<td>5.0</td>
<td>5.0</td>
</tr>
<tr>
<td>Purge Time (hrs)</td>
<td>43.00</td>
<td>12.90</td>
<td>1.27</td>
<td>1.27</td>
</tr>
<tr>
<td>Set-up and Sample Time (hours)</td>
<td>5.0</td>
<td>3.3</td>
<td>5.03</td>
<td>3.33</td>
</tr>
<tr>
<td>Total Time Per Sampling Event (hours)</td>
<td>48.8</td>
<td>16.2</td>
<td>6.30</td>
<td>4.61</td>
</tr>
<tr>
<td>Labor Cost Per Sampling Event ($/hour)</td>
<td>$1,708</td>
<td>$567</td>
<td>$220.50</td>
<td>$161.35</td>
</tr>
</tbody>
</table>

*Based on 1989 costs.

OPERATING COSTS FOR QUARTERLY MONITORING

1. Based on five-well program described in table above. Includes 1989 equipment and operating costs, but not cost of installation.
2. Bailer sampling is not graphically represented. Sampling costs accumulate at $1708.00 per event to a total of $33,090 at the end of 20 sampling periods.
TO: Greg Leshikar  
FROM: Paul Dorsh  
DATE: 2/25/00  
SUBJECT: Hydrostar pump assembly and operation

Components of Pump Assembly
There are 5 main components of the pump operating assembly: The Pump, Discharge Pipe, Actuating Rod, Well Seal/Completion Assembly, and Air Motor.

Pump - (Figure 1) The pump housing is made of stainless steel, has an outside diameter of 1 5/8" and a length of 26". The top of the housing contains a ¾" NPT female fitting used for fluid discharge. A piston, which separates the lower and upper chambers in the pump, contains upper and lower Teflon seals and a passage running through it holding a stainless steel ball check. The opening of the ball check allows fluid in the lower area to enter the upper area through the passage in the piston. The top of the piston is mounted to the actuating rod for manipulation. A spring is attached to the bottom of the piston and is anchored at the bottom ball check assembly. The spring provides force for the downstroke of the piston. The bottom ball check assembly is held in a fixed position, via 2 allen head screws located near the bottom of the pump. The bottom ball check is sealed to the pump with a Viton O-ring. The bottom ball check assembly is opened on an upstroke of the piston and allows fluid to enter the lower chamber through the bottom of the pump.

Discharge Pipe - (Figure 2 & 4) ¾" stainless steel sch-40 pipe is used. The pipe is connected to the pump via the ¾" NPT female fitting located on the top of the pump housing. The piping generally comes in 10-ft sections (can be varied) and is coupled together to achieve the customers desired length. The top of the discharge piping is attached to the Well Seal/Completion Assembly (Figure 3).

Actuating Rod - (Figure 2 & 4) ¼" stainless steel rod is used. The actuating rod is located inside the discharge pipe. The rod runs down through the pump's ¾" NPT female discharge fitting and is attached to the top of the pump's piston (Figure 1). The standard length of the manufacturer's actuating rod is 10 ft. 10-ft rod sections can be coupled together by use of a Coupling Nut to achieve our specified length. On top, the actuating rod runs through the well seal / completion assembly (Figure 3). A turnbuckle
assembly is attached to the top of the rod and is used by an air motor or manual handle for actuation.

**Well Seal / Completion Assembly** — (Figure 3) The well seal / completion assembly is the point of separation for the discharge piping and the actuating rod. The discharge pipe is connected to a discharge tee, which diverts the flow away from the actuating rod. The actuating rod continues up through the discharge tee and through a rod seal assembly, which seals the flow. A turnbuckle is attached to the top of the actuating rod, which will be used as an attachment point for the air motor. The well seal is typically a 2" diameter PVC or stainless steel cap that fits over the top of well casings. It serves the purpose of holding the pump assembly in place. This piece can be modified or removed depending on the design.

**Air Motor** — (Figure 2) The air motor sits on a platform, which is attached to the well seal, and manipulates the actuating rod. More detail on the motor is coming.

**Pump Actuation**
The air motor is attached to the ¾" actuating rod via the turnbuckle. The actuating rod, running down the discharge pipe, is attached to the piston. As air pressure is applied to the motor, the rod and piston are forced to cycle up and down.

**Pump Operation**
The pump operation consists of an upstroke cycle and a downstroke cycle (Figure 1).

**Upstroke** — When the control rod is pulled up, the upper ball check assembly restricts liquid flow and positively displaced the fluid in the upper pump chamber. The liquid is then lifted up the discharge pipe, while at the same time, the lower ball check assembly opens, allowing more fluid to enter the lower pump chamber.

**Downstroke** — The downstroke cycle is prompted by the spring attached between the upper and lower ball check assembly. Because the lower ball check assembly is stationary, the spring is in tension. The spring then pulls down on the upper ball check assembly. The upper ball check assembly opens and the lower ball check assembly
closes, causing fluid to be forced into the upper pump chamber. The pump cycle is now complete and the pumping cycle begins again with the next stroke.

According to the manufacturer, the bottom of the pump needs to sit 1" to 2" above the bottom of the tank to allow for proper fluid suction.

I hope this clears some things up for you. If you have anymore questions please give me a call (372-0289) and I'll try and help. The demo Hydrostar pump was shipped last night and should be here on Monday.
WELL SEAL / COMPLETION ASSY.

FIGURE 3

FIGURE 4
Dan:

The Flygt Model B-2060 submersible pump technical manual describes over temperature protection for the motor as follows:

Internal Protection Devices-Temperature; Motor temperatures are monitored by two thermal switches, embedded in the end coils of the stator windings. The switches have normally closed contacts and are wired in series. In order to minimize arcing they are of the snap-action type. The thermal switch opens at a temperature of 125°C + 6% (257°F + 11%) and closes at 95°C + 15% (203°F + 27%).

These snap-action switches are similar to the type in most home resistance electric house heaters, they are a very cheap bimetallic operated switch and they do arc if high enough voltage is impressed on them.

We could either not use the thermal switches or look into getting a signal from them at the intrinsically safe level.

Give me a call if this does not answer your questions.

Ray
### FLAMMABLE GAS EQUIPMENT ADVISORY BOARD
### INTERPRETATION/RECOMMENDATION REPORT

**Date:** March 20, 2000  
**Report No.:** FGEAB-00-002, Rev. 1

**Report No.:** FGEAB-00-002 Rev. 1  
**Date:** 3/20/00  

**Board Members:**  
M. G. Al-Wazani  
R. D. Gustavson  
R. A. Huckfeldt  
C. C. Scalf III  
R. L. Schlosser  
R. L. Schlosser  
D. B. Smet  

**Requestors/Presenters:**  
PM Dorm, FM Hauck, GA Leshikar, RE Merriman, BK Rariq, DW Reberger

#### Problem/Issue Statement:
Revision 1 corrects the evaluation of power cable for an electric submersible pump. The Authorization Basis does not provide flammable gas region definition for the annulus of the double-shell tanks under a condition of primary to secondary leak. The region classification and compliance of equipment to applicable ignition source control requirements needs to be developed for emergency pumping equipment.

#### Equipment/Activity Description:
In order to provide emergency pumping if a primary tank should leak to the annulus, a portable pumping system is required to be located in the DST annulus region. To provide a pump suitable for the service, appropriate flammable gas regions need to be established for the DST annulus and directly connected areas to the annulus. The proposed pumping system consists of a single or multiple Flygt® Model BS-2060 submersible electric pumps. The single stage or first stage will draw suction in the waste. The discharge of the first pump will feed the suction of the second pump in the multiple pump application. All electrical wire is contained in a single feeder cable.

The second pump is an Instrumentation Northwest HydroStar™ ground water sampling pump for removal of waste for small leakage quantities or residual leakage after bulk leakage has been removed. The HydroStar™ pump is an air driven piston pump with air discharge at the pump.

#### References:

**Authorization Basis:** HNF-SD-WM-SAR-067 and HNF-SD-WM-TSR-006, Administrative Control 5.10

#### Does equipment/activity comply with the AB ignition control requirements?
- [ ] Yes  
- [X] No  
- [ ] Other

See FGEAB Interpretation/Recommendation for flammable gas region definition.

#### If No, does equipment/activity provide equivalent design/measures/controls?
- [X] Yes  
- [ ] No  
- [ ] Other

**Explanation/Justification:**
The Flygt® Model BS-2060 Electric Submersible Pump is fitted with seal barriers and an oil barrier fluid for shaft sealing. The motor is not normally sparkling. The electrical cable enters a junction chamber and internal wiring from the junction chamber to the motor through resilient seal barriers. Therefore, a single failure of one of the seals or arcing of the motor winding is accommodated, providing equivalent safety to Ignition Source Control Set 1. The motor has a thermal switch that must meet intrinsic safety requirements if the switch is to be used. The electrical cable feed to the junction chamber must meet ISC1 requirements (NEC Class I, Division 1, Group B). The motor starter and thermal overload (if used) must be located in a nonintrusive region.

The heels pump is an Instrumentation Northwest HydroStar™ air driven piston pump with no electrical components. The pump utilizes Teflon piston seals to allow operation. In the applied condition, the Teflon piston seals are in continuous contact with the conductive piston wall and are wetted. In this applied condition, electrostatic charge build-up and discharge is precluded. Therefore, the HydroStar™ pump provides equivalent safety to Ignition Source Control Set 1.

If not equivalent, what changes are necessary to comply or provide equivalency?  
N/A
FLAMMABLE GAS EQUIPMENT ADVISORY BOARD
INTERPRETATION/RECOMMENDATION REPORT

Date: March 20, 2000

Report No: FGEAB-00-002, Rev. 1

FGEAB Interpretation/Recommendation:

Since the FSAR, HNF-SD-WM-SAR-067, does not address flammable gas conditions for a primary tank leak, the annulus of the DSTs is considered a nonintrusive region. However, under the design conditions following a postulated primary to annulus leak, the annulus is comparable to the primary tank from a flammable gas perspective. The condition has not been analyzed to determine gas retention and release behavior under this condition, therefore, the approach taken is to establish flammable gas regions and ignition source control requirements directly comparable to the Authorization Basis controls established for the primary tanks:

- Leakage collected in the bottom of the annulus is considered waste and the region classified as Waste Intrusive. Equipment extending into the waste is considered Waste Intruding Equipment.
- The vapor space in the annulus is considered comparable to the vapor space of the primary tank and the region classified as Dome Intrusive.
- Pits that drain to the annulus are considered comparable to pits draining to the primary tank and the region classified as Ex-Tank Intrusive.
- Areas around open risers to the lesser of 18 opening diameters or 15 feet are considered Ex-Tank Intrusive.
- Annulus ventilation systems are considered Dome Intrusive to the first mixing point. The ventilation system downstream of the first mixing point is considered Nonintrusive when active ventilation is on and Ex-Tank Intrusive when active ventilation is off.

The application of ignition source controls to the various regions is based on the potential for waste sludge to be included in the material leaked to the annulus. Since the sludge may potentially retain generated flammable gases, the material in the annulus is assumed comparable to wastes currently considered to be in Facility Group 1, 2, or 3 tanks. Therefore, applicable ignition controls are considered to be governed by the controls established in HNF-SD-WM-TSR-006, Administrative Control 5.10, Table 5.10.1 for the tank regions. The Facility Group for each annulus is taken to be the Facility Group for the primary tank in HNF-SD-WM-TSR-006, Administrative Control 5.9, Table 5.9.1.

<table>
<thead>
<tr>
<th>Equipment, Materials, &amp; Work Practices</th>
<th>Location</th>
<th>Ignition Control Set</th>
<th>IC Set Met</th>
<th>FGEAB Safety Equivalence Ruling</th>
<th>Approved Exception</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flygt® Model BS-2060 Electric Submersible Pump</td>
<td>FG 1, 2, 3 Waste Intrusive</td>
<td>ISC1</td>
<td>No</td>
<td>Yes*1</td>
<td></td>
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<tr>
<td>HydroStar™ Ground Water Sampling Pump</td>
<td>FG 1, 2, 3 Waste Intrusive</td>
<td>ISC1</td>
<td>No</td>
<td>Yes</td>
<td></td>
</tr>
</tbody>
</table>

*1 The electric cable must be qualified for Class 1, Division 1, Group B service. The thermal switch must be qualified for Class 1, Division 1, Group B or thermal switch must be de-energized. Motor starter and thermal overload must be located in a nonintrusive region.

General application of finding, if any:

Region definitions and Ignition Control Set applications are applicable to any Double-Shell Tank Annulus if a primary to secondary leak occurs.

FGEAB Representative: RL Schlosser
Date: March 20, 2000

FGEAB Reviewer: MG Al-Wazani
Date: March 20, 2000
Mazen and All:

The NEC, Article 501-11, allows for the use of Flexible Cords in Class I, Div. 1 areas. So this means Flexible cords meet the NEC or equivalent safety requirement below "no single point failure of energized equipment's can result in an arc, spark, or gas burn propagation to the environment external to the source enclosure."?

If this statement is true then we can look for a suitable cable, if it is not true then there is no use looking any further.

Dan tells me Mazen may have a source for a suitable cable, at this time I do not. Mazen can you pass any information on finding a suitable cable on to me when appropriate.

Thanks
Ray

Original Message

Ray,

All electrical equipment's shall meet IC set #1, this mean electrical equipment's shall be design to meet NFPA 70, Class I, Division 1, group B criteria or provide equivalent safety. As a minimum, this shall be interpreted to mean that no single point failure of energized equipment's can result in an arc, spark, or gas burn propagation to the environment external to the source enclosure.

Thanks,

Mazen
Ray:

For the FGEAB to accept the Code compliant electrical cable at the pump interface, you need to provide a Professional Engineer evaluation of each of the conditions of NEC Article 501-11 as allowed by the NEC. This will provide a basis for acceptance at the interface with the pump. Since the pump is acceptable to the FGEAB but not a Class 1, Division 1, Group B design, you need to focus your evaluation on equivalence of the design to the cable requirements of the NEC since the FGEAB only addresses equivalence to requirements, not compliance with the requirements.

Thank you,
Rich S
Preparations are underway to be ready to pump the annulus of any Double-Shell Tank in the event of a primary tank waste leak. The method for pumping an annulus is to have a submersible pump staged in a mobile trailer ready to deploy when a leak is identified. The DST's are either a Facility Group 1 or 2 and the pump column is considered Waste Intruding Equipment and must meet ISC Set 1 per Table 5.10-1 of the TSR.

The candidate pump (Flygt Model BS-2060) is an electric, submersible, centrifugal type pump. It will be part of a rigid supported column assembly that will be installed through the annulus pump pit 12" riser and extend down to a depth of approximately 50-feet.

Key information regarding the Flygt BS-2060 is summarized below:

- The pump has an air-filled motor isolated from the waste by upper and lower (2) mechanical shaft seals which are immersed in an oil bath, as shown in Figure 1. The rotating and stationary seal faces (of each seal) form a barrier to waste entry. The other barriers are achieved by o-ring of rotating seal assembly to pump shaft, and o-ring of stationary seal assembly to oil housing. (See attached sketch of tandem seal)

- Motor temperatures are monitored by two thermal switches, embedded in the end coils of the stator windings. The switches have normally closed contacts and are wired in series. In order to minimize arcing they are of the snap-action type. The thermal switch opens at a temperature of 125°C ± 6% (257°F ± 11%) and closes at 95°C ±15% (203°F ±27%). The electrical signal from the thermal switches will be modified to intrinsically safe or disconnected. Any thermal protection will be provided in the pump start/stop station located adjacent to the pit.

The following documentation is attached:

- Flygt BS-2060.390 two page cutsheet (includes basic specifications, 3x3 figures, performance data, dimensions)
- Figure 8 1/2 x 11, cutaway of pump internals
- Pages 1 thru 6 of Flygt Technical Manual
- Sketch of a representative tandem seal
- Telecon from SKF regarding bearing temperature
BS-2060.390

Small Dewatering Pump - Stainless Steel

Capacity up to 260 GPM, Heads up to 85 ft.

Applications:
BS-2060 is ideal for pumping water containing corrosive materials in concentration 3-14 pH.

Specifications
A Cable. Standard 50 ft. of AWG 12/7 SubCab cable. Other lengths available upon request.

B Junction Chamber. Cable entry incorporates a strain relief and grommet controlled compression sealing. Between the junction box and stator housing a rubber gland provides additional seal protection of the motor.

C Pump Housing. Stainless steel AISI/ASTM 316. Suction seals and leakproof Nitrile rubber O rings in precision machined grooves, with controlled compression.

D Shaft. Stainless steel AISI 329.

E Motor. Air filled, NEMA design B with class F (155°C) insulation; 2 pole, 3400 rpm. Shrink-fit to the motor housing. Allows at least 10 starts per hour. Built-in thermal sensors for additional motor overload protection.

F Bearings. Upper and lower: single row ball bearing.


I Wear Plate. Protected by Nitrile Rubber liner. Adjustable to maintain pump's hydraulic performance.

J Strainer. Stainless steel AISI 316, 156 holes 1/2” dia.

Fasteners. Stainless steel AISI 304.

Approval:
CSA approved to UL Standard #773.

Controls (not shown):
Manual controls, providing short circuit and overload protection, housed in NEMA 4X (water tight, corrosion resistant) plastic enclosures. Level control Model A.408/4X available for automatic, unattended operation.

Accessories:
Tandem connection.

ITT Flygt is a member of the following Associations:
This page intentionally left blank
Applications:
BS-2060 is ideal for pumping water containing corrosive materials in concentration 3-14 pH.
This Manual refers to Flygt's Electric Submersible Stainless Steel Contracting and Mining Pump. The B2060 is a portable centrifugal pump designed for use in a corrosive liquid environment. The pump is constructed of acid proof S15 2343 Stainless Steel capable of handling corrosive liquids as outlined on page 3 under "Chemically Acceptable Pumped Media". Where borderline chemical concentrations are encountered, or if in doubt, CONTACT FLYGT CORPORATION BEFORE USING.

Nominal Size: 3", 8 TPI NPSM Threaded Hose Connection

<table>
<thead>
<tr>
<th>ITEM NO</th>
<th>MATERIALS FOR B-2060 PUMP</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>CABLE ENTRY GROMMET-------CHLOROPRENE RUBBER</td>
</tr>
<tr>
<td>49</td>
<td>STATOR HOUSING-------------STAINLESS STEEL</td>
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<tr>
<td>51</td>
<td>JUNCTION CHAMBER COVER----STAINLESS STEEL</td>
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<td>52</td>
<td>BEARING HOUSING-----------CAST IRON</td>
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<tr>
<td>53</td>
<td>STRAINER BOTTOM-----------STAINLESS STEEL</td>
</tr>
<tr>
<td>54</td>
<td>CARRYING HANDLE-----------STAINLESS STEEL/RUBBER COATED</td>
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<tr>
<td>60</td>
<td>LOWER WEAR PLATE----------NITRILE RUBBER</td>
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<tr>
<td>63</td>
<td>SHAFT SEAL LOWER----------TUNGSTEN CARBIDE/CERAMIC</td>
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<td>72</td>
<td>SHAFT SEAL UPPER----------CARBON/CERAMIC</td>
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<tr>
<td>81</td>
<td>SHAFT/PART OF ROTOR UNIT  STAINLESS STEEL</td>
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<td>84</td>
<td>INPELLER-----------------CAST IRON or STAINLESS STEEL</td>
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<td>89</td>
<td>COOLING JACKET------------STAINLESS STEEL</td>
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<td>ALL SEAL O-RINGS----------FLUORINATED RUBBER</td>
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<td>ALL PUMP O-RINGS----------NITRILE RUBBER</td>
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<tr>
<td></td>
<td>HARDWARE (SCREWS, NUTS, &amp; BOLTS) STAINLESS STEEL</td>
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</tbody>
</table>
General: Your pump is designed to provide long and dependable service under normal and adverse conditions. Observation of certain rules and limitations will improve performance, reduce maintenance costs and extend useful service life. For more detailed information consult "Preventive Maintenance Schedule", Page 11.

Environmental Temperature Limits: The upper limit for both the pumped liquid and the general surroundings of the pump is 46°C (115°F). Operation at higher temperatures without written approval by Flygt is not covered by Warranty.

Volatileity: Volatile liquids vaporize readily even at normal (ambient) temperatures and pressures, causing the impeller to become "vapor bound". To prevent vaporizing (flashing) at the suction inlet, either the inlet pressure has to be increased or the temperature reduced. Always check vapor pressure and both Required and Available NPSH. Pumping of volatile liquids which are corrosive or hazardous is not recommended nor covered by Warranty.

Corrosion: The B2060 provides reasonable service in corrosive liquids within an approximate pH range of 3 to 11. Although the pH value will in most cases provide some indication of the nature and extent of corrosive effects, alone it is not conclusive. Excessive aeration or large underwater steel structures nearby can create galvanic action which will accelerate corrosion.

Specific Gravity: The power requirement (kw input) of a centrifugal pump increases proportionally with the Specific Gravity (S.G.) of the liquid. (See Solids Content of the Liquid).

Solids Content of the Liquid: A liquid (usually water) when containing suspended solids in various quantities, becomes a "slurry". There are no definite rules governing the pumping of slurries, some combinations are too stiff or viscous to be pumped at relatively low concentrations (clay, bentonite, & paper stock) while others can be pumped with considerable ease at much higher concentrations (coal, silt, sand, & dusts). In general, always check the S.G. and maintain a minimum flow velocity necessary to keep the solids in suspension (suggested approx. minimum = 5 F.P.S.).

Abrasion: When pumping liquids containing abrasive particles, inspect the pump (seals, wear plate & impeller) frequently. Low capacities (flow velocities) may result in sedimentation and accumulation of particles in the pump, causing abnormal wear or even clogging. On the other hand the higher the flow capacity, the higher the friction wear.

Liquid Flow: If the viscosity of the liquid is higher than that of water, the performance (head & flow output) will be adversely affected. If poor performance is encountered (low GPM and/or low head) have the viscosity checked by a competent analyst.

Submergence: The B2060 will operate with a minimum of submergence (flooded impeller). Deeper submergence will improve external cooling and reduce aeration. Depth limitation is 65 feet. Avoid depths with overconcentration of suspended solids. Check NPSH to avoid cavitation.

Voltage Limitations: Voltages at the pump terminal board must be within the following ranges: 230V Motor, 198V to 252V; 460V Motor, 396V to 506V; 575V Motor, 495 to 653V. Watch for undersized wiring systems or overlong cables which may cause excessive voltage drops. Measurement at the control box under full load is satisfactory if voltage drop in the pump cable is taken into consideration.

Voltage Balance (Three Phase): Proper balance among the three supply-voltage phases applied to the pump motor is vital. A voltage imbalance of only 1% between two phases will result in from 6 to 10% amperage imbalance. This can result in circulating currents internally in the stator, which may not appear as line-current differences but will cause excessive stator temperature rise, substantially shortening motor life, or cause a dry stator burn-out. These high temperatures can affect rotor, bearings, and shaft-seals also. Keep voltage imbalance below 1%.
Internal Protection Devices—Temperature: Motor temperatures are monitored by two thermal switches, embedded in the end coils of the stator windings. The switches have normally closed contacts and are wired in series. In order to minimize arcing they are of the snap-action type. The thermal switch opens at a temperature of 125°C + 6% (257°F + 11%) and closes at 95°C + 15% (203°F + 27%).

<table>
<thead>
<tr>
<th>CHEMICAL</th>
<th>FORMULA</th>
<th>TEMPERATURE LIMITS (°C) &amp; (°F)</th>
<th>CONCENTRATION PERCENTAGES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ammonium Hydroxide</td>
<td>NH₄OH</td>
<td>20</td>
<td>100%</td>
</tr>
<tr>
<td>Ammonium Carbonate</td>
<td>(NH₄)₂CO₃·H₂O</td>
<td>20</td>
<td>100%</td>
</tr>
<tr>
<td>Boric Acid</td>
<td>H₃BO₃</td>
<td>40</td>
<td>100%</td>
</tr>
<tr>
<td>Calcium Hydroxide</td>
<td>Ca(OH)₂</td>
<td>20</td>
<td>100%</td>
</tr>
<tr>
<td>Potassium Carbonate</td>
<td>K₂CO₃·2H₂O</td>
<td>20</td>
<td>50%</td>
</tr>
<tr>
<td>Sodium Carbonate</td>
<td>Na₂CO₃·10H₂O</td>
<td>20</td>
<td>30%</td>
</tr>
<tr>
<td>Sulfuric Acid</td>
<td>H₂SO₄</td>
<td>20</td>
<td>10%</td>
</tr>
</tbody>
</table>

Pump use limited to following chemical concentrations because of limited durability of pumps' rubber components.

<table>
<thead>
<tr>
<th>CHEMICAL</th>
<th>FORMULA</th>
<th>TEMPERATURE LIMITS (°C) &amp; (°F)</th>
<th>CONCENTRATION PERCENTAGES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acetic Acid</td>
<td>CH₃COOH</td>
<td>40</td>
<td>15%</td>
</tr>
<tr>
<td>Caustic Soda</td>
<td>NaOH</td>
<td>20</td>
<td>78%</td>
</tr>
<tr>
<td>Hydrofluoric Acid</td>
<td>HF</td>
<td>20</td>
<td>20%</td>
</tr>
<tr>
<td>Oxalic Acid</td>
<td>(COOH)₂</td>
<td>20</td>
<td>10%</td>
</tr>
<tr>
<td>Phosphoric Acid</td>
<td>H₃PO₄</td>
<td>50</td>
<td>50%</td>
</tr>
<tr>
<td>Potassium Hydroxide</td>
<td>KOH</td>
<td>20</td>
<td>15%</td>
</tr>
<tr>
<td>Stearic Acid</td>
<td>C₁₇H₃₅COOH</td>
<td>40</td>
<td>100%</td>
</tr>
<tr>
<td>Tannic Acid</td>
<td>C₁₄H₁₀O₉</td>
<td>40</td>
<td>100%</td>
</tr>
<tr>
<td>Tartaric Acid</td>
<td>C₂H₂(OH)₂(COOH)₂</td>
<td>20</td>
<td>30%</td>
</tr>
</tbody>
</table>

Table 1  CHEMICALLY ACCEPTABLE PUMPED MEDIA
Your B2060 pump is delivered connected for the voltage as specified (Fig. 1), and factory tested prior to shipment. **CAUTION:** Check that the power is off and disconnected before working on pump. The pump power cable, stator leads, and jumperstrips are arranged on the terminal board. Since the stator leads are connected to the terminal studs on top of the terminal board, the junction chamber cover must be removed to rearrange the leads for a different voltage. Be careful not to pinch stator leads or O-ring when re-installing junction chamber cover.

**POWER CABLE CONNECTIONS**
- **ALL VERSIONS**
  - **STATOR LEAD CONNECTIONS**
    - **230V (3 phase only)**
      - **STATOR LEADS COLOR CODE**
        - 1. **RED**
        - 2. **BROWN**
        - 3. **YELLOW**
        - 4. **GREEN**
        - 5. **BLUE**
        - 6. **BLACK**

**STATOR LEAD CONNECTIONS**
- **460 & 575V (3 phase only)**
- **230V (single phase only)**

**WARNING:**
GRAY LEADS, BROWN & GREEN LEADS, AND BROWN & BLUE LEADS ARE THERMAL SWITCH LEADS ONLY AND MUST NOT BE ATTACHED TO THE TERMINAL BOARD.
<table>
<thead>
<tr>
<th>VERSION</th>
<th>IMPELLER</th>
<th>RATED HP</th>
<th>RPM</th>
<th>DESIGN VOLTAGE</th>
<th>KW INPUT MAX</th>
<th>MAX CURRENT (AMPS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 Φ</td>
<td>ITEM 84A</td>
<td>3.7</td>
<td>3300</td>
<td>230/460</td>
<td>3.5</td>
<td>10/5</td>
</tr>
<tr>
<td></td>
<td>ITEM 84B</td>
<td></td>
<td></td>
<td>575*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 Φ</td>
<td>ITEM 84C</td>
<td>2.5</td>
<td>3400</td>
<td>230</td>
<td>2.3</td>
<td>10.5</td>
</tr>
<tr>
<td></td>
<td>ITEM 84D</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Separate Stator for 575 volt Service.

Power Cable: #12/3-2-1-GC Flygt Special, 7 Conductor; 3 Power, 2 Control, 1 Ground, and 1 Ground Check. Nominal O.D. 21mm = 0.83". Weight: 8 oz. per ft.

Pump Weight: 71 pounds

Table 2 IMPELLER AND ELECTRICAL DATA

MOTOR & WINDING RESISTANCES

Motor Design: Dry, shell-type, NEMA design B, squirrel cage induction motor, Class F, insulated, rated 155°C max, or 115°C rise (40°C ambient). Combined service factor of 1.10 (combined effect of voltage, frequency and specific gravity variations not to exceed this value).

<table>
<thead>
<tr>
<th>STATOR</th>
<th>RESISTANCE-ÖHMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>230/460V 3Φ</td>
<td>S1-S4, S2-S5, S3-S6 = 2.6 ± 3%</td>
</tr>
<tr>
<td>575V 3Φ</td>
<td>S1-S4, S2-S5, S3-S6 = 5.0 ± 3%</td>
</tr>
<tr>
<td>230V 1Φ</td>
<td>S1-S2, S3-S6 = 1.37 ± 3%</td>
</tr>
</tbody>
</table>

Values taken at 20°C (68°F). Winding resistance varies directly with temperature by approximately .40% per degree C.

Fig. 2 WINDING RESISTANCES

NOTE: See Instructions for "Testing Stator" on Page 16
Portable Manual Controls (Fig. 3 & 4): The Standard Flygt Control is housed in a NEMA-3 weatherproof enclosure. It must always be mounted vertically and protected from mud, water, and dust. The Portable Manual Control contains one combination circuit breaker/overload disconnect unit/motor temperature sensing coil, with hydraulic/magnetic trip elements sized for pump protection. The disconnect serves a multiple purpose: (1) manual ON-OFF switch, (2) short-circuit breaker protection, (3) closely calibrated overload protection which is factory pre-set, fast-acting and not affected by temperature changes, and (4) a motor temperature sensing coil which protects the stator windings from damage from excessive heat. If the circuit-breaker trips repeatedly, consult troubleshooting information in the Repair Section of this manual. Never bypass the circuit-breaker under any circumstances. If level regulation is desired, Flygt’s Liquid Level Regulating Control System can be supplied as an option (See Pages 23 through 28).
Jacketed Chamber

A seal chamber with internal flow passages to heat or cool the chamber fluid. Used with a thick throat bushing to thermally isolate the seal chamber from the process and to contain a minimum volume of fluid to be controlled.

Figure 4

Typical Jacketed Seal Chamber

Large Chamber

A seal chamber holding a greater fluid volume allows free fluid circulation around the seal. When mechanical seals are retrofitted to packed equipment, as little as .040" gap exists between the rotating seal and the chamber.

Figure 5

Typical Large Seal Chamber

Double Seal

Two mechanical seals that have a pressurized barrier fluid between them. The double seal can be configured in a back-to-back, tandem or face-to-face arrangement. Most back-to-back seals consist of two back-to-back rotaries running against an inboard (process side) and outboard (atmosphere side) stationary. In this configuration, the inboard stationary may shift or the inboard rotary will pop open when barrier fluid pressure drops significantly below process pressure. Tandem seals are usually two "inside" rotary seals with the barrier fluid pressure less than process pressure; however, double-balanced designs will also seal reliably when the barrier fluid pressure is greater than process pressure. The face-to-face is the most compact arrangement. Face-to-face seals usually consist of an inboard "inside" rotary seal and an outboard "outside" rotary seal. Like tandem seals, they can be double-balanced to seal independently of the barrier fluid pressure.

Figure 6

Typical Double Seals
APPENDIX D
PROCUREMENT DOCUMENTATION
Mazen:

NEC 501-11 sub-items:

Item (3) - Connections at the pump will be by the manufacture, per the specification sheets we provided to the Board earlier. The cable connection at the supply end will be in the control enclosure terminals.

Item (4) - Supports to prevent tension on the terminal connections, will be by two cable connectors (one at the pump housing and one at the motor terminal box) per the manufactures data sheets we provided to the Board earlier.

Item (5) - Seals will be the two cable connectors mentioned above at the Pump. Also per the NEC an explosion proof seal will be installed at changes in the Hazardous Classification designation, such as at the pump tank/flange (Div 1 to Div. 2) and again at the control enclosure (Div. 2 to non-classified).

One other option that Dan Reberger is considering, is to utilize the high temperature switches in the motor. My recommendation to him is to add a separate cable/connectors/supports/seals as described in (3), (4), (5) for this circuit and put Intrinsically Safe Barriers in the control panel for this circuit. One would need to have 2" of separation in the motor junction box between the power and temp. sw. leads and terminations, or a barrier.

This additional circuit would provide some additional protection, but would complicate the circuitry.

Just to confuse things a little.

Ray

-----Original Message-----
From: AI-Wazani, Mazen G
Sent: Tuesday, March 28, 2000 11:06 AM
To: Merriman, Raymond E
Cc: Schlosser, Richard L
Subject: RE: Acceptability of Flygt B-2060 Submersible Pump Electrical Cable

RAY,

You have not stated how you meeting 3,4 and 5.

-----Original Message-----
From: Merriman, Raymond E
Sent: Tuesday, March 28, 2000 10:53 AM
To: Schlosser, Richard L; Al-Wazani, Mazen G; Huckfeldt, Rick A; Scaief, C C III (Chuck); Smet, David B
Cc: Merriman, Raymond E; McDonald, Gregory P
Subject: FW: Acceptability of Flygt B-2060 Submersible Pump Electrical Cable

All:

Addressing the NEC 501-11. Flexible Cords, Class I, Division 1 and 2 article in more detail;

Item #1 - "flexible cord shall be permitted for connection between ... portable utilization equipment and the fixed portion of their supply circuit." Later in this same article "Electric submersible pumps ... shall be considered portable utilization equipment."

Based on this statement, I see no problem with using flexible cord in this submersible application.

Item #2 - (1) "Of a type approved for extra-hard usage;"

Based on the cable specification sheets and its extra-hard usage in its mining application, it meets this requirement.

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Based on the specification the cable contains two #12 ground wires, and is satisfactory.

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and this article.

I find the cable and its connections meet the requirements of NEC article 501-11 for application in DST annulus pumping; equivalency is also satisfied since it meets the stated NEC conditions.

Both Greg and I are P.E.s.

If there are any other concerns, please contact us.

Thank You

Ray Merriman, P.E.

-----Original Message-----
From: McDonald, Gregory P
Sent: Tuesday, March 28, 2000 7:59 AM
To: Merriman, Raymond E
Cc: Wallace, Debra O; Bresina, William L
Subject: RE: Acceptability of Flygt B-2060 Submersible Pump Electrical Cable

Mr. Merriman-

I have reviewed the vendor data you provided, and find the cable specified meets the requirements of NEC 501-11.

Greg McDonald
Chairman, HECB

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From: Merriman, Raymond E
Sent: Thursday, March 23, 2000 3:53 PM
To: McDonald, Gregory P
Cc: Merriman, Raymond E
Subject: FW: Acceptability of Flygt B-2060 Submersible Pump Electrical Cable

Greg:

I believe I could provide an answer to meet Mr. Schlossers comments below. However, if the HECB would provide an acceptance of this cable and its connection at the pump housing and internal at the motor terminal box, I am sure it would carry more weight.

Thanks
Ray

-----Original Message-----
From: Schlosser, Richard L
Sent: Thursday, March 23, 2000 2:59 PM
To: Merriman, Raymond E
Cc: Reberger, Dan W; AL-WAZANI, MAZEN; GUSTAVSON, ROBERT; HUCKFELDT, RICK; SCAIEF, CHARLES; SCHLOSSER, RICHARD; SMET, DAVID
Subject: Acceptability of Flygt B-2060 Submersible Pump Electrical Cable
Importance: High

Ray:

For the FGEAB to accept the Code compliant electrical cable at the pump interface, you need to provide a Professional Engineer evaluation of each of the conditions of NEC Article 501-11 as allowed by the NEC. This will provide a basis for acceptance at the interface with the pump. Since the pump is acceptable to the FGEAB but not a Class 1, Division 1, Group B design, you need to focus your evaluation on equivalence of the design to the cable requirements of the NEC since the FGEAB only addresses equivalence to requirements, not compliance with the requirements.

Thank you,

Rich
Al-Wazani, Mazen G

From: Huckfeldt, Rick A
Sent: Tuesday, March 28, 2000 11:45 AM
To: Merriman, Raymond E; Schlosser, Richard L; Al-Wazani, Mazen G; Scaief, C C III (Chuck); Smet, David B
Cc: McDonald, Gregory P
Subject: RE: Acceptability of Flygt B-2060 Submersible Pump Electrical Cable

This is more than I needed. As long as engineering specifies equipment meeting the NEC for Class I Division 1 locations, it meets the AB ignition control sets. We only need to get involved if it does not.

Rick

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From: Merriman, Raymond E
Sent: Tuesday, March 28, 2000 10:53 AM
To: Schlosser, Richard L; Al-Wazani, Mazen G; Huckfeldt, Rick A; Scaief, C C III (Chuck); Smet, David B
Cc: McDonald, Gregory P
Subject: RE: Acceptability of Flygt B-2060 Submersible Pump Electrical Cable

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I find the cable and its connections meet the requirements of NEC article 501-11 for application in DST annulus pumping; equivalency is also satisfied since it meets the stated NEC conditions.

Both Greg and I are P.E.'s.

If there are any other concerns, please contact us.

Thank You

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Thank you,
Rich S
Al-Wazani, Mazen G

From: Smet, David B
Sent: Tuesday, March 28, 2000 11:12 AM
To: Merriman, Raymond E; Schlosser, Richard L; Al-Wazani, Mazen G; Huckfeldt, Rick A; Scaief, C C III (Chuck)
Cc: McDonald, Gregory P
Subject: RE: Acceptability of Flygt 6-2060 Submersible Pump Electrical Cable

Works for me, thanks

Dave

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From: Merriman, Raymond E
Sent: Tuesday, March 28, 2000 10:53 AM
To: Schlosser, Richard L; Al-Wazani, Mazen G; Huckfeldt, Rick A; Scaief, C C III (Chuck); Smet, David B
Cc: McDonald, Gregory P
Subject: FW: Acceptability of Flygt 6-2060 Submersible Pump Electrical Cable

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Thank you,

Rich S.
All:

I faxed the cable specification for the Flygt Pump to all of you, except Chuck, yesterday. I made an incorrect notation on the bottom of the front page that the cable was "Not Class 1, Div. 1, Gp B". It has been pointed out to me that the cable does meet the requirement of NEC 501-11 and as such it does meet the above requirements for Class 1, Div. 1, Gp B.

I have also checked out the cable specification with the chairperson and secretary the Hanford Electrical Contractor Safety Board, and they agree that the cable meets the requirements of NEC 501-11.

As such, the cable is acceptable to be used in a Class 1, Div. 1, Gp B situation such as the DSTs.

Please review this information and let me know if you concur or if I have overlooked something.

Thank You

Ray
Reberger, Dan W

From: Rarig, Bradley K
Sent: Wednesday, May 10, 2000 8:02 AM
To: Reberger, Dan W
Cc: Hauck, Frank M (Marshall); Leshikar, Gregory A; Shipler, C E (Charlie)
Subject: FW: DST Annulus Pump Cable Connections

---Original Message---
From: McDonald, Gregory P
Sent: Wednesday, May 10, 2000 7:51 AM
To: Rarig, Bradley K
Cc: Perriman, Raymond E; Newhouse, R K (Keith)
Subject: FW: DST Annulus Pump Cable Connections

Brad-

I have reviewed the modifications to the pump discharge section where the pump cable connections have been relocated, and find the modification acceptable.

Greg McDonald
Chairman, HECB

---Original Message---
From: Perriman, Raymond E
Sent: Wednesday, May 10, 2000 7:43 AM
To: McDonald, Gregory P
Subject: DST Annulus Pump Cable Connections

Greg:

Have you had a chance to send Bradley a note on the "acceptance of the Connections for the DST Annulus pump"? Reberger was looking for something in writing.

Thanks

Greg McDonald, CHG Equipment Engineering,
372-1653, R3-83
# Electric Submersible Pumps

<table>
<thead>
<tr>
<th>PUMP MANUFACTURER</th>
<th>VENDOR/CONTACT/DATE</th>
<th>PERFORMANCE*</th>
<th>DIMENSIONAL**</th>
<th>CLASS 1, DIV.1, GROUP B</th>
<th>PROS</th>
<th>CONS</th>
<th>ADDITIONAL INFORMATION</th>
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</thead>
<tbody>
<tr>
<td>ABS / JC models</td>
<td>Pump Industries, Inc. Mark Osterhout Jr. 01/20/00</td>
<td>YES</td>
<td>YES</td>
<td>NO</td>
<td>+ Meets performance and dimensional criteria. + Pump housing is made of aluminum alloy. + No class 1, div. 1, Group B.</td>
<td>Can't use - Aluminum Housing</td>
<td></td>
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<tr>
<td>HOMIA</td>
<td>F.R. Mahony and Associates 01/20/00</td>
<td>YES</td>
<td>YES</td>
<td>NO</td>
<td>+ Meets performance and dimensional criteria. + Top discharge. + Pump housings are made of cast iron and aluminum alloy. + No class 1, div.1, Group B.</td>
<td>Can't use - Aluminum Housing</td>
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<tr>
<td>Ready Flow 3</td>
<td>Instrumentation Northwest, Inc. Alvin Smith 01/19/00</td>
<td>NO</td>
<td>YES</td>
<td>NO</td>
<td>+ Meets dimensional criteria. + Pump does not meet performance requirement. + Aluminum Pump housing. + No class 1, div.1, Group B.</td>
<td>Can't use - Aluminum Housing</td>
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<tr>
<td>Flygt / BS 2084</td>
<td>Whitney Equipment Carrie 01/25/00</td>
<td>YES</td>
<td>YES</td>
<td>NO</td>
<td>+ Meets performance and dimensional criteria. + Stainless steel hardware, + Top discharge. + Pump housing is made of aluminum alloy. + Pump requires of for use. + No class 1, div.1, Group B.</td>
<td>Can't use - Aluminum Housing</td>
<td></td>
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<tr>
<td>BJM / RX 1500</td>
<td>Familian N.W. 01/25/99</td>
<td>NO</td>
<td>YES</td>
<td>NO</td>
<td>+ Meets dimensional requirements. + Stainless steel housing. + Top discharge. + Pump is well below the performance requirement. + No class 1, div.1, Group B.</td>
<td>+ Very low Performance</td>
<td></td>
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</tbody>
</table>
## Electric Submersible Pumps

<table>
<thead>
<tr>
<th>Pump Manufacturer</th>
<th>Vendor/Contact/Date</th>
<th>Performance*</th>
<th>Dimensional**</th>
<th>Class 1, Div. 1, Group B</th>
<th>Pros</th>
<th>Cons</th>
<th>Additional Information</th>
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</thead>
<tbody>
<tr>
<td>Mody / G-500</td>
<td>Mody LLC Sam Mody 01/25/00</td>
<td>YES</td>
<td>YES</td>
<td>NO</td>
<td>+ Meets performance and dimensional criteria. + All Stainless steel hardware. + Top discharge.</td>
<td>+ Pump is 10.75&quot; in diameter. + No class 1, div.1, Group B.</td>
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<tr>
<td>Flygt BS-2060</td>
<td>Flygt ITT Grant Stayburg</td>
<td>NO</td>
<td>YES</td>
<td>NO</td>
<td>+ Meets dimensional criteria. + All Stainless steel hardware.</td>
<td>+ Pump is side discharge + No class 1, div.1, Group B.</td>
<td>+ Pump can be used in tandem to achieve performance criteria. + Pump can be converted to top discharge.</td>
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<tr>
<td>Gorman Rupp / 2&quot; Stainless Steel</td>
<td>Gorman-Rupp Bruce Pfleger 03/09/00</td>
<td>NO</td>
<td>YES</td>
<td>NO</td>
<td>+ Meets dimensional criteria. + All Stainless steel hardware. + Pump has MSHA Approval.</td>
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<td>+ Pump can be used in tandem to achieve performance criteria.</td>
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<td>Griswold / 6&quot; Submersible Turbine Pumps</td>
<td>Griswold Pump Company 02/25/00</td>
<td>YES</td>
<td>YES</td>
<td>NO</td>
<td>+ Meets performance and dimensional criteria. + Small Diameter + Top discharge.</td>
<td>+ Pump housing is made of cast iron. + No class 1, div.1, Group B.</td>
<td>Can't use - Cast Iron = sparking</td>
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<tr>
<td>Grundfos / Model 60s</td>
<td>Northwest Pump Travis Eschette 02/07/00</td>
<td>YES</td>
<td>YES</td>
<td>NO</td>
<td>+ Meets performance and dimensional criteria. + Small Diameter + Top discharge. + Pump all Stainless Steel</td>
<td>+ No class 1, div.1, Group B. + Low Flow Rates</td>
<td>Flow Rates are probably too low.</td>
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</table>
## Electric Submersible Pumps

<table>
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<tr>
<th>PUMP MANUFACTURER</th>
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<th>DIMENSIONAL**</th>
<th>CLASS 1, DIV.1, GROUP B</th>
<th>PROS</th>
<th>CONS</th>
<th>ADDITIONAL INFORMATION</th>
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<tbody>
<tr>
<td>Prosser / 3&quot;</td>
<td>Peninsula Pump Corp -</td>
<td>YES</td>
<td>YES</td>
<td>NO</td>
<td>+ Meets dimensional requirements.</td>
<td>+ Pump housing is made of aluminum alloy.</td>
<td>Can't use - Aluminum Housing</td>
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<tr>
<td>Standard Line</td>
<td>Stephanie 2/24/00</td>
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<td>+ Top discharge.</td>
<td>+ No class 1, div.1, Group B.</td>
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<td>9-50000</td>
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<tr>
<td>Piranha / PC Series</td>
<td>Equipment Specialties</td>
<td>NO</td>
<td>YES</td>
<td>NO</td>
<td>+ Meets dimensional requirements.</td>
<td>+ In order to meet dimensional requirement, not enough performance.</td>
<td>Can't use - Aluminum Housing</td>
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<tr>
<td></td>
<td>Company 1/28/00</td>
<td></td>
<td></td>
<td></td>
<td>+ Stainless Steel Hardware.</td>
<td>+ Aluminum housing.</td>
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</tr>
<tr>
<td></td>
<td>Scott</td>
<td></td>
<td></td>
<td></td>
<td>+ Top discharge.</td>
<td>+ Top discharge.</td>
<td></td>
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</tbody>
</table>

* The pump must be capable of producing approximately 160 ft of head at 40 GPM.

** The pump must be able to fit inside a 12" riser.
<table>
<thead>
<tr>
<th>Item No.</th>
<th>Material Description</th>
<th>Quantity</th>
<th>Unit</th>
<th>Material Description</th>
<th>Quantity</th>
<th>Unit</th>
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<tbody>
<tr>
<td>01</td>
<td>Nipple, 3/4&quot; SCHED 40 X 6&quot; L, ASTM A 197</td>
<td>1</td>
<td>EA.</td>
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<tr>
<td>02</td>
<td>Hose Connector, Male NPT, 3/4 NPT 3/4&quot; ID</td>
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<td>EA.</td>
<td>Hose, Swagelok, SS-12-1C-1-12</td>
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<td>EA.</td>
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<tr>
<td>03</td>
<td>Clamp, Hose, Worm drive, for 3/4&quot; ID Hose, Commercial Galv.</td>
<td>1</td>
<td>EA.</td>
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<tr>
<td>04</td>
<td>Hose, 3/4&quot; ID X 1/8&quot; Wall, Commercial Rubber</td>
<td>10</td>
<td>FT.</td>
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<tr>
<td>05</td>
<td>Valve, Ball, 3/4&quot;, NPT, Whitey, Part #S-63TS12</td>
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<td>EA.</td>
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<tr>
<td>06</td>
<td>Plate, 9 1/2&quot; X 1/2&quot; X 28&quot; L, ASTM A 36</td>
<td>1</td>
<td>EA.</td>
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</table>

**Date Required:** 06/21/2000

**Suggested Vendor:**

**Emergency Justification:**

- **Karen Stahl**
  - Material Coordinator
  - Date: 5/31/2000
  - MSIN: 55-13
  - Phone No.: 314-4986

- **Cognizant Engineer/DA (If applicable)**
  - Date: 5/31/2000
  - MSIN: 55-13
  - Phone No.: 314-4986

- **Cognizant Manager (If applicable)**
  - Date: 5/31/2000
  - MSIN: 55-13
  - Phone No.: 314-4986

- **QA Clauses:**
  - B34 and B61

- **Material Released To and Received By:**
  - Date: 6/10/00
  - MSIN: 600-729

- **Organ/Code/Cost Code:**
  - 77C00/111273
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<th>Item No.</th>
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<th>Material Description</th>
<th>Estimated Cost</th>
<th>Req./Store No.</th>
<th>Exp. Delivery Date</th>
<th>Safety Class</th>
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<th>Approval Designator</th>
<th>QC Level</th>
<th>Approval QC</th>
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<th>Received</th>
<th>Stock No.</th>
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<td>01</td>
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<td>Valve, Globe, 3/4&quot;, FNPT, (McMaster-Carr), Part (#4695K44)</td>
<td>Valve, Globe, 3/4&quot;, FNPT, (McMaster-Carr), Part (#4695K44)</td>
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<tr>
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<td>EA.</td>
<td>2&quot; Well Head Completion Assembly, Instrumentation NW INC, Part #38502</td>
<td>2&quot; Well Head Completion Assembly, Instrumentation NW INC, Part #38502</td>
<td>$70</td>
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<td>Actuating Rod (5' Sections W/ Coupling Nut), Instrumentation NW INC, Part #2B095</td>
<td>Actuating Rod (5' Sections W/ Coupling Nut), Instrumentation NW INC, Part #2B095</td>
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<td>Air motor, 2&quot;, Instrumentation NW INC, Part #38020</td>
<td>Air motor, 2&quot;, Instrumentation NW INC, Part #38020</td>
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<td>Gauge, Pressure, 0-100# PSI, 4 1/2&quot; Dial, 1/4&quot; MPT Bottom Connection, Ashcroft, Type</td>
<td>Gauge, Pressure, 0-100# PSI, 4 1/2&quot; Dial, 1/4&quot; MPT Bottom Connection, Ashcroft, Type</td>
<td>$70</td>
<td>MLE 42502</td>
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<td>06</td>
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<td>EA.</td>
<td>3/4&quot; FNPT Inlet and Outlet, (McMaster-Carr), Part (#49435K45) K-10</td>
<td>3/4&quot; FNPT Inlet and Outlet, (McMaster-Carr), Part (#49435K45) K-10</td>
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<td>14</td>
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<td>16</td>
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<td>Bushing, Reducing 3/4&quot; X 1/4&quot;, Threaded, ASTM A 197</td>
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<td>GS</td>
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<td>Tee, 3/4&quot;, 150#, Threaded, ASTM A 197</td>
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<tr>
<td>18</td>
<td>EA.</td>
<td>Clamp, Hose, Worm Drive, 1/2&quot; Band Width, 13/16&quot;-1 1/2 DIA Range, (McMaster-Carr),</td>
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<td>3595</td>
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<td>6/13/00</td>
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<td>210HV1 Hickman</td>
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</table>

Date Required: 06/21/2000

Suggested Vendor:

Emergency Justification:

Material Coordinator: Date | MSIN | Phone No.
Cognizant Engineer/DA (if applicable): Date | MSIN | Phone No.
Cognizant Manager (if applicable): Date | MSIN | Phone No.
Planner: Date | MSIN | Phone No.
Quality Assurance: Date | MSIN | Phone No.

Org. Code/Cost Code: 77C00/111273

Material Released To and Received By: Date

A-6002-729 (02/00)
## CHG - BILL OF MATERIAL

**End Use:** Test Skid for DST Annulus Pumps  
**Wk. Pkg. No.:** 2E-00-00963  
**Requestor:** Charles E. Golden  
**Date:** 5/30/2000

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Quantity</th>
<th>Unit</th>
<th>Material Description</th>
<th>Estimated Cost</th>
<th>Req./Store No.</th>
<th>Exp. Delivery Date</th>
<th>Safety Class</th>
<th>Approval Designator</th>
<th>QC Approval</th>
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<tr>
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<td>Pipe, 2&quot; SCHED 40, Welded, ASTM A 53 Type E GR B</td>
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<td>GS 0</td>
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<td>2101HV</td>
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<td>Screw, Hex HD, 5/8&quot;-11UNC-2A X 2 1/2&quot; LG, ANSI B18.2.1 CS</td>
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<td>Tool Crib</td>
<td>2101HV/Hickman</td>
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<td>— 8947</td>
<td>GS 0</td>
<td>NA</td>
<td>6/16/00</td>
<td>Tool Crib</td>
<td>2101HV/Hickman</td>
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</tr>
<tr>
<td>22</td>
<td>4</td>
<td>EA.</td>
<td>Washer, Plain, 5/8&quot; Bolt Size, ANSI B18.21.1 CS</td>
<td>— 4209</td>
<td>GS 0</td>
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<td>Tool Crib</td>
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<tr>
<td>23</td>
<td>3/16&quot; OD, 300 PSI Working Pressure, Hose, Polyester reinforced, 3/4&quot; ID X 1 (McMaster-Carr), Part (#5304K44)</td>
<td></td>
<td>— 3595</td>
<td>GS 0</td>
<td>NA</td>
<td>6/16/00</td>
<td>2101HV</td>
<td>Hickman</td>
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<tr>
<td>24</td>
<td>1</td>
<td>EA.</td>
<td>Pail, Storage, 5 Gallon Capacity, (McMaster-Carr), Part (#4211T3)</td>
<td>— 3595</td>
<td>GS 0</td>
<td>NA</td>
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<td>2101HV</td>
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**Date Required:** 06/21/2000  
**Suggested Vendor:**  
**Emergency Justification:**  
**Material Coordinator:**  
**Cognizant Engineer/DA (if applicable):**  
**Cognizant Manager (if applicable):**  
**Planner:**  
**Quality Assurance:**  
**Org. Code/Cost Code:** 77C00/111273  
**Material Released To and Received By:**  
**Date:** A-6002-729 (02/00)
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<th>Item No.</th>
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<th>Unit</th>
<th>Material Description</th>
<th>Estimated Cost</th>
<th>Req./Store No.</th>
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<td>25</td>
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<td>EA.</td>
<td>Elbow, 90 Deg., 3/4&quot;, 150#, FMPT, ASTM A 197</td>
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<td>GS</td>
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<td>6/15/00</td>
<td>6/12/00</td>
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<tr>
<td>26</td>
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<td>Screw, Hex, 5/16-18UNC-2A X 1&quot; L, Commercial CS</td>
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<td>6/12/00</td>
<td>Tool Crib</td>
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<tr>
<td>27</td>
<td>1</td>
<td>EA.</td>
<td>Channel, 12&quot; L, Unistrut, P1000</td>
<td>3598</td>
<td>GS</td>
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<td>6/15/00</td>
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<td>6/12/00</td>
<td>Hickman</td>
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<td>28</td>
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<td>Pipe Clamp, 3/4&quot; Size, Unistrut, P2558-07</td>
<td>3598</td>
<td>GS</td>
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<td>NA</td>
<td>6/15/00</td>
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<td>6/13/00</td>
<td>Hickman</td>
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<tr>
<td>29</td>
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<td>FT.</td>
<td>Angle Fitting, 90 Deg. (3 1/8&quot; X 1 7/8&quot;), Unistrut, P1538 A</td>
<td>3598</td>
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<td>6/13/00</td>
<td>6/13/00</td>
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<tr>
<td>30</td>
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<td>EA.</td>
<td>Channel Nat W/Spring (1/4-20UNC-2B), Unistrut, P1006-1420</td>
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Date Required: 06/21/2000

Suggested Vendor:

Emergency Justification:

Material Coordinator

Cognizant Engineer/DA (if applicable)

Cognizant Manager (if applicable)

Planner

Quality Assurance

Org. Code/Cost Code: 77C09/111273

Material Released To and Received By: ______________ Date ______________

A-5002-729 (02/00)
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<tr>
<td>31</td>
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<td>EA</td>
<td>Screw, Hex Cap (1/4&quot; X 7/16&quot; Size), HHCS025044EG</td>
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<td>32</td>
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<td>Plate, 22&quot; SQ X 3/8&quot;, ASTM A 36</td>
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<td>GS</td>
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<td>NA</td>
<td>Hickman</td>
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<td>Fab Shop</td>
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<tr>
<td>33</td>
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<td>EA</td>
<td>Plate, 24&quot; X 3/8&quot; X 34' L, ASTM A 36</td>
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<td></td>
<td>GS</td>
<td>0</td>
<td>NA</td>
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<td>6/06/00</td>
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<td>34</td>
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<td>Plate, 18&quot; SQ X 3/8&quot;, ASTM A 36</td>
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<td>NA</td>
<td>Hickman</td>
<td>6/06/00</td>
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<td>35</td>
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<td>FT</td>
<td>Plate, 2&quot; X 1/2&quot; X 3 13/16&quot; L, ASTM A 36</td>
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<td></td>
<td>GS</td>
<td>0</td>
<td>NA</td>
<td>Hickman</td>
<td>6/06/00</td>
<td>Fab Shop</td>
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<tr>
<td>36</td>
<td>1</td>
<td>EA</td>
<td>Bar, 1&quot; X 1/4&quot; X 5' L</td>
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<td>Hickman</td>
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Date Required: 06/21/2000

Mandatory Desired

Delivery Location: 2704HV/Maintenance Shop

Special Instructions

QA Clauses:

Org. Code/Cost Code: 77C09/111273

Material Released To and Received By: _____________________________ Date __________
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<tr>
<td>37</td>
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<td>Pipe, 12&quot; SCHED 40 X 72 1/2&quot; L, Welded, ASTM</td>
<td>EA.</td>
<td>-3594</td>
<td>6/16/00</td>
<td>GS 0</td>
<td>NA</td>
<td></td>
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<td>6/10/00</td>
<td>7101HV</td>
<td>Hickman</td>
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<tr>
<td>38</td>
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<td>Pipe, 3&quot; SCHED 40, Welded, ASTM A 53 Type E</td>
<td>FT.</td>
<td>-3594</td>
<td>6/16/00</td>
<td>GS 0</td>
<td>NA</td>
<td></td>
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<td></td>
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<td>6/10/00</td>
<td>7101HV</td>
<td>Hickman</td>
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<td>39</td>
<td>1</td>
<td>Pipe, 2&quot; SCHED 40 X 84&quot; L, Welded, ASTM A 53 Type E</td>
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<td>-3594</td>
<td>6/10/00</td>
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<td>Flange, 3&quot;, R.F., Screwed, 150#, ASTM A 105</td>
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<td>Hickman</td>
</tr>
<tr>
<td>41</td>
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<td>Screw, Hex, 5/8&quot;-11UNC-2A X 3 1/4&quot; LG, Commercial CS</td>
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<td>1.0D</td>
<td>6/16/00</td>
<td>GS 0</td>
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<td>42</td>
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<td>Nut, Hex, 5/8&quot; Bolt Size, Commercial CS</td>
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<td>6/16/00</td>
<td>GS 0</td>
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Date Required: 06/21/2000

Suggested Vendor: 

Emergency Justification:

Material Coordinator

Cognizant Engineer/DA (if applicable)

Cognizant Manager (if applicable)

Planer

Quality Assurance

Org. Code/Cost Code: 77C00/111273
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<td>43</td>
<td>EA.</td>
<td>Gasket, 3&quot; CL 150, R.F., Flange 1/8&quot; THK</td>
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<td>(45100 Shop Stock)</td>
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<td>44</td>
<td>EA.</td>
<td>Compressed Fiber, Garlock, Bluegard Style</td>
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<td>45</td>
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<td>Tubing, 8&quot; X 4&quot; X 1/4&quot; Wall X 72&quot; L, ASTM A 500</td>
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<td>350445</td>
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<td>46</td>
<td>EA.</td>
<td>Eyebolt, Shoulder, 1/2&quot;-13UNC-2A X 1 1/2&quot;</td>
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<td>350455</td>
<td>GS 0</td>
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<td>47</td>
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<td>Thread Length, Dia. 1.19&quot; eye, (McMaster-Carr), Part (#3014T491)</td>
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<td>49</td>
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<td>Washer, Plain, 1/2&quot; Size, Commercial CS</td>
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Date Required: **06/21/2000**

Dist. Location: **2704HV/Maintenance Shop**

Special Instructions:

QA Clauses:
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<th>Safety Class</th>
<th>Q Level</th>
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<th>QC Approval</th>
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<th>Stock No.</th>
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<td></td>
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<td>4 Washer, Lock, HLCL Spring, 1/2&quot; NOM, RGLR, Commercial CS</td>
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<td>210HV</td>
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<td>50 U-Bolt, Extended Length, 3&quot; Pipe Size, 1/2-13UNC-2A Threads, W Hex Nuts, (McMaster-Carr), Part (#8880738)</td>
<td>3595</td>
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<td>51 Wire-Tie</td>
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Date Required: 06/21/2000  
Suggested Vendor:  
Emergency Justification:  

Material Coordinator  
Date  MSIN  Phone No.
Cognizant Engineer/DA (if applicable)  
Date  MSIN  Phone No.
Cognizant Manager (if applicable)  
Date  MSIN  Phone No.
Planner  
Date  MSIN  Phone No.
Quality Assurance  
Date  MSIN  Phone No.

Org. Code/Cost Code: 77C00/111273

Material Released To and Received By:  
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A-6002-729 (02/00)
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<td>EA.</td>
<td>Enclosure, NEMA Type 4, Left side hinged door, Flange-mounted, 14X12X6, Hoffman, A-1412CHNF</td>
<td>GS</td>
<td>5/25/00</td>
<td>Q</td>
<td>3</td>
<td>Q</td>
<td>GS 3</td>
<td>Q</td>
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<td>EA.</td>
<td>Disconnect Switch, Class 9422, with flange-mounted Mechanism and Al handle, ATCN-301 Non-Fused Lockable, Square D, ATCN-301</td>
<td>GS</td>
<td>5/25/00</td>
<td>Q</td>
<td>3</td>
<td>Q</td>
<td>GS 3</td>
<td>Q</td>
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<td>3</td>
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<td>Circuit breaker, 15A, 480V, 3 PH, Square D, Part #FAL34015</td>
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<td>3</td>
<td>Q</td>
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<td>Push Button, Class 9001, Red, Full Guard, Square D, Type KRIRH13</td>
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<td>5/25/00</td>
<td>Q</td>
<td>3</td>
<td>Q</td>
<td>GS 3</td>
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<tr>
<td>5</td>
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<td>EA.</td>
<td>Conduit Connector, Liquid Tight, 1/2&quot;, Metallic, Midwest, LTB-50</td>
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<td>5/25/00</td>
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Date Required: 06/20/2000
Suggested Vendor: 
Emergency Justification: 

Material Coordinator: 6/13/00 5S-13 3-34841
Compliant Engineer/DA (if applicable): 6/13/00 5S-13 3-34841
Compliant Manager (if applicable): 6/13/00 5S-13 3-34841
Planner: 6/13/00 5S-13 3-34841
Quality Assurance: 6/13/00 5S-13 3-34841

Org. Code/Cost Code: 37Q00/111273
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<td>Cable fitting, 3/4&quot;C - Form C, O.D.</td>
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Date Required: 06/20/2000

Suggested Vendor: 

Emergency Justification: 

Material Coordinator: Date MSIN Phone No.

Cognizant Engineer/DA (if applicable): Date MSIN Phone No.

Cognizant Manager (if applicable): Date MSIN Phone No.

QA Clauses: 

Special Instructions: 

Org. Code/Cost Code: 77C00/111273

Material Released To and Received By: ___________________________ Date ________
# CHG - BILL OF MATERIAL

**End Use:** DST Annulus Pumping Control Sta.  
**Wk. Pkg. No.:** 2E-00-00955  
**ECN No.:** 658446  
**Date:** 6/09/2000  
**Requestor:** Charles E. Golden

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**Suggested Vendor:**  
**Emergency Justification:**

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**Date Required:** 06/20/2000  
**Delivery Location:** 2704HV/Maintenance Shop

**Special Instructions:**

---

**QA Clauses:**

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**Org. Code/Cost Code:** 77C00/111273

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**Material Released To and Received By:**

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**Date:**

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**Material Coordinator:**

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**Cognizant Engineer/DA (if applicable):**

---

**Cognizant Manager (if applicable):**

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**Planner:**

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**Quality Assurance:**

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**A-6002-729 (02/00)**
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Date Required: 06/20/2000

Emergency Justification:

Special Instructions:

Org. Code/Cost Code: 77C00/111273
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Date Required: 06/20/2000
Suggested Vendor: [Check Cat id]
Emergency Justification: If ok, order

Material Coordinator
Cognizant Engineer/DA (if applicable)
Cognizant Manager (if applicable)
Planner
Quality Assurance

Material Released To and Received By: _______________ Date _______________
## CHG - BILL OF MATERIAL

**End Use:** DST Annulus Pumping Control Sta.  
**Wk. Pkg. No.:** 2E-00-00955  
**ECN No.:** 658446

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- **Material Coordinator**
  - Date
  - MSIN
  - Phone No.

- **Cognizant Engineer/DA (if applicable)**
  - Date
  - MSIN
  - Phone No.

- **Cognizant Manager (if applicable)**
  - Date
  - MSIN
  - Phone No.

- **Planner**
  - Date
  - MSIN
  - Phone No.

- **Quality Assurance**
  - Date
  - MSIN
  - Phone No.

**Org. Code/Cost Code:** 77C00/111273
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**Date Required:** 06/20/2000

**Suggested Vendor:**

**Emergency Justification:**

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**Material Coordinator:**

**Cognizant Engineer/DA (if applicable):**

**Cognizant Manager (if applicable):**

**Planner:**

**Quality Assurance:**

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**Org. Code/Cost Code:** 77C00/111273

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**Material Released To and Received By:**

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**A-5002-729 (02/00)**
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<tr>
<td>52</td>
<td>3</td>
<td>Pipe Clamp, 4-1/2&quot;, Unistrut, 072N080</td>
<td>EA.</td>
<td></td>
<td></td>
<td>MLE44160</td>
<td>GS 3</td>
<td>Q</td>
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<td>7/14/00</td>
<td>598574-0</td>
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<tr>
<td>53</td>
<td>6</td>
<td>Truk Trak, 36&quot; X 20&quot; X 2.31&quot;, 5-Channel</td>
<td>EA.</td>
<td>1.25&quot; X 1.25&quot;, Hubbell, HBLT5</td>
<td></td>
<td>689103430</td>
<td>GS 0</td>
<td>NA</td>
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<td>6/13-00</td>
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</tbody>
</table>

Date Required: 06/20/2000

Suggested Vendor:

Emergency Justification:

Material Coordinator

Cognizant Engineer/DA (if applicable)

Cognizant Manager (if applicable)

Planner

QA Clauses:

Org. Code/Cost Code: 77C00/111273

Material Released To and Received By: Date

A-6002-729 (02/00)
INTEROFFICE MEMO

From: DST Engineering
Phone: 373-3926
Date: June 1, 2000
Subject: MODIFICATION OF FLYGT PUMPS FOR ANNULUS PUMPING

To: R. S. Popielarczyk
J. B. Hebdon

Copies: D. G. Bailey
G. T. Frater

The purpose of this memorandum is to document the Chief Engineer and Quality Assurance Manager approval as required by RPP-MD-110, Rev. 1 for the upgrade of a Quality Level 0 item to a Quality level 3 item.

Items to be upgraded are four submersible pumps manufactured by Flygt Corporation Model 2060. The pumps are intended for future use in the annulus pumping of a double shell tank. The pumps will be shop modified from a side to a top discharge for use in an assembly for quick deployment in the event of a waste leak to the annulus.

The four pumps have been in spare parts for 10 years and purchased as Impact Level 4 items (PO# GAP-611-630161, spare part# 6111-5514-5670, serial numbers 8770002, 8880007, 8 & 9). The pumps were refurbished in May 2000 by a certified Flygt distributor to ensure proper operation.

The Flygt Model 2060 pump design, with the modification, was approved for use in annulus pumping operation by the Flammable Gas Equipment Advisory Board (Report FGEAB-00-002, Rev. 1).

The work package for the pump modification to top discharge verifies the proper pump models.

Should you have any questions please contact me on 373-3926.

Approvals:

[Signature]
Chief Engineer

[Signature]
Q. A. Director

D. W. Reberger
Engineer

[Signature]
6-2-00
Date

[Signature]
6-2-00
Date
## PUMPING CONTROL STATION - Electrical Skid  [2E-00-00955, supplement 0]  

<table>
<thead>
<tr>
<th>BOM Item No.</th>
<th>Material</th>
<th>Status (where is it)</th>
<th>ETA</th>
<th>Responsible Person</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Disconnect Switch</td>
<td>PO 7584 - in AVS for inspection</td>
<td>7/20/00</td>
<td>Hendrickson</td>
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<tr>
<td>3</td>
<td>Circuit Breaker</td>
<td>Rec'd 6/28/00 -- Need QC buyoff</td>
<td>7/10/00</td>
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<td>7/20/00</td>
<td>Hendrickson</td>
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<tr>
<td>5</td>
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<td>7/20/00</td>
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<tr>
<td>6</td>
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<tr>
<td>7</td>
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<td>9</td>
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<tr>
<td>10</td>
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<tr>
<td>11</td>
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<td>12</td>
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<tr>
<td>13</td>
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<td>14</td>
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<tr>
<td>15</td>
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<td>7/20/00</td>
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<tr>
<td>16</td>
<td>Conduit Connector</td>
<td>PO 7584 - in AVS for inspection</td>
<td>7/20/00</td>
<td>Hendrickson</td>
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<tr>
<td>17</td>
<td>Cable Fitting</td>
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<tr>
<td>18</td>
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<tr>
<td>19</td>
<td>Cable SOW-A</td>
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<td>Hendrickson</td>
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<tr>
<td>21</td>
<td>Plug</td>
<td>PO 7584 - in AVS for inspection</td>
<td>7/20/00</td>
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<tr>
<td>22</td>
<td>Conduit Body</td>
<td>PO 7584 - in AVS for inspection</td>
<td>7/20/00</td>
<td>Hendrickson</td>
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<tr>
<td>24</td>
<td>Air Regulator</td>
<td>PO 7558 - in AVS for inspection</td>
<td>7/20/00</td>
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<tr>
<td>25</td>
<td>Air Dryer</td>
<td>PO 7567 - in AVS for inspection</td>
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<td>Hendrickson</td>
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<tr>
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<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
</tbody>
</table>
| 26 | Pipe Clamp | **PO 7596 (Factory does not have)**  
Still on order, taking care of on supplement  
# 1, changed the size | 7/13/00 | Sandall |
| 27 | Fuse FNQ-7 | PO 7584 - in AVS for inspection | 7/20/00 | Hendrickson |
| 28 | Fuse FNQ-20 | PO 7584 - in AVS for inspection | 7/20/00 | Hendrickson |
| 29 | Nut, Hex | Needs Vendor for price quote - should be able to find onsite - NO Concern - QA buy off today 06/28/00 | Toolcrib 06/29/00 | Shults |
| 30 | Beam W-shape | PO 7564 - through AVS - ready to ship | 7/20/00 | Hendrickson |
| 31 | Post Base | PO 7596 - shipped complete - to AVS | 7/20/00 | Sandall |
| 32 | Channel Brace | PO 7610 - shipped complete 7/13/00 | 7/20/00 | Sandall |
| 33 | Anular Fitting | PO 7596 - shipped complete - to AVS | 7/20/00 | Sandall |
| 34 | Screw Hex HD 1/2" | PO 7596 - shipped complete - to AVS | 7/20/00 | Sandall |
| 35 | Framing Channel | PO 7610 - shipped complete 7/13/00 | 7/20/00 | Sandall |
| 36 | Flat Plate Gusset P1356 | PO 7596 - shipped complete - to AVS | 7/20/00 | Sandall |
| 37 | Flat Plate Gusset P1334 | PO 7596 - shipped complete - to AVS | 7/20/00 | Sandall |
| 38 | Nut spring | PO 7596 - shipped complete - to AVS | 7/20/00 | Sandall |
| 39 | Screw Hex HD Cap | PO 7596 - shipped complete - to AVS | 7/20/00 | Sandall |
| 40 | Beam W-shape | PO 7564 - through AVS - ready to ship | 7/20/00 | Hendrickson |
| 41 | Pipe Clamp | **PO 7596 (Factory does not have)**  
Still on order, taking care of on supplement  
# 1, item #52 (changed the size) | 7/13/00 | Sandall |
<p>| 42 | Overload Relay for pump | PO 7584 - in AVS for inspection | 7/20/00 | Hendrickson |
| 43 | Overload Relay for air | PO 7584 - in AVS for inspection | 7/20/00 | Hendrickson |
| 44 | Wire #14 | PO 7584 - in AVS for inspection | 7/20/00 | Hendrickson |
| 45 | Enclosure | PO 7584 - in AVS for inspection | 7/20/00 | Hendrickson |
| 46 | Panel | PO 7584 - in AVS for inspection | 7/20/00 | Hendrickson |
| 47 | Panel kit | PO 7584 - in AVS for inspection | 7/20/00 | Hendrickson |
| 48 | Window kit | PO 7584 - in AVS for inspection | 7/20/00 | Hendrickson |
| 50 | Framing Channel | PO 7610 - shipped complete 7/13/00 | 7/20/00 | Hendrickson |</p>
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<tr>
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<th>Item Description</th>
<th>PO Number</th>
<th>Status</th>
<th>Date</th>
<th>Vendor</th>
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<tbody>
<tr>
<td>51</td>
<td>Fuse LPJ-2SP</td>
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<td>7/20/00</td>
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<tr>
<td>52</td>
<td>Fuse LPJ-15SP</td>
<td>PO 7584 - in AVS for inspection</td>
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<td>7/20/00</td>
<td>Hendrickson</td>
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<tr>
<td>53</td>
<td>Receptacle assembly</td>
<td>PO 7584 - in AVS for inspection</td>
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<td>7/20/00</td>
<td>Hendrickson</td>
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<tr>
<td>55</td>
<td>Receptacle Duplex</td>
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<td>7/20/00</td>
<td>Hendrickson</td>
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<tr>
<td>56</td>
<td>Ground Rod</td>
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<td>7/20/00</td>
<td>Hendrickson</td>
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<tr>
<td>57</td>
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<tr>
<td>59</td>
<td>Box</td>
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<td>8/11/00</td>
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<td>60</td>
<td>Spring Door cover</td>
<td>PO 7584 - in AVS for inspection</td>
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<td>7/20/00</td>
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<tr>
<td>64</td>
<td>Union Oring</td>
<td>PO 7470 - in AVS for inspection</td>
<td></td>
<td>7/20/00</td>
<td>Hendrickson</td>
</tr>
</tbody>
</table>
## PUMPING CONTROL STATION - Electrical Skid  [2E-00-00955, supplement 1]

<table>
<thead>
<tr>
<th>BOM Item No.</th>
<th>Material</th>
<th>Status (where is it)</th>
<th>ETA</th>
<th>Responsible Person</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Push Button</td>
<td>PO 7755 - to AVS for inspection</td>
<td>7/20/00</td>
<td>Stark</td>
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<td>5</td>
<td>Conduit Connector</td>
<td>Ordered on M/R 44160</td>
<td>7/24/00</td>
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<tr>
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<td>Nipple Conduit</td>
<td>Clarified with Reberger--need to clarify a few things with vendor -- then will change cat id</td>
<td>Stark</td>
<td>Stark</td>
</tr>
<tr>
<td>7</td>
<td>Cable Fitting</td>
<td>PO 7755 - expected delivery date 8/6/00</td>
<td>8/11/00</td>
<td>Stark</td>
</tr>
<tr>
<td>8</td>
<td>Conduit, Liquid Tight Flex</td>
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<tr>
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<td>7/20/00</td>
<td>Stark</td>
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<tr>
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<td>Panel Meter Analog</td>
<td>Need more info. from vendor, our Model 7015 is not a good #</td>
<td>Stark</td>
<td>Stark</td>
</tr>
<tr>
<td>13</td>
<td>Terminal Blocks</td>
<td>PO 7755 - to AVS for inspection</td>
<td>7/20/00</td>
<td>Stark</td>
</tr>
<tr>
<td>14</td>
<td>Fuse, LPJ-2SP</td>
<td>PO 7755 - to AVS for inspection</td>
<td>7/20/00</td>
<td>Stark</td>
</tr>
<tr>
<td>15</td>
<td>Fuse, LPJ-15SP</td>
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<tr>
<td>16</td>
<td>Thermal Unit for Air Comp</td>
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<td>7/20/00</td>
<td>Stark</td>
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<tr>
<td>19</td>
<td>Clamp, Ground Rod</td>
<td>PO 7755 - to AVS for inspection</td>
<td>7/20/00</td>
<td>Stark</td>
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<tr>
<td>20</td>
<td>Conductor</td>
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<td>7/20/00</td>
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<tr>
<td>21</td>
<td>Box 1/2</td>
<td>PO 7755 - expected delivery date 8/6/00</td>
<td>8/11/00</td>
<td>Stark</td>
</tr>
<tr>
<td>22</td>
<td>Nipple, Conduit</td>
<td>Need more info. from vendor, our Model 7015 is not a good #</td>
<td>Stark</td>
<td>Stark</td>
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<tr>
<td>23</td>
<td>Pipe Clamp 2&quot;</td>
<td>Ordered, vendor attempting to provide B-Line to improve ETA</td>
<td>7/24/00</td>
<td>Need BOM changed</td>
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<td>Fuseblock JP6</td>
<td>Ordered (4) more, Past Due</td>
<td>6/26/00</td>
<td>Buyer</td>
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<td>Connector</td>
<td>PO 7755 - to AVS for inspection</td>
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<td>No.</td>
<td>Description</td>
<td>PO Number</td>
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<td>26</td>
<td>Legend Plate &quot;ON&quot;</td>
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<td>Legend Plate &quot;OFF&quot;</td>
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<td>Legend Plate &quot;START&quot;</td>
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<td>7/20/00</td>
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<tr>
<td>29</td>
<td>Legend Plate &quot;STOP&quot;</td>
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<td>Plate 1/8&quot;</td>
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<td>35</td>
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<td>36</td>
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<td>37</td>
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<td>40</td>
<td>Hose Clamp 3/8&quot;</td>
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<td>7/28/00</td>
<td>Sandall</td>
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<tr>
<td>41</td>
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<td>7/28/00</td>
<td>Sandall</td>
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<td>42</td>
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<td>7/28/00</td>
<td>Sandall</td>
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<td>43</td>
<td>Hex Head Cap Screws</td>
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<td>7/28/00</td>
<td>Sandall</td>
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<tr>
<td>44</td>
<td>1/4-20unc2b ASTM A307</td>
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<td>45</td>
<td>1/4 lockwasher A125</td>
<td>Reberger still working this item</td>
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<td>Reberger</td>
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<tr>
<td>46</td>
<td>Mounting Track</td>
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<td>7/20/00</td>
<td>Stark</td>
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<tr>
<td>47</td>
<td>Jumper 2 pole</td>
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<tr>
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<tr>
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<td>7/20/00</td>
<td>Stark</td>
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<tr>
<td></td>
<td></td>
<td>Ordered, should be in Richland (Vendor), Shults to verify with Vendor</td>
<td>ETA?</td>
<td>Shults</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
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</tr>
<tr>
<td>51</td>
<td>Plug, 60A</td>
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</tr>
<tr>
<td>52</td>
<td>Pipe Clamp 4-1/2&quot;</td>
<td><strong>PO 7674 - expected delivery date 7/21/00</strong></td>
<td>7/28/00</td>
<td>Sandall</td>
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<tr>
<td>53</td>
<td>Truk Trak</td>
<td>Ordered, should be in Richland (Vendor), Shults to verify with Vendor</td>
<td>ETA?</td>
<td>Shults</td>
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<tr>
<td>BOM Item No.</td>
<td>Material</td>
<td>Status</td>
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<td>Responsible Person</td>
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**FUSE DISCONNECT SKID ASSEMBLY [2E-00-001222, supplement 0]**

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<td>22</td>
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<td>7/20/00</td>
<td>Stark</td>
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<td>23</td>
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<td>BOM Item No.</td>
<td>Status (where is it)</td>
<td>ETA</td>
<td>Responsible Person</td>
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</tr>
<tr>
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<td>per Denny Hert</td>
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</table>
Title – Statement of Work for Annulus Pumping Time Deployment Study
Contract 4975 – Fluor Daniel Northwest
Revision Number - 0
Date – December 9, 1999

Objective:
This task order is to authorize Fluor Daniel Northwest to initiate development of a study to determine the time period required to initiate the pumping of a Double-Shell Tank Annulus. The study will evaluate and compare several cases in which equipment is readily available in storage or equipment needs some degree of fabrication. This task order will be supplemented as necessary to allow completion of the task.

Background/Introduction:
The Code of Federal Regulations (10CFR40, Vol. 16, Part 265.193(c)(4) and the Washington Administrative Codes (WAC 173-330-640(4)(iv) require “Spilled or leaked waste and accumulated precipitation must be removed from the secondary containment system within 24 hours, or in a timely a manner as is possible to prevent harm to human health or the environment…” This requirement is applicable to pumping the annulus of a double-shell tank.

Equipment is being assembled in the 200 areas to allow the timely pumping of a double-shell tank annulus. Depending on the amount of documentation updates (i.e., drawings) and degree of equipment assembly it is desired to determine the amount of time required to complete the documentation, planning, fabrication and installation to allow initiation of the annulus pumping.

Scope:
This Task Order allows Fluor Daniel Northwest to perform, as required, the following minimum activities:
1. Identify all the required activities necessary to initiate annulus pumping
2. Estimate the amount of time required for completion of activities
3. Sequence activities and establish an estimated schedule for deployment
4. Provide a recommendation for removal of the 5 existing annulus pumps next year based on impacts to initiation of pumping. Removing contaminated pumps requires use of the Long Length Contaminated Equipment Retrieval System, which is extremely expensive and time consuming.

The study shall include the following three cases discussed below:

Case 1 – Assume submersible pumps are available and require only flange installation
   Assume rigid jumper drawings need ECN updates (Central & Annulus pump pits)
   Assume rigid jumpers (Central & Annulus pump pits) will be fabricated from available components in storage

Case 2 – Assume submersible pumps are available and require only flange installation
   Assume rigid jumper drawings are up-to-date (Central & Annulus pump pits)
   Assume rigid jumpers (Central & Annulus pump pits) will be fabricated from available components in storage

Case 3 – Assume submersible pumps are available and require only flange installation
   Assume rigid jumper drawings are up-to-date (Central & Annulus pump pits)
   Assume rigid jumpers (Central & Annulus pump pits) are fabricated and available in storage at 2101-M

The activities associated with the pumping shall include, assembly and testing of the pump, assembly of the jumpers and testing, transport of the Emergency Pumping Trailer and jumpers to the site, installation of pumps and jumpers, connection of electrical and pneumatic supplies to the pumps.

Deliverables:
A supporting document compiling the information from the deployment study by February 11, 2000. This is the latest date for completion; any delays could result in a monetary fine for LMHC. A copy of the SD computer file will be transferred to the LMHC Technical Contact.
Acceptance Criteria:
Documentation with the appropriate LMHC and FDNW approvals as established in current procedures.

Period of Performance:
Activities associated with this SOW are expected to be initiated as soon as possible after receipt of the Task Order, with completion on or before February 11, 2000.

Technical Point of Contact:
The following personnel are assigned as liaison with Fluor Daniel Northwest for the scope of work described:

- Technical Contact: D. W Reberger, LMHC, Double Shell Tank Engineering
- Administrative Contact: A. B. Johnson, & L. K. Martin, LMHC, Financial Control
- Engineer: S. J. Lepka, LMHC, Operational Configuration Management

Applicable ES&H requirements:
Standard ES&H requirements (without ISMS) are warranted for this work.

Safety Requirements:
N/A

Requirements (Including Quality Assurance Requirements):
The subcontractor is subject to Title 10, Code of Federal Regulations, Part 830.120 (10 CFR 830.120), Quality Assurance Requirements, and the enforcement actions under 10 CFR 820, General Statement of Enforcement Policy.

Hold Points:
N/A

Configuration Management Requirements:
N/A

Work Location/Potential Access Requirements:
N/A

Training:
N/A

Qualifications:
Degreed Engineering support as required.

Special Requirements:
N/A

Reporting/Administration:
Status Meetings will be as requested by LMHC or FDNW. Any documentation computer files such as Supporting Documents will be prepared in Word Perfect or Microsoft Word.
Title – Statement of Work for Annulus Pumping
Contract 4975 – Fluor Daniel Northwest
Revision Number - 0
Date – December 9, 1999

Objective:
This task order is to authorize Fluor Daniel Northwest to provide engineering support for identifying, supporting procurement, testing, and final design of a pump assembly for waste removal in the Double-Shell Tank Annulus.

Background/Introduction:
The objective is to provide a combination of two pumps capable of high flow removal of waste for the DST Annulus, and removal of the heel to the extent possible. The pumping scheme should follow that addressed in an ARES Report Number 9905303-001, March 1999, "Double-Shell Tank Annulus Pumping Alternative Evaluation" unless changed with LMHC concurrence. A spare pumping system will also be procured. These activities support Tasks 19DAPB "Prepare Procurement Specification & Procure Pump" and 19DAPC "Design, Procure, Fabricate, Receive & Store Jumpers & Pump Assemblies" of the schedule attached to correspondence LMHC-9954506R2 October 25, 1999.

Scope:
This Task Order allows Fluor Daniel Northwest to perform, as required, the following minimum activities:

Task 19DAPB
1. Review of piping system and prepare preliminary design (6 DST Farms transferring to 106-AP)
2. Prepare procurement specification for pumps
3. Support procurement activities
4. Evaluate bids, and select vendor
5. Prepare acceptance test procedure
6. Evaluate run-in data for the tested pumps
7. Develop Certified Vendor Information File

Task 19DAPC
8. Final design of pump assemblies and farm specific flanges
9. Fabrication support of pump assemblies
10. Identification of common spare jumper parts
11. Prepare spare parts list

References:
Piping pressure drop calculations for the Cross-site transfer route to AP Tank Farm have been documented in Project W-058 files in calculation numbers W058-P-044 and 048. Schematics with transfer line lengths have been developed for most tank farm routings to AP farm and can be found in the Emergency Transfer procedures TO-001-181, 182, 183, 184 and TO-430-500 as excavation schematics.

Deliverables:
Design drawings, procurement specification, acceptance test procedure all prepared in accordance with LMHC approved procedures.

Acceptance Criteria:
Documentation with the appropriate LMHC and FDNW approvals as established in current procedures.

Period of Performance:
Activities associated with this SOW are expected to be initiated as soon as possible after receipt of the Task Order, with completion on or before April 11, 2000 for Task 19DAPB and June 2, 2000 for Task 19DAPC.

Technical Point of Contact:
The following personnel are assigned as liaison with Fluor Daniel Northwest for the scope of work described:

- Technical Contact: D. W Reberger, LMHC, Double Shell Tank Engineering
Administrative Contact: A. B. Johnson, L.K. Martin LMHC, Financial Control

Project Engineer: S. J. Lepka, LMHC, Operational Configuration Management.

Applicable ES&H requirements:
Standard ES&H requirements (without ISMS) are warranted for this work.

Safety Requirements:
N/A

Requirements (Including Quality Assurance Requirements):
The subcontractor is subject to Title 10, Code of Federal Regulations, Part 830.120 (10 CFR 830.120), Quality Assurance Requirements, and the enforcement actions under 10 CFR 820, General Statement of Enforcement Policy.

Hold Points:
N/A

Configuration Management Requirements:
N/A

Work Location/Potential Access Requirements:
N/A

Training:
N/A

Qualifications:
Degreed Engineering support as required.

Special Requirements:
N/A

Reporting/Administration:
Status Meetings will be as requested by LMHC or FDNW. Any documentation computer files such as Supporting Documents will be prepared in Word Perfect or Microsoft Word.
ISMS Clause Flow Down Prescreening Questions

<table>
<thead>
<tr>
<th>Does the work involve one or more of the following?</th>
<th>Applicable</th>
<th>SME **</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Operation, maintenance, repair or testing of electrical, pneumatic, hydraulic or mechanical systems (e.g., N2 plant operation, elevator repair, substation breaker repair, etc.)</td>
<td>Yes/Maybe*</td>
<td>X IS/H</td>
</tr>
<tr>
<td>2. Construction or excavation</td>
<td>X</td>
<td>IS/IH/ENV/Rad</td>
</tr>
<tr>
<td>3. Hazardous materials, chemicals or substances (e.g., pest and weed control, chemical inventory, lead or lead-containing materials, asbestos, beryllium, hazardous or radiological waste, etc.)</td>
<td>X</td>
<td>ENV/IH/Rad</td>
</tr>
<tr>
<td>4. The activity includes deliverables or services where potential radiological harm, radiation, or radioactive material governed by 10 CFR 835 is present.</td>
<td>X</td>
<td>Rad/IH</td>
</tr>
<tr>
<td>5. Exposure to significant occupational hazards (e.g., hoisting, rigging or cranes; confined space; scaffolding or elevated work platforms; compressed gas cylinders; portable hand held tools, powered by electrical or mechanical energy; portable heating equipment; welding or cutting; explosives; heat stress, etc.)</td>
<td>X</td>
<td>IS/IH</td>
</tr>
<tr>
<td>6. Nuclear facilities, or their support systems or their authorization basis.</td>
<td>X</td>
<td>Nuc Safety</td>
</tr>
<tr>
<td>7. Tanks, lines or vessels being breached</td>
<td>X</td>
<td>IS/IH</td>
</tr>
<tr>
<td>8. Structures, systems or components designated as Safety Class, Safety Significant or identified as providing defense-in-depth or worker safety in a Facility Authorization Basis (FAB).</td>
<td>X</td>
<td>Nuc Safety</td>
</tr>
<tr>
<td>9. Work that could impact the health and safety of site personnel.</td>
<td>X</td>
<td>IS/IH</td>
</tr>
<tr>
<td>10. The potential for changes in emission, generating rates, or new discharge of hazards, radiation, petroleum, substances, or other pollutants from a facility or process to the environment (air, water, land).</td>
<td>X</td>
<td>ENV</td>
</tr>
<tr>
<td>11. Maintenance or repair of Fire Protection systems.</td>
<td>X</td>
<td>Fire Prot</td>
</tr>
</tbody>
</table>

* If any question is answered YES or MAYBE, then Subject Matter Expert (SME) evaluation is REQUIRED.

** This is not a comprehensive list of SME(s). All appropriate SME(s) shall be involved in the evaluation as needed.
Title - Statement of Work for Annulus Pumping
Contract 4975 – Fluor Daniel Northwest
Revision Number - 0
Date – December 9, 1999

Objective:
This task order is to authorize Fluor Daniel Northwest to provide engineering design support for modifying the Emergency pumping trailer to support waste removal in the Double-Shell Tank Annulus.

Background/Introduction:
The objective is to provide capabilities in the trailer to store the pump assemblies, and provide electrical and pneumatic interfaces with the farms to allow rapid response to annulus pumping operations. These activities support Tasks 19DAPD “Modify Emergency Pumping Trailer” and 19DAPE “Develop Procedures” of the schedule attached to correspondence LMHC-9954506R2 October 25, 1999.

Scope:
This Task Order allows Fluor Daniel Northwest to perform, as required, the following minimum activities:

Task 19DAPD
1. Design trailer racks for equipment storage
2. Support fabrication and installation of racks
3. Design modification to trailer electrical skid to support pumping operations in all 6 DST farms
4. Design modifications to electrical interface for six tank farms
5. Design modifications to trailer air supply to support pump operation

Task 19DAPE
6. Prepare Operational Test Procedure (OTP) for trailer and farm equipment and pumps

Task 19DAPD
7. Support OTP and prepare Operational Test Report (OTR)

References:
An electrical skid design for annulus pumping in AP Tank Farm is on Drawing H-2-90470 Sheet 4.
The Drawings for the trailer equipment are – Index H-14-103175 and H-14-103144 through H-14-103150

Deliverables:
Design drawings, procurement specification, operational test procedure and report all prepared in accordance with LMHC approved procedures.

Acceptance Criteria:
Documentation with the appropriate LMHC and FDNW approvals as established in current procedures.

Period of Performance:
Activities associated with this SOW are expected to be initiated, as soon as possible after receipt of the Task Order, with completion on or before March 15, 2000 for Task 19DAPD and May 1, 2000 for Task 19DAPE.

Technical Point of Contact:
The following personnel are assigned as liaison with Fluor Daniel Northwest for the scope of work described:

- Technical Contact: D. W Reberger, LMHC, Double Shell Tank Engineering
- Administrative Contact: A. B. Johnson, L.K. Martin, LMHC, Financial Control
- Project Engineer: S. J. Lepka, LMHC, Operational Configuration Management

Applicable ES&H requirements:
Standard ES&H requirements (without ISMS) are warranted for this work.

Safety Requirements:
N/A

Requirements (Including Quality Assurance Requirements):
The subcontractor is subject to Title 10, Code of Federal Regulations, Part 830.120 (10 CFR 830.120), *Quality Assurance Requirements*, and the enforcement actions under 10 CFR 820, *General Statement of Enforcement Policy*.

Hold Points:
N/A

Configuration Management Requirements:
N/A

Work Location/Potential Access Requirements:
N/A

Training:
N/A

Qualifications:
Degreed Engineering support as required.

Special Requirements:
N/A

Reporting/Administration:
Status Meetings will be as requested by LMHC or FDNW. Any documentation computer files such as Supporting Documents will be prepared in Word Perfect or Microsoft Word.
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<th>SME</th>
</tr>
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<td>X</td>
<td>IS/H</td>
</tr>
<tr>
<td>2. Construction or excavation</td>
<td>X</td>
<td>IS/IH/ENV/Rad</td>
</tr>
<tr>
<td>3. Hazardous materials, chemicals or substances (e.g., pest and weed control, chemical inventory, lead or lead-containing materials, asbestos, beryllium, hazardous or radiological waste, etc.)</td>
<td>X</td>
<td>ENV/IH/Rad</td>
</tr>
<tr>
<td>4. The activity includes deliverables or services where potential radiological harm, radiation, or radioactive material governed by 10 CFR 835 is present.</td>
<td>X</td>
<td>Rad/IH</td>
</tr>
<tr>
<td>5. Exposure to significant occupational hazards (e.g., hoisting, rigging or cranes; confined space; scaffolding or elevated work platforms; compressed gas cylinders; portable hand held tools, powered by electrical or mechanical energy; portable heating equipment; welding or cutting; explosives; heat stress, etc.)</td>
<td>X</td>
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<td>X</td>
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<td>7. Tanks, lines or vessels being breached</td>
<td>X</td>
<td>IS/IH</td>
</tr>
<tr>
<td>8. Structures, systems or components designated as Safety Class, Safety Significant or identified as providing defense-in-depth or worker safety in a Facility Authorization Basis (FAB).</td>
<td>X</td>
<td>Nuc Safety</td>
</tr>
<tr>
<td>9. Work that could impact the health and safety of site personnel.</td>
<td>X</td>
<td>IS/IH</td>
</tr>
<tr>
<td>10. The potential for changes in emission, generating rates, or new discharge of hazards, radiation, petroleum, substances, or other pollutants from a facility or process to the environment (air, water, land).</td>
<td>X</td>
<td>ENV</td>
</tr>
<tr>
<td>11. Maintenance or repair of Fire Protection systems.</td>
<td>X</td>
<td>Fire Prot</td>
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</table>

* If any question is answered YES or MAYBE, then Subject Matter Expert (SME) evaluation is REQUIRED.

** This is not a comprehensive list of SME(s). All appropriate SME(s) shall be involved in the evaluation as needed.
PROCUREMENT SPECIFICATION

ANNULUS HEEL PUMP

Prepared for
CH2M Hill Hanford

by
Fluor Federal Services
Contract Number 65100541

APPROVED

Fluor Federal Services (FFS)

Author  2/24/00  Robert B. Hoffmann  2/24/00

Checker  2/24/00  Bradley Rasing  2/24/00

Quality Engineering  2/24/00

CH2M Hill Hanford (CHG)

Cognizant Engineer  2/24/00

Cognizant Engineering Manager  2/28/00
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<td>SUMMARY OF SUBMITTALS</td>
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<tr>
<td>ATTACHMENT - Figure 1</td>
<td>12</td>
</tr>
</tbody>
</table>
1 SCOPe

1.1 This Specification provides the minimum requirements for an air driven heel pump, driver and any special handling equipment required for pump shipping and installation.

1.2 Work Included: Design, analysis, fabrication, inspection, testing, documentation, packaging, and shipping.

1.3 Work Not Included: Site services and installation or operation of equipment.

2 APPLICABLE DOCUMENTS

2.1 The following documents form a part of this Specification to the extent designated, except as modified by the requirements specified herein. The latest edition with addenda shall be used unless noted otherwise.

2.1.1 Hydraulic Institute (HI)

6.6 Reciprocating Pump Tests

2.1.2 National Fire Protection Association (NFPA)

70 National Electric Code (NEC)

3 REQUIREMENTS

3.1 Equipment Description

3.1.1 The pump unit shall be used to transfer the heel of the abrasive radioactive slurry that has leaked into the annulus between the inner and outer tank shell.

3.1.2 The heel pump will be installed into the annulus of double shell underground radioactive waste storage tanks, which are typically 75 to 85 feet in diameter, flat-bottomed with domed tops and approximately 6 feet of soil cover. The liquid capacity of the tanks is typically one million gallons with maximum liquid depths of up to 35 feet.

3.1.3 Pump access is through concrete pump pits located just above the waste tank annulus.

3.1.4 The heel pumps and drivers will be installed in these sealed pump pits and will not be accessible for periods of up to a year. This equipment is expected to operate for up to 2,000 hours over a 2-year period without any maintenance.

3.1.5 These pumps will be stored and installed only in the case of a leak into the tank annulus. During the time in storage it is anticipated that they will be periodically performance tested to ensure the availability of reliable pumps should there be a leak.

3.1.6 The maximum weight of the pump assembly, including motor and water, shall not exceed 1,000 lbs. The Seller shall specify both wet and dry weights of the equipment furnished.

3.1.7 The equipment furnished shall be air driven, positive displacement, and reciprocating cylinder pumps capable of pumping the fluid described herein.
3.2 Environmental Conditions

3.2.1 The heel pump shall be able to withstand the following conditions inside the pump pit and in the annulus area:

<table>
<thead>
<tr>
<th>LOCATION</th>
<th>TEMPERATURE</th>
<th>% RELATIVE HUMIDITY</th>
<th>RADIATION EXPOSURE IN RAD</th>
</tr>
</thead>
<tbody>
<tr>
<td>PUMP PIT</td>
<td>15 to 150 °F</td>
<td>0 to 100</td>
<td>50</td>
</tr>
<tr>
<td>TANK VAPOR SPACE</td>
<td>50 to 140 °F</td>
<td>0 to 100</td>
<td>400</td>
</tr>
<tr>
<td>ANNULUS LIQUID</td>
<td>65 to 140 °F</td>
<td>N/A</td>
<td>500</td>
</tr>
</tbody>
</table>

3.3 Fluid Pumped

3.3.1 The radioactive sludge settled in the tanks consists mainly of insoluble oxides and/or hydroxides of aluminum, iron, manganese, and zirconium.

3.3.2 Fluid Properties

<table>
<thead>
<tr>
<th>Specific Gravity</th>
<th>1.47</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absolute Viscosity, Centipoise</td>
<td>1.0 to 30 cP</td>
</tr>
<tr>
<td>Solids Content (vol.%)</td>
<td>0 to 20.0</td>
</tr>
<tr>
<td>Particle Size, Micron</td>
<td>0.5 to 4000*</td>
</tr>
<tr>
<td>Abrasiveness, Miller Number (ASTM G75-82)</td>
<td>less than 100</td>
</tr>
<tr>
<td>Temperature (transfer)</td>
<td>65 to 140 °F</td>
</tr>
<tr>
<td>Temperature (flush or dilution)</td>
<td>35 to 150 °F</td>
</tr>
<tr>
<td>pH</td>
<td>7 – 14</td>
</tr>
</tbody>
</table>

Although 50-micron particle size is the nominal design point, the pump must be fully capable of operating with the full range of particle sizes. The number of larger (500 to 4000 micron) particles will be relatively small (less than 1% of the total particles). Particles in the range of 50 to 500 micron will constitute less than 5% of the total particles. Particles ranging in size from 0.5 to 50 micron will constitute approximately 95% of the total particles.

3.4 Performance Requirements

3.4.1 The pump shall be designed to deliver a minimum 2 gpm at 100 feet of head.

3.4.2 Any special design features that improve the pump's ability to pump closer to the bottom of the annulus shall be considered.
3.4.3 The transfer pump shall deliver the rated head and flow at a minimum NPSHA of 19 feet at 140 °F (assumes zero submergence).

3.4.4 The pump shall have a stable head/capacity curve that continuously rises from rated capacity to shut-off.

3.5 Design

3.5.1 Assembly

3.5.1.1 The pump assembly specified herein includes pump parts and driver.

3.5.1.2 The design pressure of the pressure-retaining components shall be the maximum pressure of the pump at shut-off when pumping fluid of the highest specific gravity specified herein.

3.5.1.3 The pump suction will be located as close as possible to the bottom of the tank without obstructing the suction flow.

3.5.2 Pump Installation

3.5.2.1 Installation of the pump will be by a single (preferred), mobile crane operation. The fully assembled pump, driver, and column will be lifted from the horizontal to the vertical position and then lowered through a 12-inch (inside diameter) adapter into the waste storage tank annulus. Prior to installation the Heel Pump will be attached to its companion Transfer Pump (procured under a separate specification) and both will be installed simultaneously.

3.5.2.2 The pump shall be provided with a lifting attachment. The Seller shall detail any special handling requirements in the instruction manual to ensure that the pump assembly can be safely lifted and installed without damage to the pump or tank.

3.5.2.3 The pump assembly will be fully assembled (by the Buyer) prior to installation into the waste tank.

3.5.3 Dimensional Restrictions

3.5.3.1 The pump assembly will consist of the air driven heel pump specified herein and a motor driven transfer pump. Together they shall not exceed 11-1/2 inches in diameter so the pump can pass freely through a 12-inch inside diameter riser into the annulus. (See Figure 1)

3.5.3.2 The pump assembly length shall be determined by the Buyer, based on locating the pump's suction as close as possible to the tank bottom, given the elevations from the existing riser flange to the inside bottom of tank annulus. The column piping and fittings shall be designed and supplied by the Buyer.

3.5.4 Materials

3.5.4.1 Materials shall be selected by the Seller based on acceptable performance when subjected to the chemical and radiation exposures described herein. Wetted parts shall be made of corrosion-resistant materials, suitable for this environment and shall be constructed of non-sparking materials, or shall have been analyzed and evaluated.
to be incapable of sparking under the applied conditions. Material selection shall be identified in Seller documents submitted to the Buyer.

3.5.4.2 Brass, bronze, and copper base materials, if used, shall not come in contact with the waste tank fluid or vapor. The use of aluminum and chrome is not acceptable.

3.5.4.3 Materials used shall be clearly identified on the bill of material as to material type and grade; however, Certified Material Test Reports (CMTR's) are not required.

3.5.4.4 Chemical and physical properties of the elastomers shall be suitable for the chemical and radiation environment in which they are used.

3.5.4.5 Lubricants, adhesives, and gaskets shall be constructed of non-sparking materials, or shall have been analyzed and evaluated to be incapable of sparking under the applied conditions.

3.5.4.6 Exposed polymer materials shall be constructed of, as a minimum, the anti-static class of materials.

3.6 Fabrication Processes

3.6.1 Fabrication by welding, as well as any weld repairs to such parts, shall be performed and inspected by operators and procedures qualified in accordance with the Seller's QA Program.

3.7 Marking

3.7.1 The pump shall have a manufacturer's nameplate using the Sellers standard practice. The nameplate shall include the assembly weight (dry and wet) and purchase order number.

3.8 Cleaning/Painting

3.8.1 The pump, including parts, shall be delivered to the Site clean and free of any oils, tape adhesives, weld splatter, dirt, loose debris, and other contaminants.

3.8.2 Solvents and cleaning solutions used on stainless steels shall be chloride-free.

3.8.3 Stainless steel components do not require painting except as needed for identification or for targeting. Paint used on stainless steel shall be epoxy-phenolic.

3.9 Inspection/Examination

3.9.1 Inspection shall be done in accordance with the manufacturers standard practice.

3.10 Testing

3.10.1 General

3.10.1.1 The Buyer reserves the right to witness all tests and shall be given a minimum of 10 working days written notice prior to each test date.

3.10.1.2 The performance tests shall be conducted using only job components.
3.10.1.3 Water used for hydrostatic and performance testing shall be tested for chlorides. The chloride content of the test medium shall not exceed 50 ppm for water temperatures of 149 °F and less. The chloride content for water at elevated testing temperatures of 212 °F shall not exceed 1 ppm.

3.10.2 Hydrostatic Testing

3.10.2.1 The pump shall be hydrostatically tested in accordance with the Sellers standard practice.

3.10.3 Performance Testing

3.10.3.1 Performance testing shall be done to the Sellers standard practice.

3.11 Instruction Manuals

Instruction manuals shall be provided that contain storage, installation, start-up and maintenance instructions for the pump and all associated equipment.

Pump lifting requirements shall be provided in detail along with any special precautions related to either handling or operating the equipment furnished. The use of any special tooling provided shall be explained in detail. All drawings and procedures required for pump installation and operation shall be included in the manual for quick reference.

4 QUALITY ASSURANCE

4.1 Quality Assurance Program

The Seller shall have a Quality Assurance Program (QAP) that establishes quality control. The QAP shall identify procedures or workmanship standards. (If the Seller has an established QAP he shall furnish a matrix which cross-references the established program with criteria listed.) The QAP shall include details on the following programmatic functions:

4.1.1 Organization: The organization structure, functional responsibilities, levels of authority, and lines of communication for activities affecting quality shall be documented. Persons or organizations responsible for ensuring that an appropriate QAP has been established and verifying that activities affecting quality have been correctly performed shall have sufficient authority, access to work areas, and organizational freedom to:

a. Identify quality problems.

b. Initiate, recommend, or provide solutions to quality problems through designated channels.

c. Verify implementation of solutions.

d. Ensure that further processing, delivery, installation, or use is controlled until proper disposition of a nonconformance, deficiency, or unsatisfactory condition has occurred.
The documented QAP shall be planned, implemented, and maintained. The program shall provide control over activities affecting quality to an extent consistent with their importance. The program shall be established at the earliest time consistent with the schedule for accomplishing the activities.

The program shall provide for the planning and accomplishment of activities affecting quality under suitably controlled conditions. The program shall provide for any special controls, processes, test equipment, tools, and skills to attain the required quality and for verification of quality.

The program shall provide for indoctrination and training, as necessary, of personnel performing activities affecting quality to ensure that suitable proficiency is achieved and maintained.

The program shall establish responsibility and authority to stop work or to control further operations where conditions adverse to Specification and quality requirements are identified and immediate corrective actions are required.

Design Control: The design shall be defined, controlled, and verified. Applicable design inputs shall be appropriately specified on a timely basis and correctly translated into design documents. Design interfaces shall be identified and controlled. Design adequacy shall be verified by persons other than those who designed the item. Design changes, including field changes, shall be governed by control measures commensurate with those applied to the original design.

Instructions, Procedures, and Drawings: Activities affecting quality shall be prescribed by and performed in accordance with documented instructions, procedures, or drawings of a type appropriate to the circumstances. These documents shall include or reference appropriate quantitative or qualitative acceptance criteria for determining that prescribed activities have been satisfactorily accomplished.

Document Control: The preparation, issue, and change of documents that specify quality requirements or prescribe activities affecting quality shall be controlled to ensure that correct documents are being employed. Ensure the latest approved issue of Specifications and Drawings are used for designing, procuring, manufacturing, assembling, inspecting, and testing.

Identification and Control of Items: Controls shall be established to ensure that only correct and accepted items are used or installed. Identification shall be maintained on the items or in documents traceable to the items, or in a manner that ensures identification is established and maintained. Controls for receiving inspection shall include provisions for detection and exclusion of misrepresented products.

Control of Processes: Processes affecting quality or services shall be controlled. Special processes that control or verify quality, such as those used in welding, heat treating, and nondestructive examination, shall be performed by qualified personnel using qualified procedures in accordance with specified requirements.

Inspection: Inspection required to verify conformance of an item or activity to specified requirements shall be planned and executed. Characteristics to be employed shall be specified. Inspection results shall be documented. Inspections shall be performed by persons other than those responsible for the work.
4.1.9 Test Control: Tests required to verify conformance of an item to specified requirements and to demonstrate that items will perform satisfactorily in service shall be planned and executed. Characteristics to be tested and test methods to be employed shall be specified. Test results shall be documented and their conformance with acceptance criteria shall be evaluated.

4.1.10 Control of Measuring and Test Equipment: Tools, gages, instruments, and other measuring and test equipment used for activities affecting quality shall be controlled and, at specified periods, calibrated and adjusted to maintain accuracy within necessary limits.

4.1.11 Nonconformance Reporting: Items that do not conform to specified requirements shall be controlled to prevent inadvertent installation or use. Controls shall provide for identification, documentation, evaluation, segregation when practical, and disposition of nonconforming items, and for notification to affected organizations. In addition, the Seller shall deliver copies of all Seller-initiated nonconformance reports to Buyer at time of initiation and closeout.

4.1.12 Quality Assurance Records: Records that furnish documentary evidence of quality shall be specified, prepared, and maintained. Records shall be legible, identifiable, and retrievable. Records shall be protected against damage, deterioration, or loss.

5 SUBMITTALS - See Summary of Submittals for number of copies, purpose, and when required.

5.1 General

5.1.1 Identify each submittal by this Specification number, item number, PO number, and Seller's identification number.

5.1.2 Data shall be sufficiently clear to allow legible copies to be made on standard reproduction equipment after microfilming.

5.1.3 Allow 21 calendar days for Buyer review and disposition.

5.1.4 Approval by the Buyer does not relieve the Seller of responsibility for accuracy or adequacy of design under this Specification.

5.1.5 Submittals are divided into 2 types: 1) those requiring "approval" (e.g., approval data or prepurchase evaluation data); and 2) those "not requiring approval" (e.g., vendor information data).

5.1.6 Submittals "not requiring approval" will be reviewed to verify completeness and adequacy for their intended purposes. Unacceptable items will be handled as specified below:

5.1.6.1 A submittal requiring approval that is not approved, is identified as: 1) "Not Approved, Revise and Resubmit." The submittal is considered technically deficient, or incomplete, and therefore unacceptable. Resubmittal is required, hence fabrication, procurement, or performance of procedures shall not proceed; or 2) "Approved with Exception." Fabrication, procurement, and performance of procedures may proceed, and resubmittal is required to verify incorporation of the exception.
Submittals "not requiring approval" that are determined to be incomplete or inadequate will be returned marked "Resubmit." An explanation of the deficiencies will be included for corrective action by the Seller.

List

5.2.1 (Item 1) Quality Assurance Program (4.1).

5.2.2 (Item 2) Schedule: Schedule showing shipment of the equipment after receipt of the order.

5.2.3 (Item 3) Drawings

a. General arrangement and outline drawings for the pump assembly and motor, showing overall dimensions and overall weights.

b. Cross-sectional drawings showing the details of the proposed equipment, including bill of materials to reflect the actual equipment and scope proposed.

5.2.4 (Item 4) Catalog bulletins and descriptive data illustrating the pump and motor being offered.

5.2.5 (Item 5) Preliminary performance curve with high- and low-end rating points, including efficiency, water NPSHR, and air consumption expressed as functions of capacity.

5.2.6 (Item 6) Certified pump and driver outline drawings with dimensions and bill of materials.

5.2.7 (Item 7) Instruction Manuals (3.11).

5.2.8 (Item 8) Bill of Materials.

6 PREPARATION FOR DELIVERY

6.1 Preservation: Item shall be protected from dirt, soil, and moisture.

6.2 Packaging: Item shall be boxed or crated in a manner to prevent damage during shipping.

6.3 Marking: Packages shall be suitably marked on the outside to facilitate identification of the purchase order, the procurement specification, the package contents, and any special handling instructions.

6.4 The Seller shall recommend the preferred method of shipping and provide protection of the equipment during transit and storage.
### SUMMARY OF SUBMITTALS

<table>
<thead>
<tr>
<th>Item</th>
<th>Title</th>
<th>Copies</th>
<th>Purpose</th>
<th>When required</th>
</tr>
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<tr>
<td>1</td>
<td>Quality Assurance Program</td>
<td>2</td>
<td>Prepurchase Evaluation</td>
<td>With bid</td>
</tr>
<tr>
<td>2</td>
<td>Schedule</td>
<td>2</td>
<td>Prepurchase Evaluation</td>
<td>With bid</td>
</tr>
<tr>
<td>3</td>
<td>Drawings</td>
<td>2</td>
<td>Prepurchase Evaluation</td>
<td>With bid</td>
</tr>
<tr>
<td>4</td>
<td>Catalog Bulletin/Descriptive Data</td>
<td>2</td>
<td>Prepurchase Evaluation</td>
<td>With bid</td>
</tr>
<tr>
<td>5</td>
<td>Preliminary Performance Curve</td>
<td>2</td>
<td>Prepurchase Evaluation</td>
<td>With bid</td>
</tr>
<tr>
<td>6</td>
<td>Certified Pump Dimensional Drawings</td>
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<td>Prior to fabrication</td>
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<tr>
<td>7</td>
<td>Instruction Manuals</td>
<td>5</td>
<td>Vendor Information</td>
<td>With Shipment</td>
</tr>
<tr>
<td>8</td>
<td>Bill of Materials</td>
<td>2</td>
<td>Approval</td>
<td>Prior to Fabrication</td>
</tr>
</tbody>
</table>
1. OW.

GAL.

WASTE LEVEL.

TYP WASTE TANK

COLUMN BY BUYER

ANNULUS SUBMERSIBLE PUMPS (BY OTHERS)

INSIDE BOT OF ANNULUS

INSIDE BOT OF ANNULUS TANK BOTTOM

FIGURE 1
SCALE: 1 1/2" = 1'-0"
PROCUREMENT SPECIFICATION

ANNULUS SUBMERSIBLE TRANSFER PUMP

Prepared for
CH2M Hill Hanford

by
Fluor Federal Services
Contract Number 65100541

APPROVED
Fluor Federal Services (FFS)

Author Date Technical Documents Date
Marshall 2/17/00 Robert B. 2/17/00

Checker Date Project Management Date
R. Dale 2/17/00 Bradley 2/17/00

Quality Engineering Date
R. Hall 2/17/00

CH2M Hill Hanford (CHG)

Cognizant Engineer Date
Dean 2/17/00

Cognizant Engineering Manager Date
Bard 2/17-00

02/17/00
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<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
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<td>Title and Approval Page</td>
<td>1</td>
</tr>
<tr>
<td>Table of Contents</td>
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<td>1 SCOPE</td>
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<td>2 APPLICABLE DOCUMENTS</td>
<td>3</td>
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<td>3 REQUIREMENTS</td>
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<td>4 QUALITY ASSURANCE</td>
<td>8</td>
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<tr>
<td>5 SUBMITTALS</td>
<td>10</td>
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<td>6 PREPARATION FOR DELIVERY</td>
<td>11</td>
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<td>SUMMARY OF SUBMITTALS</td>
<td>12</td>
</tr>
<tr>
<td>ATTACHMENT - Figure 1</td>
<td>13</td>
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</table>

02/17/00
SCOPE

1. This Specification provides the minimum requirements for a submersible transfer pump and driver, and any special handling equipment required for pump shipping and installation.

1.2 Work Included: Pump design, analysis, fabrication, inspection, testing, documentation, packaging, and shipping.

1.3 Work Not Included: Design and manufacture of pump dilution water system and column piping. Site services and assembly, installation or operation of equipment.

APPLICABLE DOCUMENTS

2.1 The following documents form a part of this Specification to the extent designated, except as modified by the requirements specified herein. The latest edition with addenda shall be used unless noted otherwise.

2.1.1 Hydraulic Institute (HI)

2.1.2 National Electrical Manufacturers Association (NEMA)

2.1.3 National Fire Protection Association (NFPA)

2.1.4 Underwriters Laboratories Inc. (UL)

REQUIREMENTS

3.1 Equipment Description

3.1.1 The pump unit shall be used to transfer abrasive radioactive slurry that has leaked into the annulus between the inner and outer tank shell.

3.1.2 The transfer pump will be installed into the annulus of double shell underground radioactive waste storage tanks, which are typically 75 to 85 feet in diameter, flat-bottomed with domed tops and approximately 6 feet of soil cover. The liquid capacity of the tanks is typically one million gallons with maximum liquid depths of up to 35 feet.

3.1.3 Pump access is through concrete pump pits located just above the waste tank annulus.

3.1.4 The transfer pumps and drivers will be installed in the annulus and will not be accessible for periods of up to a year. This equipment is expected to operate for up to 2,000 hours over a 2-year period without any maintenance.
3.1.5 These pumps will be stored in a warehouse and installed only in the case of a leak into the tank annulus. During the time in storage it is anticipated that they will be periodically performance tested to ensure the availability of reliable pumps should there be a leak.

3.1.6 The maximum weight of the pump assembly, including motor and water, shall not exceed 1,000 lbs. The Seller shall specify both wet and dry weights of the equipment furnished.

3.2 Environmental Conditions

3.2.1 The transfer pump shall be able to withstand the following conditions inside the pump pit and in the annulus area:

<table>
<thead>
<tr>
<th>LOCATION</th>
<th>TEMPERATURE</th>
<th>% RELATIVE HUMIDITY</th>
<th>RADIATION EXPOSURE IN RAD</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>PER HOUR</td>
</tr>
<tr>
<td>PUMP PIT</td>
<td>15 to 150 °F</td>
<td>0 to 100</td>
<td>50</td>
</tr>
<tr>
<td>TANK VAPOR SPACE</td>
<td>50 to 140 °F</td>
<td>0 to 100</td>
<td>400</td>
</tr>
<tr>
<td>ANNULUS LIQUID</td>
<td>65 to 140 °F</td>
<td>N/A</td>
<td>500</td>
</tr>
</tbody>
</table>

3.3 Fluid Pumped

3.3.1 The radioactive sludge settled in the tanks consists mainly of insoluble oxides and/or hydroxides of aluminum, iron, manganese, and zirconium.

3.3.2 Fluid Properties

<table>
<thead>
<tr>
<th>Specific Gravity</th>
<th>1.47</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absolute Viscosity, Centipoise</td>
<td>1.0 to 30 cP</td>
</tr>
<tr>
<td>Solids Content (vol.%)</td>
<td>0 to 20.0</td>
</tr>
<tr>
<td>Particle Size, Micron</td>
<td>0.5 to 4000*</td>
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<td>Abrasiveness, Miller Number (ASTM G75-82)</td>
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</tr>
<tr>
<td>PH</td>
<td>7 - 14</td>
</tr>
</tbody>
</table>

* Although 50-micron particle size is the nominal design point, the pump must be fully capable of operating with the full range of particle sizes. The number of larger (500 to 4000 micron) particles will be relatively small (less than 1% of the total particles). Particles in the range of 50 to 500 micron will constitute less than 5% of the total particles. Particles ranging in size from 0.5 to 50 micron will constitute approximately 95% of the total particles.
3.4 Performance Requirements

3.4.1 The pump shall be designed to deliver a range of flows from 40 gpm at 160 feet of head to 140 gpm at approximately 100 feet of head. Multiple units in tandem are acceptable.

3.4.2 If multiple units are used, only the lowest pump shall be required to have the pump suction submersed in the pumpage.

3.4.3 Any special design features that improve the pumps ability to pump closer to the bottom of the annulus shall be considered.

3.4.4 The transfer pump shall deliver the rated head and flow at a minimum NPSHA of 19 feet at 140 °F (assumes zero submergence).

3.4.5 The pump shall have a stable head/capacity curve that continuously rises at least 5% from rated capacity to shut-off.

3.4.6 The pump shall be designed to tolerate reverse rotation or be provided with an anti-reverse rotation device if reverse rotation of the pump is unacceptable.

3.5 Design

3.5.1 Assembly

3.5.1.1 The pump assembly specified herein includes pump parts and driver. The pump(s) will be connected to the buyer's discharge column and to the adjacent Heel pump (procured under a separate specification) at the site prior to installation in the Annulus. If the pump(s) are not furnished with a top discharge, it will be field modified to a top discharge configuration.

3.5.1.2 The pump will have a system (by the Buyer) to add 50 gpm of dilution water at 100 psig or less pressure, injected at the suction of the pump in a manner that directs the diluent into the pump.

3.5.1.3 The design pressure of the pressure-retaining components shall be the maximum pressure of the pump at shut-off when pumping fluid of the highest specific gravity specified herein.

3.5.1.4 The rotor assembly shall be sized and supported to minimize vibration and promote maximum bearing life.

3.5.1.5 Impeller design shall be the Seller's choice but shall be free draining.

3.5.1.6 The pump shall be designed such that the first classical running critical speed (wet) is at least 25% above the maximum operating speed.

3.5.1.7 The pump suction will be located as close as possible to the bottom of the tank without obstructing the suction flow.

3.5.1.8 The pump shall have a top discharge (or be convertible to a top discharge) with a 3" NPT male connection.

3.5.2 Pump Installation
3.5.2.1 Installation of the pump will be by a single (preferred), mobile crane operation. The fully assembled pump, motor, and column will be lifted from the horizontal to the vertical position and then lowered through a 12-inch (inside diameter) adapter into the waste storage tank annulus.

3.5.2.2 The pump(s) shall be provided with a lifting attachment. The power cable and motor cable entry point shall be located to prevent being damaged during installation. The Seller shall detail any special handling requirements in the instruction manual to ensure that the pump assembly can be safely lifted and installed without damage to the pump or tank.

3.5.3 Dimensional Restrictions

3.5.3.1 The pump assembly will consist of the pump(s) specified herein and an air driven heel pump. Together they shall not exceed 11-1/2 inches in diameter so the pump can pass freely through a 12-inch inside diameter riser into the annulus. The transfer pump diameter shall not exceed 9.5" in diameter. (See Figure 1)

3.5.3.2 The pump assembly length will be determined by the Buyer, based on locating the pump's suction as close as possible to the tank bottom, given the elevations from the existing riser flange to the inside bottom of tank annulus. The column piping and fittings will be designed and supplied by the Buyer.

3.5.3.3 The pump suction inlet shall be provided with a screen. The strainer/screen openings shall be determined by the Seller to protect the pump's internal passages from large solids.

3.5.4 Mechanical Shaft Seals

3.5.4.1 If required, the mechanical shaft seals shall be the Seller's choice for this service.

3.5.4.2 The pump mechanical seal materials shall be compatible with the pumped fluid.

3.5.5 Submersible Electric Motors

3.5.5.1 Motor horsepower shall be non-overloading when operating at any point on the pump curve, with the fluid specified in this Specification.

3.5.5.2 The motors shall be induction-type without sparking contacts. Where circuits are located in the tank (e.g., submersible motors), they shall be designed to meet the requirements of NFPA 70 for use in a Class I, Division 1, Group B (hydrogen) atmosphere or equivalent.

3.5.5.3 The pumps shall be provided with a 70-foot pigtail power cable to facilitate power hookup. The motors shall be supplied without a terminal box. The pigtail shall be flexible and be suitable for the Class 1, Division 1, Group B environment.

3.5.5.4 The motor shall be rated 460 V, 3-phase, 60 Hz.

3.5.6 Materials

3.5.6.1 Materials shall be selected by the Seller based on acceptable performance when subjected to the chemical and radiation exposures described herein. Wetted parts shall be made of corrosion-resistant materials, suitable for this environment and shall be constructed of non-sparking materials, or shall have been analyzed and evaluated to...
be incapable of sparking under the applied conditions. Material selection shall be identified in Seller documents submitted to the Buyer.

3.5.6.2 Brass, bronze, and copper base materials, if used, shall not come in contact with the waste tank fluid or vapor. The use of aluminum and chrome is not acceptable.

3.5.6.3 Materials used shall be clearly identified on the bill of material as to material type and grade; however, Certified Material Test Reports (CMTR's) are not required.

3.5.6.4 Chemical and physical properties of the elastomers shall be suitable for the chemical and radiation environment in which they are used.

3.5.6.5 Lubricants, adhesives, and gaskets shall be constructed of non-sparking materials, or shall have been analyzed and evaluated to be incapable of sparking under the applied conditions.

3.5.6.6 Exposed polymer materials shall be constructed of, as a minimum, the anti-static class of materials.

3.6 Fabrication Processes

3.6.1 Fabrication by welding, as well as any weld repairs to such parts, shall be performed and inspected by operators and procedures qualified in accordance with the Seller's QA Program.

3.7 Marking

3.7.1 The pump shall have a manufacturer's nameplate using the Sellers standard practice. The nameplate shall include the assembly weight (dry and wet), purchase order number and this specification number.

3.8 Cleaning/Painting

3.8.1 The pump, including parts, shall be delivered to the Site, clean and free of any oils, tape adhesives, weld splatter, dirt, loose debris, and other contaminants.

3.8.2 Solvents and cleaning solutions used on stainless steels shall be chloride-free.

3.8.3 Stainless steel components do not require painting except as needed for identification or for targeting. Paint used on stainless steel shall be epoxy-phenolic.

3.9 Inspection/Examination

3.9.1 Inspection shall be done in accordance with the manufacturer's standard practice.

3.10 Testing

3.10.1 General

3.10.1.1 Performance testing and hydrostatic testing of the pump/motor are required. The Buyer reserves the right to witness all tests and shall be given a minimum of 10 working days written notice prior to each test date.

3.10.1.2 The performance tests shall be conducted using only job components.
3.10.1.3 Water used for hydrostatic and performance testing shall be tested for chlorides. The chloride content of the test medium shall not exceed 50 ppm for water temperatures of 149 °F and less. The chloride content for water at elevated testing temperatures of 212 °F shall not exceed 1 ppm.

3.10.2 Motor Testing

3.10.2.1 The motor shall be given a routine test to demonstrate that it is free from mechanical and electrical defects. The test shall be performed in accordance with the Sellers standard practice.

3.10.3 Hydrostatic Testing

3.10.3.1 The pump shall be hydrostatically tested in accordance with the Sellers standard practice.

3.10.4 Performance Testing

3.10.4.1 Performance testing shall be done to the Sellers standard practice and shall comply with the Hydraulic Institute's requirements for centrifugal pump testing.

3.11 Instruction Manuals

Instruction manuals shall be provided that contain storage, installation, start-up and maintenance instructions for the pump and all associated equipment. Specifically, mechanical seal operating instructions shall be included in addition to the pump instructions.

Pump lifting requirements shall be provided in detail along with any special precautions related to either handling or operating the equipment furnished. The use of any special tooling provided shall be explained in detail. All drawings and procedures required for pump installation and operation shall be included in the manual for quick reference.

4 QUALITY ASSURANCE

4.1 Quality Assurance Program

The Seller shall have a Quality Assurance Program (QAP) that establishes quality control. The QAP shall identify procedures or workmanship standards. (If the Seller has an established QAP he shall furnish a matrix which cross-references the established program with criteria listed.) The QAP shall include details on the following programmatic functions:

4.1.1 Organization: The organization structure, functional responsibilities, levels of authority, and lines of communication for activities affecting quality shall be documented. Persons or organizations responsible for ensuring that an appropriate QAP has been established and verifying that activities affecting quality have been correctly performed shall have sufficient authority, access to work areas, and organizational freedom to:

a. Identify quality problems.

b. Initiate, recommend, or provide solutions to quality problems through designated channels.

c. Verify implementation of solutions.
d. Ensure that further processing, delivery, installation, or use is controlled until proper disposition of a nonconformance, deficiency, or unsatisfactory condition has occurred.

4.1.2 The documented QAP shall be planned, implemented, and maintained. The program shall provide control over activities affecting quality to an extent consistent with their importance. The program shall be established at the earliest time consistent with the schedule for accomplishing the activities.

The program shall provide for the planning and accomplishment of activities affecting quality under suitably controlled conditions. The program shall provide for any special controls, processes, test equipment, tools, and skills to attain the required quality and for verification of quality.

The program shall provide for indoctrination and training, as necessary, of personnel performing activities affecting quality to ensure that suitable proficiency is achieved and maintained.

The program shall establish responsibility and authority to stop work or to control further operations where conditions adverse to Specification and quality requirements are identified and immediate corrective actions are required.

4.1.3 Design Control: The design shall be defined, controlled, and verified. Applicable design inputs shall be appropriately specified on a timely basis and correctly translated into design documents. Design interfaces shall be identified and controlled. Design adequacy shall be verified by persons other than those who designed the item. Design changes, including field changes, shall be governed by control measures commensurate with those applied to the original design.

4.1.4 Instructions, Procedures, and Drawings: Activities affecting quality shall be prescribed by and performed in accordance with documented instructions, procedures, or drawings of a type appropriate to the circumstances. These documents shall include or reference appropriate quantitative or qualitative acceptance criteria for determining that prescribed activities have been satisfactorily accomplished.

4.1.5 Document Control: The preparation, issue, and change of documents that specify quality requirements or prescribe activities affecting quality shall be controlled to ensure that correct documents are being employed. Ensure the latest approved issue of Specifications and Drawings are used for designing, procuring, manufacturing, assembling, inspecting, and testing.

4.1.6 Identification and Control of Items: Controls shall be established to ensure that only correct and accepted items are used or installed. Identification shall be maintained on the items or in documents traceable to the items, or in a manner that ensures identification is established and maintained. Controls for receiving inspection shall include provisions for detection and exclusion of misrepresented products.

4.1.7 Control of Processes: Processes affecting quality or services shall be controlled. Special processes that control or verify quality, such as those used in welding, heat treating, and nondestructive examination, shall be performed by qualified personnel using qualified procedures in accordance with specified requirements.

4.1.8 Inspection: Inspection required to verify conformance of an item or activity to specified requirements shall be planned and executed. Characteristics to be employed shall be specified. Inspection results shall be documented. Inspections shall be performed by persons other than those responsible for the work.
4.1.9 Test Control: Tests required to verify conformance of an item to specified requirements and to demonstrate that items will perform satisfactorily in service shall be planned and executed. Characteristics to be tested and test methods to be employed shall be specified. Test results shall be documented and their conformance with acceptance criteria shall be evaluated.

4.1.10 Control of Measuring and Test Equipment: Tools, gages, instruments, and other measuring and test equipment used for activities affecting quality shall be controlled and, at specified periods, calibrated and adjusted to maintain accuracy within necessary limits.

4.1.11 Nonconformance Reporting: Items that do not conform to specified requirements shall be controlled to prevent inadvertent installation or use. Controls shall provide for identification, documentation, evaluation, segregation when practical, and disposition of nonconforming items, and for notification to affected organizations. In addition, the Seller shall deliver copies of all Seller-initiated nonconformance reports to Buyer at time of initiation and closeout.

4.1.12 Quality Assurance Records: Records that furnish documentary evidence of quality shall be specified, prepared, and maintained. Records shall be legible, identifiable, and retrievable. Records shall be protected against damage, deterioration, or loss.

5 SUBMITTALS - See Summary of Submittals for number of copies, purpose, and when required.

5.1 General

5.1.1 Identify each submittal by this Specification number, item number, PO number, and Seller's identification number.

5.1.2 Data shall be sufficiently clear to allow legible copies to be made on standard reproduction equipment after microfilming.

5.1.3 Allow 21 calendar days for Buyer review and disposition.

5.1.4 Approval by the Buyer does not relieve the Seller of responsibility for accuracy or adequacy of design under this Specification.

5.1.5 Submittals are divided into 2 types: 1) those requiring "approval" (e.g., approval data or prepurchase evaluation data); and 2) those "not requiring approval" (e.g., vendor information data).

5.1.6 Submittals "not requiring approval" will be reviewed to verify completeness and adequacy for their intended purposes. Unacceptable items will be handled as specified below:

5.1.6.1 A submittal requiring approval that is not approved, is identified as: 1) "Not Approved, Revise and Resubmit." The submittal is considered technically deficient, or incomplete, and therefore unacceptable. Resubmittal is required, hence fabrication, procurement, or performance of procedures shall not proceed; or 2) "Approved with Exception." Fabrication, procurement, and performance of procedures may proceed, and resubmittal is required to verify incorporation of the exception.
Submittals "not requiring approval" that are determined to be incomplete or inadequate will be returned marked "Resubmit." An explanation of the deficiencies will be included for corrective action by the Seller.

5.2 List

5.2.1 (Item 1) Quality Assurance Program (4.1).

5.2.2 (Item 2) Schedule: Schedule showing shipment of the equipment after receipt of the order.

5.2.3 (Item 3) Drawings

a. General arrangement and outline drawings for the pump assembly and motor, showing overall dimensions and overall weights.

b. Cross-sectional drawings showing the details of the proposed equipment, including bill of materials to reflect the actual equipment and scope proposed.

5.2.4 (Item 4) Catalog bulletins and descriptive data illustrating the pump and motor being offered.

5.2.5 (Item 5) Mechanical shaft seal drawing showing type, manufacturer, and bill of materials.

5.2.6 (Item 6) Preliminary performance curve with high- and low-end rating points, including efficiency, water NPSHR, and power expressed as functions of capacity. Minimum flow, maximum flow, and any limitations of operation shall be indicated.

5.2.7 (Item 7) Certified pump and driver outline drawings with dimensions and bill of materials.

5.2.8 (Item 8) Certified mechanical shaft seal dimensional drawing(s) and bill of materials.

5.2.9 (Item 9) Instruction manuals. (3.11)

6 PREPARATION FOR DELIVERY

6.1 Preservation: Item shall be protected from dirt, soil, and moisture.

6.2 Packaging: Item shall be boxed or crated in a manner to prevent damage during shipping.

6.3 Marking: Packages shall be suitably marked on the outside to facilitate identification of the purchase order, the procurement specification, the package contents, and any special handling instructions.

6.4 The Seller shall recommend the preferred method of shipping and provide protection of the equipment during transit and storage.
## SUMMARY OF SUBMITTALS

<table>
<thead>
<tr>
<th>Item</th>
<th>Title</th>
<th>Copies</th>
<th>Purpose</th>
<th>When required</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Quality Assurance Program</td>
<td>2</td>
<td>Prepurchase Evaluation</td>
<td>With bid</td>
</tr>
<tr>
<td>2</td>
<td>Schedule</td>
<td>2</td>
<td>Prepurchase Evaluation</td>
<td>With bid</td>
</tr>
<tr>
<td>3</td>
<td>Drawings</td>
<td>2</td>
<td>Prepurchase Evaluation</td>
<td>With bid</td>
</tr>
<tr>
<td>4</td>
<td>Catalog Bulletin/Descriptive Data</td>
<td>2</td>
<td>Prepurchase Evaluation</td>
<td>With bid</td>
</tr>
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<td>5</td>
<td>Mechanical Shaft Seal Drawing/Control Panel Information</td>
<td>2</td>
<td>Prepurchase Evaluation</td>
<td>With bid</td>
</tr>
<tr>
<td>6</td>
<td>Preliminary Performance Curve</td>
<td>2</td>
<td>Prepurchase Evaluation</td>
<td>With bid</td>
</tr>
<tr>
<td>7</td>
<td>Certified Pump Dimensional Drawings</td>
<td>2</td>
<td>Approval</td>
<td>Prior to fabrication</td>
</tr>
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<td>8</td>
<td>Mechanical Shaft Seal Drawing</td>
<td>2</td>
<td>Approval</td>
<td>Prior to fabrication</td>
</tr>
<tr>
<td>9</td>
<td>Instruction Manuals</td>
<td>5</td>
<td>Vendor Information</td>
<td>With Shipment</td>
</tr>
<tr>
<td>10</td>
<td>Bill of Materials</td>
<td>2</td>
<td>Approval</td>
<td>Prior to fabrication</td>
</tr>
</tbody>
</table>
FIGURE 1
SCALE: 1 1/2" = 1'-0"
APPENDIX E
DRAWINGS
APPENDIX F
SPARE PARTS
Dan,

Going to need the following parts:

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Item</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2&quot; Horizontal Connector</td>
</tr>
<tr>
<td></td>
<td>3&quot; Horizontal Connector</td>
</tr>
<tr>
<td></td>
<td>2&quot; Gasket</td>
</tr>
<tr>
<td></td>
<td>3&quot; Gasket</td>
</tr>
<tr>
<td></td>
<td>Lifting Bail (H-2-30777)</td>
</tr>
<tr>
<td></td>
<td>2&quot; Horizontal Lifting Bail (H-2-90162-2)</td>
</tr>
<tr>
<td></td>
<td>3&quot; Horizontal Lifting Bail (H-2-90162-3)</td>
</tr>
<tr>
<td>2</td>
<td>2&quot; Sched 40 SR 90 Degree Elbow (ASTM A403 304-L SST)</td>
</tr>
<tr>
<td>2</td>
<td>2&quot; Sched 40 LR 90 Degree Elbow (ASTM A403 304-L SST)</td>
</tr>
<tr>
<td>2</td>
<td>2&quot; Sched 40 LR 90 Degree Elbow (ASTM A234 GR WPB CS)</td>
</tr>
<tr>
<td>10'-0&quot;</td>
<td>2&quot; Schedule 40 Pipe (ASTM A312 304-L SST)</td>
</tr>
<tr>
<td>10'-0&quot;</td>
<td>2&quot; Schedule 40 Pipe (ASTM A53 Type S GR B CS)</td>
</tr>
<tr>
<td>10'-0&quot;</td>
<td>2&quot; Flex Hose</td>
</tr>
</tbody>
</table>

The jumper for AP Central Pump Pit is a "Flex" ... the rest are rigid. That's why the callout for the Flex Hose and Horizontal Lifting Bails.

.... Rick Romine
  Fluor Federal Services
  372-1140
Bradley,
As we discussed we need a list of parts (ie, connector heads, pipe, elbows etc.) for jumpers needed to support annulus pumping for the Central Pump pits in the six tank farms.

I need just the bare essentials to make any one jumper, no matter which one. I believe Rick has the drawings, let me know if you need anything else.

Thanks
### SPARE PARTS CATALOG

**STOCK CLASS/CAPTION**: 6111

<table>
<thead>
<tr>
<th>STOCK NUMBER</th>
<th>IL/SC</th>
<th>PART DESCRIPTION</th>
<th>UOI</th>
<th>UNIT PRICE</th>
</tr>
</thead>
<tbody>
<tr>
<td>6111-5500-3350</td>
<td>4</td>
<td>PLATE; MOUNTING; (P/N 1050472)</td>
<td>EA</td>
<td>42.45</td>
</tr>
<tr>
<td>6111-5500-5650</td>
<td>4</td>
<td>PUMP; (SATURN, TEFLON, FLUID HANDLING, FLUORCARBON MODEL NO. SP-4000)</td>
<td>EA</td>
<td>580.00</td>
</tr>
<tr>
<td>6111-5514</td>
<td>4</td>
<td>PUMP, EP NO.: P-24-TX-2; MFG.: FLYGT</td>
<td>EA</td>
<td>3829.58</td>
</tr>
<tr>
<td>6111-5514-5670</td>
<td>4</td>
<td>PUMP, SUMP; PUMP, SUMP, SUBMERSIBLE, STAINLESS</td>
<td>EA</td>
<td>3829.58</td>
</tr>
</tbody>
</table>

**Note**: PUMP - SUMP PUMP -- SEE ITEM -5670 LISTED BELOW --
3/20/00 12:46:58 PM  Insight - Report

PUMP; SUBMERSIBLE; STAINLESS STEEL; 1 9900-4399-7001 4 2,016.00 EBP-C01-A00
1/2 HP, 2-7 GPM

PUMP; LIQUID; 91-765; 1 9900-4450-8001 2 1.00 ECP-B12-BOO
10 EA DANIEL, JAMES P

PUMP; MIXER;
1 EA BENEGAS, TONY R
HMR #3 SPARE 101-ST MIXER PUMP,

SUBMERSIBLE SLURRY PUMP, 200HP, 2800GPM,
REFERENCE DWG. H-14-100320

PUMP; SUBMERSIBLE;
1 EA WIGGINS, DIRK D
FLYGT MODEL B-2060 (MODIFIED)-REQUESTOR
HAS RUN-IN DATA. OWNED BY SALTWELLS.

0 EA DAY, JAMES L 9900-4920-1001 4 100.00
0 EA DAY, JAMES L 9900-4920-1007 4 100.00

PUMP; SUBMERSIBLE; 1/3 HP 9900-5015-6001 4 138.75 EBO-E08-A00
2 EA BISSELL, ROBERT L
SUMP PUMP, AUTOMATIC, STOCK #1N363.

PUMP;
1 EA VIGUE, JERRY L
MAG. DRIVE, ANSIMAG MODEL 1516-CA

PUMP;
1 EA SHOEMAKE, NANCY C
CHEMICAL DISTRIBUTION SUMP FLOW PUMP

PUMP; 1X1
1 EA HUNTER, JAMES A
GOULD MODEL 3196 50-B

PUMP;
1 EA HUNTER, JAMES A
U.S. PUMP TURBINE WITH MARATHON ELECTRIC

PUMP (T839369) S/N 1121 MODEL 2110 3530 RPM.
APPENDIX G
JUMPERS
## Annulus/Primary Tank Pump-out Jumpers

*Best Case (Assumes a Flex/Rigid design)*

<table>
<thead>
<tr>
<th>Primary Tank Transfer Jumper</th>
<th>Total Jumpers</th>
<th>Primary Route</th>
<th>Annulus Route</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AN</strong> Primary Tank Transfer Jumper</td>
<td>H-2-72025</td>
<td>AN-01A, 02A, 06A, 07A (All unique as-built dimensions)</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>H-2-94863</td>
<td>AN-03A, 04A, 05A (All unique as-built dimensions)</td>
<td>1</td>
</tr>
<tr>
<td>Annulus Jumper Central Pit</td>
<td>H-2-72025</td>
<td>Fits All Pits</td>
<td>1</td>
</tr>
<tr>
<td>Annulus Jumper Annulus Pit</td>
<td>H-2-72028</td>
<td>Fits All Pits (Needs modification)</td>
<td>1</td>
</tr>
<tr>
<td><strong>AP</strong> Primary Tank Transfer Jumper</td>
<td>H-2-90725</td>
<td>Assem 1 AP-02A, 04A, 05A, 07A (All unique as-built dimensions)</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Assem 2 AP-01A, 03A, 06A, 08A (All unique as-built dimensions)</td>
<td>1</td>
</tr>
<tr>
<td>Annulus Jumper Central Pit (Flex)</td>
<td>H-2-90726</td>
<td>Fits All Pits (need 2 type rigid)</td>
<td>2</td>
</tr>
<tr>
<td>Annulus Jumper Annulus Pit (Flex)</td>
<td>H-2-90729</td>
<td>Fits All Pits (Needs modification 2 different orientations)</td>
<td>2</td>
</tr>
<tr>
<td><strong>AW</strong> Primary Tank Transfer Jumper</td>
<td>H-2-70445</td>
<td>AW-01A, 03A, 04A, 05A, 06A (Dimensions maybe same for all pits)</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>H-2-70466</td>
<td>AW-02E (Jumpers maintained, Evap Camp)</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>H-2-70467</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>H-2-70468</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>H-2-70470</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annulus Jumper Central Pit</td>
<td>H-2-70444</td>
<td>Fits All Pits</td>
<td>1</td>
</tr>
<tr>
<td>Annulus Jumper Annulus Pit</td>
<td>H-2-70451</td>
<td>Fits All Pits (Needs modification)</td>
<td>1</td>
</tr>
<tr>
<td><strong>AY</strong> Primary Tank Transfer Jumper (D Pit)</td>
<td>H-2-70772</td>
<td>AY-01D (Needs as-built unknown pump)</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>H-2-70774</td>
<td>AY-02D (Needs as-built unknown pump)</td>
<td>1</td>
</tr>
<tr>
<td>Annulus Jumper Central Pit</td>
<td>H-2-64457</td>
<td>Fits Both Pits (Plus AZ Farm)</td>
<td>1</td>
</tr>
<tr>
<td>Annulus Jumper Annulus Pit to Tank</td>
<td>H-2-64441</td>
<td>Fits Both Pits (Plus AZ Farm) (Needs Modification)</td>
<td>1</td>
</tr>
<tr>
<td>Annulus Jumper Annulus Pit to Pit</td>
<td>H-2-64458</td>
<td>Fits Both Pits (Plus AZ Farm) (Needs Modification)</td>
<td>1</td>
</tr>
<tr>
<td><strong>AZ</strong> Primary Tank Transfer Jumper</td>
<td>H-2-64436</td>
<td>Fits Both Pits</td>
<td>1</td>
</tr>
<tr>
<td>Annulus Jumper Central Pit</td>
<td>H-2-64457</td>
<td>Same Jumper as AY Farm</td>
<td>1</td>
</tr>
<tr>
<td>Annulus Jumper Annulus Pit to Tank</td>
<td>H-2-64441</td>
<td>Same Jumper as AY Farm</td>
<td>1</td>
</tr>
<tr>
<td>Annulus Jumper Annulus Pit to Pit</td>
<td>H-2-64458</td>
<td>Same Jumper as AY Farm</td>
<td>1</td>
</tr>
<tr>
<td><strong>SY</strong> Primary Tank Transfer Jumper</td>
<td>H-2-46251</td>
<td>SY-01A &amp; 03A (Dimensions are same for both pits)</td>
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</tr>
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<td></td>
<td>H-2-76536</td>
<td>SY-02A (Jumpers maintained for Cross-site)</td>
<td>1</td>
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<tr>
<td></td>
<td>H-2-76537</td>
<td>Fits All Pits</td>
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<tr>
<td>Annulus Jumper Central Pit</td>
<td>H-2-37800</td>
<td>Fits All Pits (Needs modification)</td>
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<tr>
<td>Annulus Jumper Annulus Pit</td>
<td>H-2-68388</td>
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Jumper Totals 9 13
## Annulus/Primary Tank Pump-out Jumpers
### (Worst Case)

<table>
<thead>
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<th>Primary Route</th>
<th>Annulus Route</th>
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<td>AN Primary Tank Transfer Jumper</td>
<td>H-2-72026</td>
</tr>
<tr>
<td></td>
<td>H-2-94863</td>
</tr>
<tr>
<td>Annulus Jumper Central Pit</td>
<td>H-2-72025</td>
</tr>
<tr>
<td>Annulus Jumper Annulus Pit</td>
<td>H-2-72028</td>
</tr>
<tr>
<td>AP Primary Tank Transfer Jumper</td>
<td>H-2-90725</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Annulus Jumper Central Pit</td>
<td>H-2-90726</td>
</tr>
<tr>
<td>Annulus Jumper Annulus Pit</td>
<td>H-2-90729</td>
</tr>
<tr>
<td>AW Primary Tank Transfer Jumper</td>
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</tr>
<tr>
<td></td>
<td>H-2-70467</td>
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<tr>
<td>Annulus Jumper Central Pit</td>
<td>H-2-70444</td>
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<tr>
<td>Annulus Jumper Annulus Pit</td>
<td>H-2-70451</td>
</tr>
<tr>
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<tr>
<td></td>
<td>H-2-70774</td>
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<tr>
<td>Annulus Jumper Central Pit</td>
<td>H-2-64457</td>
</tr>
<tr>
<td>Annulus Jumper Annulus Pit to Tank</td>
<td>H-2-64441</td>
</tr>
<tr>
<td>Annulus Jumper Annulus Pit to Pit</td>
<td>H-2-64458</td>
</tr>
<tr>
<td>AZ Primary Tank Transfer Jumper</td>
<td>H-2-64436</td>
</tr>
<tr>
<td>Annulus Jumper Central Pit</td>
<td>H-2-64457</td>
</tr>
<tr>
<td>Annulus Jumper Annulus Pit to Tank</td>
<td>H-2-64441</td>
</tr>
<tr>
<td>Annulus Jumper Annulus Pit to Pit</td>
<td>H-2-64458</td>
</tr>
<tr>
<td>SY Primary Tank Transfer Jumper</td>
<td>H-2-46251</td>
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<tr>
<td></td>
<td>H-2-76536</td>
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<td>H-2-37800</td>
</tr>
<tr>
<td>Annulus Jumper Annulus Pit</td>
<td>H-2-68388</td>
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</table>

| Jumper Totals | 32 | 60 |
Annulus/Primary Tank Pump-out Jumpers
(Planning Case)

<table>
<thead>
<tr>
<th>Total Jumpers</th>
<th>Primary Route</th>
<th>Annulus Route</th>
</tr>
</thead>
</table>

| AN Primary Tank Transfer Jumper | H-2-72026 | AN-01A, 02A, 06A, 07A | 4 |
|                               | H-2-94863 | AN-03A, 04A, 05A | 3 |
| Annulus Jumper Central Pit     | H-2-72025 | Fits All Pits | 1 |
| Annulus Jumper Annulus Pit     | H-2-72028 | Fits All Pits (Needs modification) | 1 |
| AP Primary Tank Transfer Jumper| H-2-90725 | Assem 1 AP-02A, 04A, 05A, 07A | 4 |
|                               |           | (All unique as-built dimensions) |  |
|                               |           | Assem 2 AP-01A, 03A, 06A, 08A | 4 |
|                               |           | (All unique as-built dimensions) |  |
| Annulus Jumper Central Pit     | H-2-90726 | Fits All Pits (need 2 type rigs) | 2 |
| (Flex)                       |           | (All unique as-built dimensions) |  |
| Annulus Jumper Annulus Pit     | H-2-90729 | Fits All Pits (Needs modification 2 different orientations) | 2 |
| (Flex)                       |           | (All unique as-built dimensions) |  |
| AW Primary Tank Transfer Jumper| H-2-70445 | AW-01A, 03A, 04A, 05A, 06A | 1 |
|                               | H-2-70466 | (Dimensions maybe same for all pits) |  |
|                               | H-2-70467 | AW-02E |  |
|                               | H-2-70468 | (Jumpers maintained, Evap Camp) |  |
|                               | H-2-70470 |           |  |
| Annulus Jumper Central Pit     | H-2-70444 | Fits All Pits | 1 |
| Annulus Jumper Annulus Pit     | H-2-70451 | Fits All Pits (Needs modification) | 1 |
| AY Primary Tank Transfer Jumper (D Pit) | H-2-70772 | AY-01D | 1 |
|                               | H-2-70774 | (Needs as-built unknown pump) |  |
| Annulus Jumper Central Pit     | H-2-64457 | Fits Both Pits (Plus AZ Farm) | 1 |
| Annulus Jumper Annulus Pit to Tank | H-2-64441 | Fits Both Pits (Plus AZ Farm) | 1 |
|                               |           | (Needs Modification) |  |
| Annulus Jumper Annulus Pit to Pit | H-2-64458 | Fits Both Pits (Plus AZ Farm) | 1 |
|                               |           | (Needs Modification) |  |
| AZ Primary Tank Transfer Jumper | H-2-64436 | Fits Both Pits | 1 |
| Annulus Jumper Central Pit     | H-2-64457 | Same Jumper as AY Farm |  |
| Annulus Jumper Annulus Pit to Tank | H-2-64441 | Same Jumper as AY Farm |  |
|                               |           | Same Jumper as AY Farm |  |
| SY Primary Tank Transfer Jumper | H-2-46251 | SY-01A & 03A | 1 |
|                               | H-2-76536 | (Dimensions are same for both pits) |  |
|                               | H-2-76537 | SY-02A |  |
|                               |           | (Jumpers maintained for Cross-site) |  |
| Annulus Jumper Central Pit     | H-2-37800 | Fits All Pits | 1 |
| Annulus Jumper Annulus Pit     | H-2-68388 | Fits All Pits (Needs modification) | 1 |

Jumper Totals: 20 & 13
APPENDIX H
CALCULATIONS
This sheet shows the status and description of the attached Design Analysis sheets.

**Discipline:** 454  
**Project/Area/Unit:** 65100541/25/9  
**Calculation No.:** DSTAP-P-001

**Project No. & Name:** Double Shell Tank Annulus Pumping

**Calculation Item:** DST Annulus Pump Line Losses

These calculations apply to:

- **Drawing No.:** N/A
- **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?**  
[X] Yes  [ ] No

**This calculation verified by independent “check” calculations?**  
[ ] Yes  [X] No

---

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<td>A18a</td>
<td></td>
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</tr>
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<td>Referenced Drawings</td>
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<tr>
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<td>Various Drawings</td>
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**REVISION**

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</tbody>
</table>
OBJECTIVE:

The objective of this calculation is to determine the line losses of a piping route that transfers waste from the annulus in tank AN-106 to tank AP-104, via existing lines. The line losses will then be used to select an annulus pump that will satisfy the pressure requirements of the route.

DESIGN CRITERIA / INPUT:

- **Flow Rate:** 40 GPM minimum (Ref. 4)
- **Dynamic Viscosity:** 30 centipoise maximum (Ref. 3)
- **Specific Gravity:** 1.47 maximum (Ref. 3)
- **Temperature:** 140° F maximum (Ref. 3)
- **Safety Classification:** General Service (Ref. 9)

METHODS:

1.) The Darcy-Weisbach equation is used in determining the friction pressure losses.

2.) Friction losses due to standard fittings are calculated using the pipe resistance coefficients (K factors) found in Crane Technical Paper No. 410.

3.) The total pressure losses of the system is determined using Bernoulli's equation.

The worst case route for an annulus pump is to transfer from tank AN-106 to AP-106 via existing lines. A transfer route walkdown (Ref. 1) consisting of all the transfer lines was given by the client. However, the walkdown considers a transfer from tank AN-106 to AP-104. This route can be considered equivalent in losses to the AN-106 to AP-106 route with minimal error. Therefore, pump selection shall be based on the results of the transfer from AN-106 to AP-104 (Ref. 1).

The components (valve types, fittings, bends, length of pipe) of the piping in each individual process pit and transfer line used in the transfer route were determined. Similar components were then summed together and a resistance coefficient was determined for each type of component. All resistance coefficients were then summed together and used to determine the head loss due to friction.
ASSUMPTIONS:

1.) The Purex nozzles are equivalent in resistance to a 90 degree miter bend.
2.) Clean Out Boxes on the transfer lines are equivalent in resistance to a "thru" tee.
3.) The equivalent roughness of carbon and stainless steel pipe is 0.00015 ft.
4.) Bends in the 2" and 3" transfer lines have a bend radius of 36".
5.) The discharge of the pump is located near the bottom of tank AN-106 in the annulus area.
6.) The velocity of the fluid at the pump discharge is equal to the velocity of the fluid entering tank AN-104.
7.) All 2 and 3-way ball valves in the transfer route have flow coefficients equivalent to PBM SP 30-40 series (2-way) and MP 70-80 series (3-way) valves.
8.) The changes between the 2" and 3" pipe are all located within a purex nozzle and will be considered sudden.
9.) Because of the nature of the transfer route, a few of the pits require new jumper designs. Assumptions for the jumper designs will be made based on the configuration of the pit and are as noted in the calculation.
10.) Assume that the pressure in tank AP-104 is atmospheric.
11.) It is reasonable to expect that pipe flow will be laminar for Reynolds number less than 2000 and turbulent for Reynolds numbers greater than 3000. When the Reynolds number is between 2000 and 3000 the type of flow is very unpredictable and often changes back and forth between laminar and turbulent states. However, since there will be vibrations in the piping system due to the pumping operation, it is safe to assume that for Reynolds numbers approaching 2000, the flow is turbulent.

REFERENCES:

1.) AN-106 to AP-104 transfer route walkdown, Document No. TO-001-181.
3.) E-mail dated 1/25/00 from Dan Reberger to Marshall Hauck consisting of Revised Design Criteria.
4.) E-mail dated 2/8/00 from Dan Reberger to Paul Dorsh, pertaining to Flow Rates.
6.) PBM Catalog.
7.) Sketch from ARES showing Double Shell Tank Annulus Pumping Data.
8.) Statement of Work for Annulus Pumping, Revision No. 0, Contract 4975.
REFERENCES CONT:

9.) E-mail dated December 17, 1999 from Dan Reberger to Bradley Rarig, stating Design Criteria
10.) Various reference drawings supporting the transfer route walkdown (Ref. 1).

References are located in Appendix A.

CONCLUSIONS:

The total line loss of the transfer route, at a fluid discharge of 40 GPM, is 175 ft. Therefore, a pump should be selected that will satisfy this operating condition. Multiple pumps operating in tandem are acceptable, if necessary, to achieve this discharge head.

Due to other criteria for selecting a pump, i.e., physical dimensions, material composition, and flammable gas classification, an "off the shelf" pump(s) of this performance level may not be assessable. Because of the long length of pipe, a smaller flow rate will dramatically drop the required pump discharge head. For example, a 30 GPM flow rate would require only 130 ft of discharge head. Thus, a pump which satisfies the other criteria, but operates slightly below the performance criteria (175 ft @ 40 GPM), may need to be selected.
Fluor Federal Services

DESIGN ANALYSIS

Client: CH2M HILL Hanford Group
Subject: DOUBLE SHELL TANK ANNULUS PUMPING
DST ANNULUS PUMP LINE LOSSES
Location: 200 E AREA HANFORD

Fluid Properties

Desired Flow Rate

\[ Q = 40 \text{ GPM} \]

\( \text{Q} = 154 \cdot \text{in}^3/\text{sec} \) (Ref. 4, A9)

Specific Gravity of Fluid

\( \text{SG} = 1.47 \) (Ref. 3, A7)

Temperature of Fluid

\( T = 140 \text{ F} \) (Ref. 3, A7)

Density of Water

\( \rho_w = 61.38 \cdot \text{lb/ft}^3 \) (Ref. 5, A13)

Density of Fluid

\( \rho = \rho_w \cdot \text{SG} \)

\( \rho = 90.23 \cdot \text{lb/ft}^3 \) (Ref. 3, A7)

Dynamic Viscosity

\( \mu = 30 \cdot \text{cp} \) (Ref. 3, A7)

Pipe Roughness

\( k_s = 0.00015 \cdot \text{ft} \) (Ref. 5, A10)

3" Sch 40 Pipe Properties

Inside Diameter of 3" Sch 40 Pipe

\( D_3 = 3.068 \cdot \text{in} \)

Inside Area of Pipe

\( A_3 = \frac{\pi}{4} \cdot D_3^2 \)

\( A_3 = 7.39 \cdot \text{in}^2 \)

Velocity of Fluid

\( V_3 = \frac{Q}{A_3} \)

\( V_3 = 1.74 \cdot \text{ft/sec} \)

Reynolds Number

\( \text{Re}_3 = \frac{V_3 \cdot D_3 \cdot \rho}{\mu} \)

\( \text{Re}_3 = 1986.4 \) (assumed turbulent)

Friction Factor

\[ f_3 = \frac{0.25}{\log \left( \frac{k_s}{3.7 \cdot D_3} + \frac{5.74}{\text{Re}_3^{0.9}} \right)^2} \]

\( f_3 = 0.052 \) (Ref. 5, A11)

Friction Factor in Zone of Complete Turbulence

\( f_{t3} = 0.018 \) (Ref. 2, A4)
**FLUOR FEDERAL SERVICES**

**DESIGN ANALYSIS**

**Client:** CH2M HILL Hanford Group  
**Subject:** DOUBLE SHELL TANK ANNULUS PUMPING  
**Location:** 200 E AREA HANFORD  
**Date:** 02/08/00  
**Checked:** 4/13/00  
**Revised:**  

---

**Flow Coefficient of 3 Way T-Port Through (GPM)**  
\[ C_{V3} = 460 \]  
(Ref. 6, A15)

**Flow Coefficient of 3 Way T-Port Branch (GPM)**  
\[ C_{Vb3} = 270 \]  
(Ref. 6, A15)

**Flow Coefficient of 2 Way Ball Valve (GPM)**  
\[ C_{V2} = 625 \]  
(Ref. 6, A14)

---

**2" Sch 40 Pipe Properties**

**Inside Diameter of 3" Sch 40 Pipe**  
\[ D_2 = 2.067\text{-in} \]

**Inside Area of Pipe**  
\[ A_2 = \frac{\pi}{4} D_2^2 \]  
\[ A_2 = 3.36\text{-in}^2 \]

**Velocity of Fluid**  
\[ V_2 = \frac{Q}{A_2} \]  
\[ V_2 = 3.82\text{-ft/sec} \]

**Reynolds Number**  
\[ Re_2 = \frac{V_2 D_2 \rho}{\mu} \]  
\[ Re_2 = 2948.4 \] (assumed turbulent)

**Friction Factor**  
\[ f_2 = \frac{0.25}{\log \left( \frac{k_s}{3.7 D_2} + \frac{5.74}{Re_2^{0.8}} \right)^2} \]  
\[ f_2 = 0.046 \]  
(Ref. 5, A11)

**Friction Factor in Zone of Complete Turbulence**  
\[ f_{t2} = 0.019 \]  
(Ref. 2, A4)

**Flow Coefficient of 3 Way T-Port Through (GPM)**  
\[ C_{Vt2} = 176 \]  
(Ref. 6, A15)

**Flow Coefficient of 3 Way T-Port Branch (GPM)**  
\[ C_{Vb2} = 108 \]  
(Ref. 6, A15)

**Flow Coefficient of 2 Way Ball Valve (GPM)**  
\[ C_{V2} = 300 \]  
(Ref. 6, A14)
# DESIGN ANALYSIS

**Client:** CH2M HILL Hanford Group  
**Subject:** DOUBLE SHELL TANK ANNULUS PUMPING  
**Location:** 200 E AREA HANFORD

**Transfer Pits and Components**

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<th>Valve Pit 241-AN-A</th>
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<td>Pipe Diameter - 2&quot;</td>
<td>Pipe Diameter - 2&quot;</td>
<td>Pipe Diameter - 3&quot;</td>
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<td>L.R. Bends - 3</td>
<td>L.R. Bends - 2</td>
<td>L.R. Bends - 2</td>
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<tr>
<td>Purex Connectors - 2</td>
<td>Purex Connectors - 2</td>
<td>Purex Connectors - 3</td>
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<td>3 Way B.V. (Branch),</td>
<td>10&quot; Rad Bends - 1</td>
<td>3 Way B.V. (Branch) - 3</td>
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<tr>
<td>new design - 1</td>
<td>Sudden Expansion - 1</td>
<td>3 Way B.V. (Thru) - 2</td>
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<tr>
<td>Length of Pipe - 10 ft</td>
<td>Length of Pipe - 10 ft</td>
<td>2 Way B.V. - 2</td>
</tr>
<tr>
<td>Additional Annulus Pipe</td>
<td>Ref Dwg - B3 &amp; B4</td>
<td>Length of Pipe - 14 ft</td>
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<tr>
<td>(Inside of Tank Annulus) - 45 ft</td>
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<td>Ref Dwg - B6 &amp; B7</td>
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<td>Ref Dwg - B1/Assumption</td>
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<table>
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<th>Pump Pit 241-AZ-02B</th>
<th>Valve Pit 241-AX-A</th>
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<td>Pipe Diameter - 2&quot;</td>
<td>Pipe Diameter - 3&quot;</td>
</tr>
<tr>
<td>L.R. Bends - 1</td>
<td>L.R. Bends - 2</td>
<td>L.R. Bends - 1</td>
</tr>
<tr>
<td>Purex Connectors - 3</td>
<td>Purex Connectors - 2</td>
<td>Purex Connectors - 2</td>
</tr>
<tr>
<td>3 Way B.V. (Thru) - 1</td>
<td>Sudden Expansion - 1</td>
<td>15&quot; Rad Bends - 1</td>
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<tr>
<td>2 Way B.V. - 2</td>
<td>Length of Pipe - 8.5 ft</td>
<td>Length of Pipe - 9 ft</td>
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<tr>
<td>Sudden Contraction - 1</td>
<td>Ref Dwg - B12</td>
<td>Ref Dwg - B16</td>
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<td>Length of Pipe - 11 ft</td>
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<td></td>
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<tr>
<td>Ref Dwg - B8/Assumption</td>
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<th>Valve Pit 241-AW-A</th>
<th>Central Pump Pit 241-AW-02A</th>
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<td>Pipe Diameter - 3&quot;</td>
<td>Pipe Diameter - 3&quot;</td>
</tr>
<tr>
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<td>L.R. Bends - 2</td>
<td>L.R. Bends - 4</td>
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<tr>
<td>S.R. Bends - 1</td>
<td>Purex Connectors - 3</td>
<td>Purex Connectors - 2</td>
</tr>
<tr>
<td>Purex Connectors - 2</td>
<td>2 Way B.V. - 2</td>
<td>3 Way B.V. (Thru) - 1</td>
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<tr>
<td>3 Way B.V. (Branch) - 1</td>
<td>15&quot; Rad Bends - 2 (1 + 2 @ 45deg)</td>
<td>Length of Pipe - 10 ft</td>
</tr>
<tr>
<td>Length of Pipe - 7.5 ft</td>
<td>Ref Dwg - B26, B27 &amp; B28</td>
<td>Ref Dwg - B29, B30</td>
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<tr>
<td>Ref Dwg - B23</td>
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<th>Pump Pit 241-AP-04A</th>
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<td>15&quot; Rad Bends - 1</td>
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<td>Length of Pipe - 30 ft</td>
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<tr>
<td>Ref Dwg - B35 &amp; B36</td>
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Transfer Pits and Components (Ref. 1 & 10)
### DESIGN ANALYSIS

**Client:** CH2M HILL Hanford Group  
**Subject:** DOUBLE SHELL TANK ANNULUS PUMPING  
**Location:** 200 E AREA HANFORD  
**Project/Area/Unit:** 65100541 / 25 / 9  
**Date:** 02/08/00  
**Checked:** 4/13/00  
**Revised:**  

**Total 2” Pit Components**

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<td>L.R. Bends</td>
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</tr>
<tr>
<td>Purex Connectors</td>
<td>6</td>
</tr>
<tr>
<td>3 Way B.V. (Branch)</td>
<td>1</td>
</tr>
<tr>
<td>10” Rad Bends</td>
<td>1</td>
</tr>
<tr>
<td>Sudden Expansions</td>
<td>2</td>
</tr>
<tr>
<td>Length of Pipe</td>
<td>63.5 ft</td>
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</table>

**Total 3” Pit Components**

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<td>L.R. Bends</td>
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<tr>
<td>Purex Connectors</td>
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</tr>
<tr>
<td>S.R. Bends</td>
<td>1</td>
</tr>
<tr>
<td>3 Way B.V. (Branch)</td>
<td>6</td>
</tr>
<tr>
<td>3 Way B.V. (Thru)</td>
<td>6</td>
</tr>
<tr>
<td>2 Way B.V.</td>
<td>9</td>
</tr>
<tr>
<td>15” Rad Bends</td>
<td>5</td>
</tr>
<tr>
<td>Sudden Contraction</td>
<td>1</td>
</tr>
<tr>
<td>Length of Pipe</td>
<td>106.5 ft</td>
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**Resistance Coefficients for 3” Pits**

<table>
<thead>
<tr>
<th>Component</th>
<th>Formula</th>
<th>Value</th>
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<tr>
<td>L.R. Bends</td>
<td>$K_1 = (14 \cdot f_{3}) \cdot 25$</td>
<td>$K_1 = 6.3$ (Ref. 2, A5)</td>
</tr>
<tr>
<td>Purex Connectors</td>
<td>$K_2 = (60 \cdot f_{3}) \cdot 22$</td>
<td>$K_2 = 23.76$ (Ref. 2, A5)</td>
</tr>
<tr>
<td>Diameter of Ball Valve (in)</td>
<td>$D = 3.0$</td>
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</tr>
<tr>
<td>3 Way Ball Valves (Branch)</td>
<td>$K_3 = \left( \frac{891 \cdot D^4}{Cv_{b3}^2} \right) \cdot 6$</td>
<td>$K_3 = 5.94$ (Ref. 2, A6)</td>
</tr>
<tr>
<td>3 Way Ball Valves (Thru)</td>
<td>$K_4 = \left( \frac{891 \cdot D^4}{Cv_{t3}^2} \right) \cdot 6$</td>
<td>$K_4 = 2.05$ (Ref. 6, A6)</td>
</tr>
<tr>
<td>2 Way Ball Valves</td>
<td>$K_5 = \left( \frac{891 \cdot D^4}{Cv_{3}^2} \right) \cdot 9$</td>
<td>$K_5 = 1.66$ (Ref. 2, A6)</td>
</tr>
<tr>
<td>S.R. Bends</td>
<td>$K_6 = (20 \cdot f_{3}) \cdot 1$</td>
<td>$K_6 = 0.36$ (Ref. 2, A5)</td>
</tr>
<tr>
<td>15” Rad Bends</td>
<td>$K_7 = (15.5 \cdot f_{3}) \cdot 5$</td>
<td>$K_7 = 1.39$ (Ref. 2, A5)</td>
</tr>
<tr>
<td>Length of Pipe</td>
<td>$L = 106.5$ ft</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$K_8 = f_{3} \cdot \frac{L}{D_{3}}$</td>
<td>$K_8 = 21.55$</td>
</tr>
</tbody>
</table>
Sudden Contraction

\[ K_9 = 0.25 \]  

(Ref. 5, A12)

Sum of the Resistance Coefficients for the 3" Pits

\[ K_{p3} = \sum_{i=1}^{9} K_i \]  

\[ K_{p3} = 63.26 \]

Resistance Coefficients for 2" Pits

L.R. Bends
Qty = 7

\[ K_1 = (14 \cdot f_{12}) \cdot 0.8 \]  

\[ K_1 = 2.13 \]  

(Ref. 2, A5)

Purex Connectors
Qty = 6

\[ K_2 = (60 \cdot f_{12}) \cdot 0.9 \]  

\[ K_2 = 10.26 \]  

(Ref. 2, A5)

Diameter of Ball Valve (in)

\[ D = 2.0 \]

3 Way Ball Valves (Branch)
Qty = 1

\[ K_3 = \left( \frac{891 \cdot D^4}{C_{v b_2}} \right) \cdot 1 \]  

\[ K_3 = 1.22 \]  

(Ref. 2, A6)

10" Rad Bends
Qty = 1

\[ K_4 = (15.5 \cdot f_{12}) \cdot 1 \]  

\[ K_4 = 0.29 \]  

(Ref. 2, A5)

Sudden Expansion
Qty = 2

\[ K_5 = 0.35 \cdot 2 \]  

\[ K_5 = 0.7 \]  

(Ref. 5, A12)

Length of Pipe

\[ L = 63.5 \text{ ft} \]

\[ K_6 = f_2 \cdot \frac{L}{D_2} \]  

\[ K_6 = 16.82 \]

Sum of the Resistance Coefficients for the Pits

\[ K_{p2} = \sum_{i=1}^{6} K_i \]  

\[ K_{p2} = 31.43 \]
Transfer Lines and Components

2" PW-476
36" Rad Bends - 1
Length of Pipe - 35 ft
Ref Dwg - B2

3" SN-266
36" Rad Bends - 5
Length of Pipe - 99 ft
Ref Dwg - A1, B2 & B5

3" SN-268
36" Rad Bends - 4
Length of Pipe - 25 ft
Ref Dwg - A1, B5

2" SN-260
36" Rad Bends - 9
Length of Pipe - 375 ft
COB - 3
Ref Dwg - A2, B9, B10 & B11

2" SN-600
36" Rad Bends - 16
Length of Pipe - 783 ft
COB - 5
Ref Dwg - B13 & B14

3" SN-201/ SN-214
36" Rad Bends - 15
Length of Pipe - 573 ft
COB - 5
Ref Dwg - B18, B19, & B20

3" SN-220
36" Rad Bends - 12
Length of Pipe - 568 ft
COB - 3
Ref Dwg - B21, B24, & B25

3" SN-267
36" Rad Bends - 5
Length of Pipe - 110 ft
Ref Dwg - B25

3" SN-609
36" Rad Bends - 13
Length of Pipe - 715 ft
Ref Dwg - B31, B32, B33, & B34

3" SN-614
36" Rad Bends - 6
Length of Pipe - 299 ft
Ref Doc - TO-001-181 (A3)

Total 2" Line Components
36" Rad Bends - 26
Length of Pipe - 1193 ft
COB - 8

Total 3" Line Components
36" Rad Bends - 60
Length of Pipe - 2389 ft
COB - 8
Resistance Coefficients for 3" Lines

36° Rad Bends
Qty = 60

\[ K_1 = (34 \cdot f_{13}) \cdot 60 \]
\[ K_1 = 36.72 \quad \text{(Ref. 2, A5)} \]

COB
Qty = 8

\[ K_2 = (20 \cdot f_{13}) \cdot 8 \]
\[ K_2 = 2.88 \quad \text{(Ref. 2, A5)} \]

Length of Pipe

\[ L = 2389 \text{ ft} \]

\[ K_3 = f_3 \frac{L}{D_3} \]
\[ K_3 = 483.38 \]

Sum of the Resistance Coefficients for the 3" Lines

\[ K_{13} = \sum_{i=1}^{3} K_i \]
\[ K_{13} = 522.98 \]

Total Value of 3" Resistance Coefficients

\[ K_3 = K_{p3} + K_{13} \]
\[ K_3 = 586.24 \]

Total Head Loss of 3" Components

\[ h_3 = K_3 \frac{V_3^2}{2g} \]
\[ h_3 = 27.45 \text{ ft} \]

Resistance Coefficients for 2" Lines

36° Rad Bends
Qty = 26

\[ K_1 = (46 \cdot f_{12}) \cdot 26 \]
\[ K_1 = 22.72 \quad \text{(Ref. 2, A5)} \]

COB
Qty = 8

\[ K_2 = (20 \cdot f_{12}) \cdot 8 \]
\[ K_2 = 3.04 \quad \text{(Ref. 2, A5)} \]

Length of Pipe

\[ L = 1193 \text{ ft} \]

\[ K_3 = f_2 \frac{L}{D_2} \]
\[ K_3 = 316.02 \]
FLUOR FEDERAL SERVICES

DESIGN ANALYSIS

Client: CH2M HILL Hanford Group

Subject: DOUBLE SHELL TANK ANNULUS PUMPING
DST ANNULUS PUMP LINE LOSSES

Location: 200 E AREA HANFORD

Sum of the Resistance Coefficients for the 2" Lines

\[ K_{12} = \sum_{i=1}^{3} K_i \quad K_{12} = 341.79 \]

Total Value of 2" Resistance Coefficients

\[ K_2 = K_{p2} + K_{12} \quad K_2 = 373.21 \]

Total Head Loss of 2" Components

\[ h_2 = K_2 \frac{V_2^2}{2g} \quad h_2 = 84.83\text{ft} \]

Total Frictional Head Loss

Combined 2" and 3"
Components

\[ h_L = h_2 + h_3 \quad h_L = 112.29\text{ft} \]

Static Head

Elevation of Pump Discharge

\[ z_a = 612.3\text{ft} \] (Ref dwg B1 & A16)

Elevation of Pipe End

\[ z_b = 675\text{ft} \] (Ref dwg B38)

Considering Bernoulli's equation, \( P_a/\gamma + V_a^2/2g + z_a = P_b/\gamma + V_b^2/2g + z_b + \Sigma K_{ab}V^2/2g \), with position "a" located at the discharge of the annulus pump and position "b" located at the purex nozzle going into tank AN04 (point e), we find the required pressure head of the annulus pump to be:

\[ P_a/\gamma = P_b/\gamma + (V_b^2/2g - V_a^2/2g) + (z_b - z_a) + \Sigma K_{ab}V^2/2g \]

or, with zero terms canceled out (\( P_b \) is atmospheric) and in terms of feet (\( P_a/\gamma \) is the pressure head = \( H \), \( \Sigma K_{ab}V^2/2g \) is the friction head = \( h_L \), \( V_a = V_2 \) and \( V_b = V_3 \)):

\[ H = h_L + (V_3^2/2g - V_2^2/2g) + (z_b - z_a) \]

Required Pressure Head

\[ H = h_L + \left( \frac{V_3^2}{2g} - \frac{V_2^2}{2g} \right) + (z_b - z_a) \quad H = 174.81\text{ft} \]

Required Pressure

\[ P = \frac{H \times SG}{2.31} \quad P = 111.24\text{psi} \]
APPENDIX A

References
FIGURE 16 - TK-AN-106 TO 241-AN-B EXCAVATION WALKDOWN

TK-AN-106

CENTRAL PUMP PIT
241-AN-06A

241-AN-B

SN-266
SN-268
SN-260

EXCAVATION WALKDOWN CONTINUED ON FIGURE 18

Ref: 001181e8.ds4

Calc No: DSTAP-P-001, Rev. 0
Ref. 1 A1 of A18
FIGURE 19 - COB-AZ-1 TO TK-104-AP EXCAVATION WALKDOWN

CONTINUOUS EXCAVATION WALKDOWN
CONTINUED ON FIGURE 18

Calc No: DSTAP-P-001, Rev. 0
Ref. 1 A3 of A18
"K" FACTOR TABLE—Sheet 1 of 4

Representative Resistance Coefficients (K) for Valves and Fittings

("K" is based on use of schedule pipe as listed on page 2-10)

PIECE FRICTION DATA FOR CLEAN COMMERCIAL STEEL PIPE

WITH FLOW IN ZONE OF COMPLETE TURBULENCE

<table>
<thead>
<tr>
<th>Nominal Size</th>
<th>1/2&quot;</th>
<th>3/4&quot;</th>
<th>1&quot;</th>
<th>1 1/4&quot;</th>
<th>1 1/2&quot;</th>
<th>2&quot;</th>
<th>2 1/2&quot;, 3&quot;</th>
<th>4&quot;</th>
<th>5&quot;</th>
<th>6&quot;</th>
<th>8-10&quot;</th>
<th>12-16&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Friction Factor ($f_1$)</td>
<td>.027</td>
<td>.025</td>
<td>.023</td>
<td>.022</td>
<td>.021</td>
<td>.019</td>
<td>.018</td>
<td>.017</td>
<td>.016</td>
<td>.015</td>
<td>.014</td>
<td>.013</td>
</tr>
</tbody>
</table>

FORMULAS FOR CALCULATING "K" FACTORS

FOR VALVES AND FITTINGS WITH REDUCED PORT

(Ref. Pages 2-11 and 3-4)

- **Formula 1**
  \[ K_3 = \frac{0.8 \left( \sin \frac{\theta}{2} (1 - \beta^2) \right)}{\beta^2} - K_1 \]

- **Formula 2**
  \[ K_2 = \frac{0.5 (1 - \beta^2) \sqrt{\sin \frac{\theta}{2}}}{\beta^2} - K_1 \]

- **Formula 3**
  \[ K_2 = \frac{2.6 \left( \sin \frac{\theta}{2} \right) (1 - \beta^2)^2}{\beta^2} - K_1 \]

- **Formula 4**
  \[ K_2 = \frac{(1 - \beta^2)^2}{\beta^2} - K_1 \]

- **Formula 5**
  \[ K_2 = \frac{K_1}{\beta^2} + \text{Formula 1} + \text{Formula 3} \]

- **Formula 6**
  \[ K_3 = \frac{K_1}{\beta^2} + \text{Formula 2} + \text{Formula 4} \]

- **Formula 7**
  \[ K_3 = \frac{K_1}{\beta^2} + \beta \left( \text{Formula 2} + \text{Formula 4} \right) \text{ when } \theta = \]

  \[ K_3 = \frac{K_1 + \beta \left[ 0.5 (1 - \beta^2) + (1 - \beta^2)^2 \right]}{\beta^2} \]

\[ \beta = \frac{d_1}{d_2} \]
\[ \beta^2 = \left( \frac{d_1}{d_2} \right)^2 \frac{d_1}{d_2} \]

Subscript 1 defines dimensions and coefficients with reference to the smaller diameter.

Subscript 2 refers to the larger diameter.

*Use "K" furnished by valve or fitting supplier when available.

SUDDEN AND GRADUAL CONTRACTION

If: \( \theta < 45^\circ \) .......... \( K_3 = \text{Formula 1} \)

\( 45^\circ < \theta < 180^\circ \) .......... \( K_3 = \text{Formula 2} \)

SUDDEN AND GRADUAL ENLARGEMENT

If: \( \theta < 45^\circ \) .......... \( K_3 = \text{Formula 3} \)

\( 45^\circ < \theta < 180^\circ \) .......... \( K_3 = \text{Formula 4} \)
"K" Factor Table—Sheet 4 of 4

Representative Resistance Coefficients (K) for Valves and Fittings

(for formulas and friction data, see page A-26)

("K" is based on use of schedule pipe as listed on page 2-10)

Plug Valves and cocks

Straight-Way

3-Way

If: \( \beta = 1 \),

\( K_1 = \frac{18}{T} \)

If: \( \beta = 1 \),

\( K_1 = \frac{30}{T} \)

If: \( \beta = 1 \),

\( K_1 = \frac{90}{T} \)

If: \( \beta < 1 \) \( K_2 = \text{Formula 6} \)

Standard Elbows

90°

45°

\( K = \frac{30}{T} \)

\( K = \frac{16}{T} \)

Standard Tees

Flow thru run \( . . . . . . K = \frac{20}{T} \)

Flow thru branch \( . . . . . . K = \frac{60}{T} \)

Pipe Entrance

Inward Projecting

Flush

Pipe Exit

Projecting

Sharp-Edged

Rounded

The resistance coefficient, \( K_n \), for pipe bends other than 90° may be determined as follows:

\[
K_n = (n - 1) \left( 0.25 \pi \frac{r^2}{d^2} + 0.5 K \right) + K
\]

\( n \) = number of 90° bends

\( K \) = resistance coefficient for one 90° bend (per table)

Close Pattern Return Bends

\( \frac{r}{d} = \frac{10}{2} = 5 \)

\( \frac{r}{d} = \frac{18}{2} = 9 \)

\( K = \frac{50}{T} \)

\( K = \frac{15.5^*}{T} \)
Problem: Find the flow coefficient $C_v$ for a 6-inch Class 125 cast iron globe valve with full area seat.

Solution:

$$K = 340 f_r$$ ........................................ page A-27

$$f_r = 0.015$$ ........................................ page A-26

$$K = 340 \times 0.15 = 5.1$$

$$C_v = 490$$ ........................................ dotted lines on chart
I forgot the criteria on Flammable Gas Controls and pressure.

In our recent meetings on annulus pumping, it was apparent that the pumping specifications previously provided were not adequate. I’m currently in the process of developing a technical rational for the Pump Design Criteria. The following is a draft of the criteria. Let me know if there are any questions or concerns.

**Submersible Centrifugal**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Flow</td>
<td>50 - 300* gpm</td>
</tr>
<tr>
<td>SpG</td>
<td>1.0 - 1.47</td>
</tr>
<tr>
<td>Viscosity</td>
<td>1.0 - 30 centipoise</td>
</tr>
<tr>
<td>Solids</td>
<td>0 - 20 Volume %</td>
</tr>
<tr>
<td>Temperature</td>
<td>65 - 140°F</td>
</tr>
<tr>
<td>Discharge Pressure</td>
<td>230 maximum**</td>
</tr>
<tr>
<td>Flammable Gas Controls</td>
<td>Ignition Source Control Set #1 (Class 1 Division 1 GroupB or equivalent)***</td>
</tr>
<tr>
<td>Waste Flow</td>
<td>33 - 200 gpm****</td>
</tr>
<tr>
<td>Dilution water Flow</td>
<td>17 - 100 gpm****</td>
</tr>
</tbody>
</table>

* The maximum flow rate of 300 gpm is based on an accident in the Tank Farm FSAR 3.4.2.7 Surface Leak Resulting in a Pool.

** Maximum design pressure for transfer lines in SY Farm (Spec B-101-C3) and A & AX Farms (Spec B-102-C1)

*** Mineral insulated Cable meets requirements for equivalency. Series 300 stainless is acceptable as non-sparking.

**** The dilution water flow may be required to be as high as 50% of the waste flow. It’s recognized that design constraints may prevent reaching dilution water flows above 40 gpm. In this case throttling existing waste line valves will be used to set the proper dilution. The design constraints anticipated are water supply pressure, pressure drop through hose connections, and the limiting pipe diameter that can be coupled with the pump assemblies.

**Heel Pump**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Flow</td>
<td>2 - 5 gpm</td>
</tr>
<tr>
<td>SpG</td>
<td>1.0 - 1.47</td>
</tr>
<tr>
<td>Viscosity</td>
<td>1.0 - 30 centipoise</td>
</tr>
</tbody>
</table>
Solids 0 - 20 Volume %
Temperature 65 - 140°F
Discharge Pressure 230 maximum *
Flammable Gas Controls Ignition Source Control Set #1 (Class 1 Division 1 Group B or equivalent)**
Dilution water Flow None Required

Note: It is assumed that the heel pump will be used just to remove the last few inches of liquid from the annulus. Repeated water flushes of the annulus may be performed to remove the residual radioactive components. So it is anticipated that the actual solution SpG will probably be significantly lower than the maximum stated above.

* Maximum design pressure for transfer lines in SY Farm (Spec B-101-C3) and A & AX Farms (Spec B-102-C1)

** Mineral insulated cable meets requirements for equivalency. Series 300 stainless is acceptable as non-sparking.
I'm reducing it to 40 to 140 as a range, and documenting it in a letter, which I hope to get to you soon.

Dan,

I was "officially" updating the line loss calculation for the DST Annulus Pumps. The latest Design Criteria e-mail I have from you considers flow rates from 50 - 300 GPM. I know some talk has been made about lowering the flow rate to 40 GPM or lower. Has the flow rate criteria changed or is 50 GPM still the number?

Paul Dorsh
Fluor Federal Services
372-0289
The roughness for various kinds of pipe, as given by Moody (29), is plotted with data from the American Society of Mechanical Engineers (ASME).
Colebrook–White formula, from which the Moody diagram was developed, Swamee and Jain (39) developed explicit formulas relating \( f, h_f, Q, \) and \( D \). It is reported that their formulas yield results that deviate no more than 3% from those obtained from the Moody diagram for the following ranges of \( k_r/D \) and \( Re \):

\[
10^{-5} < k_r/D < 2 \times 10^{-2} \text{ and } 4 \times 10^3 < Re < 10^6.
\]

The formulas for \( f \) and \( Q \) are

\[
f = \frac{0.25}{\left[ \log \left( \frac{k_r}{3.7D} + \frac{5.74}{Re^{0.8}} \right) \right]^2} \tag{10.26}
\]

\[
Q = -2.22D^{5/2} \sqrt{gh_f/L} \log \left( \frac{k_r}{3.7D} + \frac{1.78\nu}{D^{5/2} \sqrt{gh_f/L}} \right) \tag{10.27}
\]

They also developed a formula for the explicit determination of \( D \). A modified version of that formula, given by Streeter and Wylie (38), is

\[
D = 0.66 \left[ k_r^{1.21} \left( \frac{LQ^2}{gh_f} \right)^{4.75} + \nu Q^8 \left( \frac{L}{gh_f} \right)^{5.2} \right]^{0.04} \tag{10.28}
\]

If you want to solve for head loss given \( Q, L, D, k_r, \) and \( \nu \), simply solve for \( f \) by Eq. (10.26) and compute \( h_f \) with the Darcy–Weisbach equation, Eq. (10.22). Straightforward calculations for \( Q \) and \( D \) can also be made if \( h_f \) is known. However, for problems involving head losses in addition to \( h_f \), an iterative solution is required. For computing \( Q \), you can assume an \( f \) and solve for \( Q \) from the energy equation after substituting \( Q/A \) in that equation. Then compute \( Re \) and use the result in Eq. (10.26) to get a better estimate of \( f \), and so on, until \( Q \) converges analogous to the procedure for determining \( Q \) using the Moody diagram. In this case, however, Eq. (10.26) is substituted for the Moody diagram. Similarly, you can determine \( D \) if you are given \( Q, \nu \), the change in pressure or head, and the geometric configuration.

### EXAMPLE 10.8

Solve Example 10.5 using Eq. (10.27).

**Solution** From Fig. 10.8, \( k_r \) for asphalted cast-iron pipe is given as 1.2 \( \times \) 10\(^{-4} \) m. From the given conditions, \( h_f/L = 0.0122 \). Assume \( T = 20°C \), so \( \nu = 10^{-6} \text{ m}^2/\text{s} \). Then, using Eq. (10.27), we have

\[
Q = -2.22(0.20 \text{ m})^{5/2} \sqrt{9.81 \text{ m/s}^2 \times 0.0122} \times \log \left( \frac{1.2 \times 10^{-4} \text{ m}}{3.7 \times 0.20 \text{ m}} + \frac{1.78 \times 10^{-6} \text{ m}^3/\text{s}}{(0.20 \text{ m})^{5/2} \sqrt{9.81 \text{ m/s}^2 \times 0.0122}} \right)
\]

\[
= 0.050 \text{ m}^3/\text{s}
\]
### Table 10.2 Loss Coefficients for Various Transitions and Fittings

<table>
<thead>
<tr>
<th>Description</th>
<th>Sketch</th>
<th>Additional Data</th>
<th>( K )</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pipe entrance</td>
<td></td>
<td>( r/d ) ( K_c )</td>
<td></td>
<td>(2)*</td>
</tr>
<tr>
<td>( h_d = K_c V^2/2g )</td>
<td></td>
<td>0.0</td>
<td>0.50</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.1</td>
<td>0.12</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt;0.2</td>
<td>0.03</td>
<td></td>
</tr>
<tr>
<td>Contraction</td>
<td></td>
<td>( D_2/D_1 ) ( K_c ) ( K_c )</td>
<td></td>
<td>(2)</td>
</tr>
<tr>
<td></td>
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<td>0.0</td>
<td>0.08</td>
<td>0.50</td>
</tr>
<tr>
<td></td>
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<td>0.20</td>
<td>0.08</td>
<td>0.49</td>
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<td>0.07</td>
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<td>0.60</td>
<td>0.06</td>
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<td></td>
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<td>0.80</td>
<td>0.06</td>
<td>0.20</td>
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<tr>
<td></td>
<td></td>
<td>0.90</td>
<td>0.06</td>
<td>0.10</td>
</tr>
<tr>
<td>Expansion</td>
<td></td>
<td>( D_1/D_2 ) ( K_c ) ( K_c )</td>
<td></td>
<td>(2)</td>
</tr>
<tr>
<td></td>
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<td>0.87</td>
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<td>0.40</td>
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<td>0.70</td>
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<td></td>
<td></td>
<td>0.60</td>
<td>0.15</td>
<td>0.41</td>
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<tr>
<td></td>
<td></td>
<td>0.80</td>
<td>0.10</td>
<td>0.15</td>
</tr>
<tr>
<td>( h_d = K_c V^2/2g )</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>90(^\circ) miter bend</td>
<td></td>
<td></td>
<td></td>
<td>(37)</td>
</tr>
<tr>
<td></td>
<td></td>
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<tr>
<td></td>
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<td></td>
<td></td>
<td>(37)</td>
</tr>
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<td>90(^\circ) smooth bend</td>
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<tr>
<td>Threaded pipe fittings</td>
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<td>(37)</td>
</tr>
<tr>
<td>Globe valve—wide open</td>
<td></td>
<td>( K_9 ) = 10.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Angle valve—wide open</td>
<td></td>
<td>( K_9 ) = 5.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gate valve—wide open</td>
<td></td>
<td>( K_9 ) = 0.2</td>
<td></td>
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</tr>
<tr>
<td>Gate valve—half open</td>
<td></td>
<td>( K_9 ) = 5.6</td>
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<td></td>
</tr>
<tr>
<td>Return bend</td>
<td></td>
<td>( K_9 ) = 0.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tee straight-through flow</td>
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<td>( K_9 ) = 0.4</td>
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<td></td>
</tr>
<tr>
<td>side-outlet flow</td>
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<td>( K_9 ) = 1.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>90(^\circ) elbow</td>
<td></td>
<td>( K_9 ) = 0.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>45(^\circ) elbow</td>
<td></td>
<td>( K_9 ) = 0.4</td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Density</th>
<th>Specific Weight</th>
<th>Dynamic Viscosity</th>
<th>Kinematic Viscosity</th>
<th>Vapor Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>kg/m³</td>
<td>N/m³</td>
<td>N*s/m²</td>
<td>m²/s</td>
<td>N/m³ abs.</td>
</tr>
<tr>
<td>0°C</td>
<td>1.00</td>
<td>9810</td>
<td>1.79 x 10⁻³</td>
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<td>9810</td>
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<td>9810</td>
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<td>15°C</td>
<td>0.99</td>
<td>9800</td>
<td>1.14 x 10⁻³</td>
<td>1.14 x 10⁻⁶</td>
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<tr>
<td>20°C</td>
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<td>9790</td>
<td>1.00 x 10⁻³</td>
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<td>2340</td>
</tr>
<tr>
<td>25°C</td>
<td>0.97</td>
<td>9781</td>
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<td>8.94 x 10⁻⁷</td>
<td>3170</td>
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<tr>
<td>30°C</td>
<td>0.96</td>
<td>9771</td>
<td>7.97 x 10⁻⁴</td>
<td>8.00 x 10⁻⁷</td>
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<td>35°C</td>
<td>0.95</td>
<td>9751</td>
<td>7.20 x 10⁻⁴</td>
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<tr>
<td>40°C</td>
<td>0.94</td>
<td>9732</td>
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<td>6.58 x 10⁻⁷</td>
<td>7380</td>
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<td>45°C</td>
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<td>9713</td>
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<td>5.93 x 10⁻⁷</td>
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<tr>
<td>50°C</td>
<td>0.94</td>
<td>9693</td>
<td>5.47 x 10⁻⁴</td>
<td>5.53 x 10⁻⁷</td>
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<tr>
<td>55°C</td>
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<td>4.66 x 10⁻⁴</td>
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<td>60°C</td>
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<td>9635</td>
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<td>9605</td>
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<td>9576</td>
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<th>Lbf-s/ft²</th>
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<td>40°F</td>
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<td>70°F</td>
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<td>62.00</td>
<td>1.42 x 10⁻⁵</td>
<td>0.739 x 10⁻⁵</td>
<td>0.949</td>
</tr>
<tr>
<td>100°F</td>
<td>1.92</td>
<td>61.72</td>
<td>1.17 x 10⁻⁵</td>
<td>0.609 x 10⁻⁵</td>
<td>1.69</td>
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<td>110°F</td>
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<td>61.38</td>
<td>0.981 x 10⁻⁵</td>
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<td>0.838 x 10⁻⁵</td>
<td>0.442 x 10⁻⁵</td>
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<td>130°F</td>
<td>1.89</td>
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<td>0.726 x 10⁻⁵</td>
<td>0.385 x 10⁻⁵</td>
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<td>140°F</td>
<td>1.87</td>
<td>60.12</td>
<td>0.637 x 10⁻⁵</td>
<td>0.341 x 10⁻⁵</td>
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<td>150°F</td>
<td>1.86</td>
<td>59.83</td>
<td>0.593 x 10⁻⁵</td>
<td>0.319 x 10⁻⁵</td>
<td>14.70</td>
</tr>
</tbody>
</table>

*Notes: (1) Bulk modulus Eₗ of water is approximately 2.2 G Pa (3.2 x 10⁵ psi); (2) Water-air surface tension is approximately 7.3 x 10⁻³ N/m (5 x 10⁻⁵ lbf/ft) from 10°C to 50°C.

CV FACTORS FOR SP SERIES VALVES

CV is defined as the number of U.S. gallons per minute, of ambient temperature water, that will flow through a valve at 1 psi pressure drop.

<table>
<thead>
<tr>
<th>SP 30-40 Series</th>
<th>SI 70-80 Series</th>
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<tr>
<td><strong>Size Code</strong></td>
<td><strong>Size Code</strong></td>
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<tr>
<td><strong>Pipe Size</strong></td>
<td><strong>Port Diameter</strong></td>
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<tr>
<td>SP-32</td>
<td>1/2&quot;</td>
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<tr>
<td>SP-33</td>
<td>3/4&quot;</td>
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<tr>
<td>SP-34</td>
<td>1&quot;</td>
</tr>
<tr>
<td>SP-35</td>
<td>1-1/4&quot;</td>
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<td>SP-36</td>
<td>1-1/2&quot;</td>
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<td>SP-37</td>
<td>2&quot;</td>
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<td>SP-38</td>
<td>2-1/2&quot;</td>
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<td>3&quot;</td>
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<tr>
<td>SP-40</td>
<td>4&quot;</td>
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<tr>
<td>SP-41</td>
<td>6&quot;</td>
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VACUUM AND CYCLE TESTS FOR SP SERIES VALVES

VACUUM PERFORMANCE

PBM valves excel under vacuum conditions as well as under pressure conditions. Typical test results showing helium leakage at 10^-7 Torr are provided.

<table>
<thead>
<tr>
<th>Typical Vacuum Test Results</th>
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<tbody>
<tr>
<td>Valves</td>
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<tr>
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</tr>
<tr>
<td>2&quot;</td>
</tr>
<tr>
<td>4&quot;</td>
</tr>
</tbody>
</table>

CYCLE TESTING

The life of a ball valve is dependent upon service conditions, and therefore impossible to predict. However, PBM cycle-tests valves using 100 psid of ambient temperature water pressure across the seats with the valve in the closed position. These test conditions represent a typical wear causing force on the seats and packings. PBM also tests valves in a steam environment up to 180 F.

Replacement of valve gaskets or O-rings is recommended at each disassembly. Replacement of other non-moving parts would only be dictated by the corrosion or erosion caused by the flow media. In most applications, PBM ball valves will operate trouble-free for many years.
**Cv FACTORS — MP/MI 70-80 SERIES**

Cv is defined as the number of U.S. gallons of water per minute of ambient temperature water that will flow through a valve at 1 psi pressure drop.

**MP 70-80 SERIES Cv FACTORS (MEASURED IN GPM)**

<table>
<thead>
<tr>
<th>Valve Size</th>
<th>Dive</th>
<th>Forum</th>
<th>Cv</th>
<th>Max</th>
<th>Max</th>
<th>Max</th>
<th>Max</th>
<th>Max</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>MP-72</td>
<td>1/2&quot;</td>
<td>0.62</td>
<td>12</td>
<td>14</td>
<td>9</td>
<td>14</td>
<td>9</td>
<td>14</td>
<td>9</td>
</tr>
<tr>
<td>MP-73</td>
<td>3/4&quot;</td>
<td>0.56</td>
<td>12</td>
<td>14</td>
<td>9</td>
<td>14</td>
<td>9</td>
<td>14</td>
<td>9</td>
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<tr>
<td>MP-74</td>
<td>1&quot;</td>
<td>1.00</td>
<td>33</td>
<td>38</td>
<td>24</td>
<td>33</td>
<td>24</td>
<td>33</td>
<td>24</td>
</tr>
<tr>
<td>MP-75</td>
<td>1 1/4&quot;</td>
<td>1.00</td>
<td>32</td>
<td>36</td>
<td>24</td>
<td>31</td>
<td>24</td>
<td>31</td>
<td>24</td>
</tr>
<tr>
<td>MP-76</td>
<td>1 1/2&quot;</td>
<td>1.50</td>
<td>78</td>
<td>93</td>
<td>58</td>
<td>78</td>
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<tr>
<td>MP-77</td>
<td>2&quot;</td>
<td>2.00</td>
<td>148</td>
<td>176</td>
<td>108</td>
<td>148</td>
<td>108</td>
<td>148</td>
<td>108</td>
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<td>MP-79</td>
<td>3&quot;</td>
<td>3.00</td>
<td>380</td>
<td>460</td>
<td>270</td>
<td>380</td>
<td>270</td>
<td>380</td>
<td>270</td>
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<tr>
<td>MP-80</td>
<td>4&quot;</td>
<td>4.00</td>
<td>680</td>
<td>820</td>
<td>490</td>
<td>680</td>
<td>490</td>
<td>680</td>
<td>490</td>
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<td>MP-42</td>
<td>6&quot;</td>
<td>6.00</td>
<td>1541</td>
<td>1851</td>
<td>1111</td>
<td>1541</td>
<td>1111</td>
<td>1541</td>
<td>1111</td>
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</table>

**NOTES:**
1. Most values represent MP Series valves with 150# flanged end fittings.
2. MP Series valves with Female NPT end fittings.
3. Flanged end fittings are not available for MP 75 (1 1/4").
4. 1 1/4" and double angle port are not full port design.

**MI 70-80 SERIES Cv FACTORS (MEASURED IN GPM)**

<table>
<thead>
<tr>
<th>Valve Size</th>
<th>Dive</th>
<th>Forum</th>
<th>Cv</th>
<th>Max</th>
<th>Max</th>
<th>Max</th>
<th>Max</th>
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<tbody>
<tr>
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<td>1/2&quot;</td>
<td>0.37</td>
<td>3.5</td>
<td>5.3</td>
<td>3.0</td>
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<td>2.6</td>
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<tr>
<td>MI-73</td>
<td>3/4&quot;</td>
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<td>11</td>
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<td>1 1/2&quot;</td>
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<td>56</td>
<td>85</td>
<td>49</td>
<td>56</td>
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<td>MI-77</td>
<td>2&quot;</td>
<td>1.87</td>
<td>110</td>
<td>160</td>
<td>93</td>
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<td>230</td>
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</table>

**NOTES:**
1. 6" and double angle port are not True-Bore design.

**VACUUM AND CYCLE TESTS — MP/MI 70-80 SERIES**

**Vacuum Testing**

PBM valves excel under vacuum conditions as well as under pressure conditions. Typical test results showing helium leakage at 10⁻⁷ Torr are provided.

**Cycle Testing**

The life of a ball valve is dependent upon service conditions and, therefore, impossible to predict. However, PBM cycle-tests valves using 100 psid of ambient temperature water pressure across the seats with the valve in the closed position. These test conditions represent a typical wear-causing force on the seats and packings. PBM also tests valves in a steam environment up to 380°F.

Replacement of valve gaskets or O-rings is recommended at each disassembly. Replacement of other non-moving parts is dictated only by the corrosion caused by the flow media. In most applications, PBM ball valves will operate trouble-free for many years.
40-50 GPM
1.35
140°F

EXISTING ANNUlus PUMP

TYPICAL DOUBLE SHELL TANK ANNULUS
Title – Statement of Work for Annulus Pumping
Contract 4975 – Fluor Daniel Northwest
Revision Number – 0
Date – December 9, 1999

Objective:
The objective is to authorize Fluor Daniel Northwest to provide engineering support for identifying, supporting procurement, testing, and final design of a pump assembly for waste removal in the Double Shell Tank Annulus.

Background/Introduction:
The objective is to provide a combination of two pumps capable of high flow removal of waste for the DST Annulus, and removal of the heel to the extent possible. The pumping scheme should follow that addressed in an ARES Report Number 9905303-001, March 1999, “Double Shell Tank Annulus Pumping Alternative Evaluation” unless changed with LMHC concurrence. A spare pumping system will also be procured. These activities support Tasks 19DAPB “Prepare Procurement Specification & Procure Pump” and 19DAPC “Design, Procure, Fabricate, Receive & Store Jumpers & Pump Assemblies” of the schedule attached to correspondence LMHC-9954506R2 October 25, 1999.

Scope:
This Task Order allows Fluor Daniel Northwest to perform, as required, the following minimum activities:

Task 19DAPB
1. Review of piping system and prepare preliminary design (6 DST Farms transferring to 106-AP)
2. Prepare procurement specification for pumps
3. Support procurement activities
4. Evaluate bids, and select vendor
5. Prepare acceptance test procedure
6. Evaluate run-in data for the tested pumps
7. Develop Certified Vendor Information File

Task 19DAPC
8. Final design of pump assemblies and farm specific flanges
9. Fabrication support of pump assemblies
10. Identification of common spare jumper parts
11. Prepare spare parts list

References:
Piping pressure drop calculations for the Cross-site transfer route to AP Tank Farm have been documented in Project W-058 files in calculation numbers W058-P-044 and 048. Schematics with transfer line lengths have been developed for most tank farm routings to AP farm and can be found in the Emergency Transfer procedures TO-001-181, 182, 183, 184 and TO-430-500 as excavation schematics.

Deliverables:
Design drawings, procurement specification, acceptance test procedure all prepared in accordance with LMHC approved procedures.

Acceptance Criteria:
Documentation with the appropriate LMHC and FDNW approvals as established in current procedures.

Period of Performance:
Activities associated with this SOW are expected to be initiated as soon as possible after receipt of the Task Order, with completion on or before April 11, 2000 for Task 19DAPB and June 2, 2000 for Task 19DAPC.

Technical Point of Contact:
The following personnel are assigned as liaison with Fluor Daniel Northwest for the scope of work described:

- Technical Contact: D. W. Reberger, LMHC, Double Shell Tank Engineering
- Administrative Contact: A. B. Johnson, L.K. Martin LMHC, Financial Control
- Project Engineer: S. J. Lepka, LMHC, Operational Configuration Management.
Applicable ES&H requirements:
Standard ES&H requirements (without ISMS) are warranted for this work.

Safety Requirements:
N/A

Requirements (Including Quality Assurance Requirements):
The subcontractor is subject to Title 10, Code of Federal Regulations, Part 830.120 (10 CFR 830.120), Quality Assurance Requirements, and the enforcement actions under 10 CFR 820, General Statement of Enforcement Policy.

Hold Points:
N/A

Configuration Management Requirements:
N/A

Work Location/Potential Access Requirements:
N/A

Training:
N/A

Qualifications:
Degreed Engineering support as required.

Special Requirements:
N/A

Reporting/Administration:
Status Meetings will be as requested by LMHC or FDNW. Any documentation computer files such as Supporting Documents will be prepared in Word Perfect or Microsoft Word.
From: Reberger, Dan W
Sent: Friday, December 17, 1999 12:53 PM
To: Rarig, Bradley K
Cc: Hauck, Frank M (Marshall); Baide, Daniel G (Dan); Lepka, Stanley J (Stan)
Subject: Design Procedures and Criteria for Annulus Pumping

The design of any jumper or pump piping assembly for annulus pumping, is expected to have Design Pressure, Thermal Expansion, Sustained and Seismic load calculations performed and documented. The calculation documentation should be issued as a Supporting Document. The preferred material for the pump assembly is stainless steel. All materials for trailer racks and instrument skids can be carbon steel.

Design Criteria:
The design and analysis of jumper/pump piping shall be in accordance with the following criteria:
1. HNF-PRO-097, Rev-0 Engineering Design and Evaluation
2. WHC-SD-W236A-DA-002, Rev-0 Stress Analysis of Single port Jumper Connectors

Design Codes & Standards:
1. ASME Code B31.3a 1996 "Process Piping"
2. WHC-SD-RE-DGS-002 Rev-3 Jumper Design Standard

Design Parameters:
1. Design Pressure 300 psig
2. Design Temperature 340°F
3. Corrosion Allowance 1.0 mils/yr.
4. Waste Specific Gravity 1.30
5. Classification General Service

Updated, see Ref. 3
This document was too large to scan as a single document. It has been divided into smaller sections.

Section 2 of 2

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APPENDIX B

Referenced Drawings
Calculation No.: DSTAP-P-001
B30 of B38
AN-106 to AP-104 System and Pump Curves

![Graph showing flow rate and head for AN-106 to AP-104 system and pump curves. The graph includes three curves: Manufacturer's Tandem Pump Curve, 8880009/8880008 Tandem Pump Test, and AN-106 to AP-104 System Curve.](image-url)
This sheet shows the status and description of the attached Design Analysis sheets.

**Discipline:** 454  
**Project/Area/Unit:** 65100541/25/9  
**Calculation No.:** DSTAP-P-002

**Project No. & Name:** Double Shell Tank Annulus Pumping

**Calculation Item:** Annulus Jumper Orifice Design

These calculations apply to:

- **Drawing No.:** N/A

The status of these calculations is:

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

Incorporated in Final Drawings: [X] Yes  [ ] No

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

---

**Original and Revised Calculation Approvals:**

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<th>Rev. 1 Signature/Date</th>
<th>Rev. 2 Signature/Date</th>
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<td></td>
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<td><strong>Checked by</strong></td>
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<tr>
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<td><strong>Approved Vendor Data</strong></td>
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**Appendix A**

- Attached References
  - A1-A3  
    Crane Technical Paper No. 410
  - A4-A5  
    E-mail consisting of Design Parameters.
  - A6  
    E-mail pertaining to Flow Rates
  - A7-A12  
    Engineering Fluid Mechanics
  - A13  
    Flygt Catalog Cut Sheet
  - A14  
    PBM Catalog Cut Sheet
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### REVISION

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OBJECTIVE:

The objective of this calculation is to size an orifice, which will be used to reduce the flow rate in the annulus pump pit transfer piping. The transfer line connecting the annulus pump pit to the central pump pit in the AY-101, AY-102, and AZ-102 tanks are not contained within encasement piping (they are direct buried). Therefore, a flow rate restriction of 50 GPM is placed on these lines. If a leak occurs past the first shell of the double shell tanks, an electric submersible pump will be used to transfer waste out of the annulus area. An orifice will be placed in the annulus pump pit jumper and will be sized to restrict the flow rate discharged from the pump to 50 GPM, when measured at the annulus jumper / transfer line connection.

DESIGN CRITERIA / INPUT:

Flow Rate: 50 GPM maximum  
Dynamic Viscosity: 30 centipoise maximum  
Specific Gravity: 1.47 maximum  
Temperature: 140°F maximum  
Discharge Pressure 78 ft

METHODS:

1.) The Darcy-Weisbach equation is used in determining the friction pressure losses.

2.) Friction losses due to standard fittings are calculated using the pipe resistance coefficients (K factors) found in Crane Technical Paper No. 410.

3.) The total pressure losses of the system is determined using Bernoulli's equation.

The Flygt pump performance curve will be used to determine the system's operating pressure required to achieve a 50 GPM flow rate. A pressure drop due to the resistance of the components will be compared to this operating pressure and a difference in pressure will be established. The orifice will be sized in a way that produces a pressure drop equal to the difference, and thus produce a flow rate equal to 50 GPM at the entrance of the "directly buried" transfer line.

Because of the similarity between the annulus pit arrangements in tanks AY-101, AY-102 and AZ-102, only one "generalized" calculation will be completed. The results of the calculation can be applied to any of these tanks with very minimal error.
ASSUMPTIONS:

1.) The Purex nozzles are equivalent in resistance to a 90 degree miter bend.

2.) The equivalent roughness of stainless steel pipe is 0.00015 ft.

3.) The discharge of the pump is will be at the bottom of the tank in the annulus area.

4.) Only one pump (Flygt BS 2060.390) will be used to transfer the waste. (i.e. no tandem operation)

5.) The 3-way ball valve used in the annulus jumper has a flow coefficient equivalent to PBM MP 70-80 series (3-way) valve.

6.) 3" schedule 80 pipe will be used from the discharge of the pump to the pump flange. 2" schedule 40 pipe will be used on the annulus jumper.

7.) The orifice will have an assumed flow coefficient of K = 0.65.

REFERENCES:


2.) E-mail dated 1/25/00 from Dan Reberger to Marshall Hauck consisting of Revised Design Criteria.

3.) E-mail dated 3/15/00 from Dan Reberger to Marshal Hauck, pertaining to Flow Restrictions.


5.) Flygt Pump BS-2060.390, Performance Data Sheet.

6.) PBM Catalog Cut Sheet.

7.) Referenced Drawing, ARES sketch of Double Shell Tank Annulus Pumping Data.

8.) Sketches showing the typical annulus pump pit assembly and jumper layout.

9.) Statement of Work for Annulus Pumping, Revision No. 0, Contract 4975.

References are attached in Appendix A

CONCLUSIONS:

A centrally located orifice with a diameter of 0.9" should be used in an annulus jumper which requires a 50 GPM flow restriction. Again, this number assumes that only one Flygt submersible pump is used (as opposed to a tandem operation).
Fluid Properties

Maximum Flow Rate

\[ Q := 50 \text{ GPM} \quad Q = 192.5 \cdot \frac{\text{in}^3}{\text{sec}} \quad (\text{Ref. 3, A6}) \]

Specific Gravity of Fluid

\[ SG := 1.47 \quad (\text{Ref. 2, A4}) \]

Temperature of Fluid

\[ T := 140^\circ F \quad (\text{Ref. 2, A4}) \]

Density of Water

\[ \rho_w := 61.38 \cdot \frac{\text{lb}}{\text{ft}^3} \quad (\text{Ref. 4, A10}) \]

Density of Fluid

\[ \rho := \rho_w \cdot SG \quad \rho = 90.229 \cdot \frac{\text{lb}}{\text{ft}^3} \quad (\text{Ref. 2, A4}) \]

Dynamic Viscosity

\[ \mu := 30 \cdot \text{cp} \quad (\text{Ref. 2, A4}) \]

Pipe Roughness

\[ k_s := 0.00015 \cdot \text{ft} \quad (\text{Ref. 4, A11}) \]

2" Sch 40 Pipe Properties

Inside Diameter of 2" Sch 40 Pipe

\[ D_2 := 2.067 \text{ in} \]

Inside Area of Pipe

\[ A_2 := \frac{\pi}{4} \cdot D_2^2 \quad A_2 = 3.356 \cdot \text{in}^2 \]

Velocity of Fluid

\[ V_2 := \frac{Q}{A_2} \quad V_2 = 4.781 \cdot \frac{\text{ft}}{\text{sec}} \]

Reynolds Number

\[ \text{Re}_2 := \frac{V_2 \cdot D_2 \cdot \rho}{\mu} \quad \text{Re}_2 = 3685.5 \quad (\text{flow is turbulent}) \]

Friction Factor

\[ f_2 := \frac{0.25}{\log \left( \frac{k_s + 0.64}{3.7 \cdot D_2 \cdot 0.9 \cdot \text{Re}_2} \right)^{0.25}} \quad f_2 = 0.043 \quad (\text{Ref. 4, A7}) \]
Friction Factor in Zone of Complete Turbulence

\[ f_{t2} = 0.019 \]  
(Ref. 1, A1)

Flow Coefficient of 3 Way T-Port Through

\[ C_v_{t2} = 176 \]  
(Ref. 6, A14)

3" Sch 80 Pipe Properties

Inside Diameter of 3" Sch 80 Pipe

\[ D_3 = 2.9 \text{ in} \]

Inside Area of Pipe

\[ A_3 = \frac{\pi}{4} D_3^2 \quad A_3 = 6.605 \text{ in}^2 \]

Velocity of Fluid

\[ V_3 = \frac{Q}{A_3} \quad V_3 = 2.429 \text{ ft/sec} \]

Reynolds Number

\[ \text{Re}_3 = \frac{V_3 D_3^{0.9}}{\mu} \quad \text{Re}_3 = 2626.9 \]

It is reasonable to expect that pipe flow will be laminar for Reynolds number less than 2000 and turbulent for Reynolds numbers greater than 3000. When the Reynolds number is between 2000 and 3000 the type of flow is very unpredictable and often changes back and forth between laminar and turbulent states. However, since there will be vibrations in the piping system due to the pumping operation, it is safe to assume that the flow is turbulent.  
(Ref. 4, A12)

Friction Factor

\[ f_3 = \frac{0.25}{\log \left( \frac{k_s}{3.7 D_3} + \frac{5.74}{\text{Re}_3^{0.9}} \right)^2} \quad f_3 = 0.047 \]  
(Ref. 4, A7)
Resistance Coefficients for 2" Pipe

L.R. Bends
Qty = 3

\[ K_1 = (14 \cdot f_{12}) \cdot 3 \]
\[ K_1 = 0.798 \]  
(Ref. 1, A2)

Purex Connectors
Qty = 2

\[ K_2 = (60 \cdot f_{12}) \cdot 2 \]
\[ K_2 = 2.28 \]  
(Ref. 1, A2)

Inside Diameter of 2" Sch 40 Pipe (in)

\[ D = 2.067 \]

3 Way Ball Valves (Branch)
Qty = 1

\[ K_3 = \left( \frac{891 \cdot D^4}{C_v \cdot t_2^2} \right) \cdot 1 \]
\[ K_3 = 0.525 \]  
(Ref. 1, A3)

3" x 2" Contraction
Assume \( \theta = 60^\circ \)

\[ \frac{D_2}{D_3} = 0.713 \]
\[ K_4 = 0.06 \]  
(Ref. 4, A8)

Approx. Length of 2" Sch 40 Pipe

\[ L_2 = 7 \text{ ft} \]  
(Ref. 8, A16)

\[ K_5 = f \cdot \frac{L_2}{D_2} \]
\[ K_5 = 1.731 \]

Sum of 2" Coefficient Resistance Factors

\[ K_2 = \sum_{i=1}^{5} K_i \]
\[ K_2 = 5.394 \]

Head Loss due to Friction in 2" Pipe

\[ h_{L,2} = \frac{V^2}{2 \cdot g} \cdot K_2 \]
\[ h_{L,2} = 1.916 \text{ ft} \]
Resistance Coefficients for 3" Pipe

Pipe Entrance

\[ K_1 = 0.78 \]  \hspace{1cm} \text{(Ref. 1, A2)}

Approx. Length of 3" Sch 80 Pipe

\[ L_3 = 47\text{-ft} \]  \hspace{1cm} \text{(Ref. 7, A15)}

\[ K_2 = f_3 \left( \frac{L_3}{D_3} \right) \]

\[ K_2 = 9.162 \]

Sum of 3" Coefficient Resistance Factors

\[ K_3 = \sum_{i=1}^{2} K_i \]

\[ K_3 = 9.942 \]

Head Loss due to Friction in 3" Pipe

\[ h_{L3} = \frac{V_3^2}{2g} \cdot K_3 \]

\[ h_{1.2} = 1.916\text{-ft} \]

Static Head

Approx. Elevation of Pump Discharge

\[ z_a = 0\text{-ft} \]  \hspace{1cm} \text{(Ref. 7, A15)}

Approx. Elevation of Pit Nozzle

\[ z_b = 47\text{-ft} + 5\text{-ft} \]

Single Pump Discharge Head at 50 GPM

Pump Discharge

\[ H_p = 78\text{-ft} \]  \hspace{1cm} \text{(Ref. 5, A13)}
Considering Bernoulli’s equation, \( P_a + \frac{1}{2} \rho V_a^2 + g z_a \) = \( P_b + \frac{1}{2} \rho V_b^2 + g z_b + \sum K V^2 g + h_o \), with position “a” located at the discharge of the annulus pump and position “b” located at the purex nozzle connecting the annulus jumper to the pit wall, we find the required pressure drop of the orifice to be:

\[
 h_o = (P_a - P_b) + (\frac{1}{2} \rho V_a^2 - \frac{1}{2} \rho V_b^2) + (z_a - z_b) - \sum K V^2 g
\]

or, with zero terms canceled out (P_b is atmospheric) and in terms of feet (\( P_a \) is the pressure head = \( H_p \), \( \sum K V^2 g \) is the friction head = \( h_L \), and \( h_o \) is the head loss due to the orifice):

\[
 h_o = H_p + (\frac{1}{2} \rho V_a^2 - \frac{1}{2} \rho V_b^2) + (z_a - z_b) - h_{L3} - h_{L2}
\]

**Required Head Loss of Orifice**

\[
 h_o = H_p + \left( \frac{V_a^2}{2g} - \frac{V_b^2}{2g} \right) - (z_a - z_b) = h_{L3} - h_{L2}
\]

\[
 h_o = 22.91 \text{ ft}
\]

**Assumed Flow Coefficient**

\[
 K := 0.65 \tag{Assumption 7}
\]

**Orifice Area**

\[
 A_o := \frac{Q}{K \cdot \frac{1}{2} \rho V_h o}
\]

\[
 A_o = 0.643 \text{ in}^2 \tag{Ref. 4, A9}
\]

**Diameter of Orifice**

\[
 d := \sqrt{\frac{A_o}{\pi}}
\]

\[
 d = 0.905 \text{ in}
\]

**Check Assumed Flow Coefficient**

**Ratio of Diameters**

\[
 \frac{d}{D_2} = 0.438 \tag{apply the Reynolds number of 3700 and the Ratio of Diameters to the graph on page A9 to find the Flow Coefficient}
\]

**Check of Flow Coefficient w/ Re = 3700**

\[
 K := 0.65 \tag{Ref. 4, A9}
\]

As seen by the graph (Ref. 4, A9) the Flow Coefficient, \( K \) is approximately equal to 0.65. Thus, the flow coefficient assumption and the orifice diameter are correct.
CALCULATION No: DSTAP-P-002, Rev. 0
APPENDIX A

References
"K" FACTOR TABLE—SHEET 1 of 4

Representative Resistance Coefficients (K) for Valves and Fittings

("K" is based on use of schedule pipe as listed on page 2-10)

PIECE FRICION DATA FOR CLEAN COMMERCIAL STEEL PIPE
WITH FLOW IN ZONE OF COMPLETE TURBULENCE

<table>
<thead>
<tr>
<th>Nominal Size</th>
<th>½&quot;</th>
<th>¾&quot;</th>
<th>1&quot;</th>
<th>1¼&quot;</th>
<th>1½&quot;</th>
<th>2&quot;</th>
<th>2½, 3&quot;</th>
<th>4&quot;</th>
<th>5&quot;</th>
<th>6&quot;</th>
<th>8-10&quot;</th>
<th>12-16&quot;</th>
<th>18-24&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Friction Factor (f₁)</td>
<td>.027</td>
<td>.023</td>
<td>.022</td>
<td>.021</td>
<td>.019</td>
<td>.018</td>
<td>.017</td>
<td>.016</td>
<td>.015</td>
<td>.014</td>
<td>.013</td>
<td>.012</td>
<td></td>
</tr>
</tbody>
</table>

FORMULAS FOR CALCULATING "K" FACTORS*
FOR VALVES AND FITTINGS WITH REDUCED PORT
(Ref: Pages 2-11 and 3-4)

- **Formula 1**
  \[ K_2 = \frac{0.8(\sin\frac{\theta}{2})(1 - \beta^2)}{\beta^3} \]

- **Formula 2**
  \[ K_2 = \frac{0.5(1 - \beta^2)\sqrt{\sin\frac{\theta}{2}}}{\beta} \]

- **Formula 3**
  \[ K_2 = \frac{2.6(\sin\frac{\theta}{2})(1 - \beta^2)^2}{\beta^3} \]

- **Formula 4**
  \[ K_2 = \frac{(1 - \beta^2)^3}{\beta^3} \]

- **Formula 5**
  \[ K_2 = \frac{K_1 + 0.5 \sqrt{\sin\frac{\theta}{2}}(1 - \beta^2) + (1 - \beta^2)^3}{\beta^3} \]

* Use "K" furnished by valve or fitting supplier when available.

### SUDDEN AND GRADUAL CONTRACTION

- **K₁** = Formula 1
- **K₂** = Formula 2

### SUDDEN AND GRADUAL ENLARGEMENT

- **K₁** = Formula 3
- **K₂** = Formula 4
"K" FACTOR TABLE—SHEET 4 of 4

Representative Resistance Coefficients (K) for Valves and Fittings
(for formulas and friction data, see page A-26)
("K" is based on use of schedule pipe as listed on page 2-10)

PLUG VALVES AND COCKS

STANDARD ELBOWS

MITRE BENDS

90° PIPE BENDS AND FLANGED OR BUTT-WELDING 90° ELBOWS

CLOSE PATTERN RETURN BENDS

<table>
<thead>
<tr>
<th>R/D</th>
<th>K</th>
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<tr>
<td>1</td>
<td>20</td>
</tr>
<tr>
<td>1.5</td>
<td>14</td>
</tr>
<tr>
<td>1.75</td>
<td>12</td>
</tr>
<tr>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>2.5</td>
<td>8</td>
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<td>6</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>6</td>
<td>2</td>
</tr>
</tbody>
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The resistance coefficient, \( K_n \), for pipe bends other than 90° may be determined as follows:

\[
K_n = (n-1) \left( 0.25 \frac{r}{d} + 0.5 K \right) + K
\]

where:
- \( n \) = number of 90° bends
- \( K \) = resistance coefficient for one 90° bend (per table)
Equivalents of Resistance Coefficient $K$
And Flow Coefficient $C_v$

Calc No: DSTAP-P-002, Rev. 0
Ref. 1 A3 of A19

$$K = \frac{891 \cdot d^4}{C_v^2}$$
$$C_v = \frac{29.9 \cdot d^2}{\sqrt{K}}$$

Problem: Find the flow coefficient $C_v$ for a 6-inch Class 125 cast iron globe valve with full area seat.

Solution:
$$K = 340 \cdot f_r$$  
$$f_r = 0.015$$
$$K = 340 \times 0.15 = 51$$
$$C_v = 490$$

dotted lines on chart
I forgot the criteria on Flammable Gas Controls and pressure.

In our recent meetings on annulus pumping, it was apparent that the pumping specifications previously provided were not adequate. I’m currently in the process of developing a technical rational for the Pump Design Criteria. The following is a draft of the criteria. Let me know if there are any questions or concerns.

Submersible Centrifugal

- **Total Flow**: 50 - 300 gpm
- **SpG**: 1.0 - 1.47
- **Viscosity**: 1.0 - 30 centipoise
- **Solids**: 0 - 20 Volume %
- **Temperature**: 65 - 140 F
- **Discharge Pressure**: 230 maximum
- **Flammable Gas Controls**: Ignition Source Control Set #1 (Class 1 Division 1 Group B or equivalent)
- **Waste Flow**: 33 - 200 gpm
- **Dilution water Flow**: 17 - 100 gpm

*The maximum flow rate of 300 gpm is based on an accident in the Tank Farm FSAR 3.4.2.7 Surface Leak Resulting in a Pool.

** Maximum design pressure for transfer lines in SY Farm (Spec B-101-C3) and A & AX Farms (Spec B-102-C1)

*** Mineral insulated Cable meets requirements for equivalency. Series 300 stainless is acceptable as non-sparking.

**** The dilution water flow may be required to be as high as 50% of the waste flow. It’s recognized that design constraints may prevent reaching dilution water flows above 40 gpm. In this case throttling existing waste line valves will be used to set the proper dilution. The design constraints anticipated are water supply pressure, pressure drop through hose connections, and the limiting pipe diameter that can be coupled with the pump assemblies.

Heel Pump

- **Total Flow**: 2 - 5 gpm
- **SpG**: 1.0 - 1.47
- **Viscosity**: 1.0 - 30 centipoise
Solids: 0 - 20 Volume %
Temperature: 65 - 140°F
Discharge Pressure: 230 maximum
Flammable Gas Controls: Ignition Source Control Set #1 (Class 1 Division 1 Group B or equivalent)
Dilution water Flow: None Required

Note: It is assumed that the heel pump will be used just to remove the last few inches of liquid from the annulus. Repeated water flushes of the annulus may be performed to remove the residual radioactive components. So it is anticipated that the actual solution SpG will probably be significantly lower than the maximum stated above.

* Maximum design pressure for transfer lines in SY Farm (Spec B-101-C3) and A & AX Farms (Spec B-102-C1)

** Mineral insulated Cable meets requirements for equivalency. Series 300 stainless is acceptable as non-sparking.
Dorsh, Paul M

From: Rang, Bradley K
Sent: Wednesday, March 15, 2000 11:39 AM
To: Hauck, Frank M (Marshall)
Cc: Dorsh, Paul M
Subject: RE: 50 gpm flow limit in AY & AZ Tank Farms for Annulus pumps

Yes, I sent an email to Dan and he agreed. Copy was forwarded to Contracts.

bkr

-----Original Message-----
From: Hauck, Frank M (Marshall)
Sent: Wednesday, March 15, 2000 11:17 AM
To: Rang, Bradley K
Cc: Dorsh, Paul M
Subject: FW: 50 gpm flow limit in AY & AZ Tank Farms for Annulus pumps

Bradley,

Can we proceed with the design of this orifice, ie is it now in the "scope of supply"?

Marshall

-----Original Message-----
From: Reberger, Dan W
Sent: Wednesday, March 15, 2000 10:59 AM
To: Hauck, Frank M (Marshall)
Cc: Dorsh, Paul M; Rang, Bradley K
Subject: 50 gpm flow limit in AY & AZ Tank Farms for Annulus pumps

Marshall,

The flow restriction of 50 gpm for annulus pumping applies to transfer lines from Tanks 101-AY, 102-AY and 102-AZ. The transfer lines from these three tanks are direct buried and the flow rate must be lower than 50gpm. The flow should be calculated at the pipe position just outside the annulus pump pit. If a breach in the pipe at the outside pit wall were to occur, the breached flow should not exceed 50 gpm.

Call me if you have any questions.
Colebrook–White formula, from which the Moody diagram was developed, Swamee and Jain (39) developed explicit formulas relating \( f \), \( h_f \), \( Q \), and \( D \). It is reported that their formulas yield results that deviate no more than 3% from those obtained from the Moody diagram for the following ranges of \( k_s/D \) and \( Re \):

\[
10^{-5} < k_s/D < 2 \times 10^{-2} \quad \text{and} \quad 4 \times 10^3 < Re < 10^6.
\]

The formulas for \( f \) and \( Q \) are

\[
f = \frac{0.25 \left( \frac{k_s}{3.7D} + \frac{5.74}{Re^{0.8}} \right)^2}{\log \left( \frac{k_s}{3.7D} + \frac{5.74}{Re^{0.8}} \right)} \quad \text{(10.26)}
\]

\[
Q = -2.22 D^{5/2} \sqrt{gh_f/L} \log \left( \frac{k_s}{3.7D} + \frac{1.78 \nu}{D^{5/2} \sqrt{gh_f/L}} \right) \quad \text{(10.27)}
\]

They also developed a formula for the explicit determination of \( D \). A modified version of that formula, given by Streeter and Wylie (38), is

\[
D = 0.66 \left[ k_s^{1.25} \left( \frac{LQ}{gh_f} \right)^{4.75} + \nu Q^{0.4} \left( \frac{L}{gh_f} \right)^{1.27} \right]^{0.94} \quad \text{(10.28)}
\]

If you want to solve for head loss given \( Q \), \( L \), \( D \), \( k_s \), and \( \nu \), simply solve for \( f \) by Eq. (10.26) and compute \( h_f \) with the Darcy–Weisbach equation, Eq. (10.22). Straightforward calculations for \( Q \) and \( D \) can also be made if \( h_f \) is known. However, for problems involving head losses in addition to \( h_f \), an iterative solution is required. For computing \( Q \), you can assume an \( f \) and solve for \( Q \) from the energy equation after substituting \( Q/A \) in that equation. Then compute \( Re \) and use the result in Eq. (10.26) to get a better estimate of \( f \), and so on, until \( Q \) converges analogous to the procedure for determining \( Q \) using the Moody diagram. In this case, however, Eq. (10.26) is substituted for the Moody diagram. Similarly, you can determine \( D \) if you are given \( Q \), \( \nu \), the change in pressure or head, and the geometric configuration.

### Example 10.8

Solve Example 10.5 using Eq. (10.27).

**Solution** From Fig. 10.8, \( k_s \) for asphalted cast-iron pipe is given as \( 1.2 \times 10^{-4} \) m. From the given conditions, \( h_f/L = 0.0122 \). Assume \( T = 20^\circ C \), so \( \nu = 10^{-6} \text{ m}^2/\text{s} \). Then, using Eq. (10.27), we have

\[
Q = -2.22(0.20 \text{ m})^{5/2} \sqrt{9.81 \text{ m/s}^2 \times 0.0122} \\
\times \log \left( \frac{1.2 \times 10^{-4} \text{ m}}{3.7 \times 0.20 \text{ m}} + \frac{1.78 \times 10^{-6} \text{ m}^3/\text{s}}{(0.20 \text{ m})^{5/2} \sqrt{9.81 \text{ m/s}^2 \times 0.0122}} \right)
\]

\[
= 0.050 \text{ m}^3/\text{s}
\]
## TABLE 10.2 LOSS COEFFICIENTS FOR VARIOUS TRANSITIONS AND FITTINGS

<table>
<thead>
<tr>
<th>Description</th>
<th>Sketch</th>
<th>Additional Data</th>
<th>$K$</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pipe entrance</td>
<td><img src="image" alt="Sketch" /></td>
<td>$r/d$</td>
<td>$K_e$</td>
<td>(2)*</td>
</tr>
<tr>
<td>$h_L = K_e V^2/2g$</td>
<td><img src="image" alt="Sketch" /></td>
<td>$d$</td>
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<td>$0.50$</td>
</tr>
<tr>
<td></td>
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<td>$0.1$</td>
<td>$0.12$</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>$&gt;0.2$</td>
<td>$0.03$</td>
<td></td>
</tr>
<tr>
<td>Contraction</td>
<td><img src="image" alt="Sketch" /></td>
<td>$D_2/D_1$</td>
<td>$K_C$</td>
<td>(2)</td>
</tr>
<tr>
<td>$h_L = K_C V^2/2g$</td>
<td><img src="image" alt="Sketch" /></td>
<td>$\theta = 60^\circ$</td>
<td>$0.08$</td>
<td>$0.50$</td>
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<tr>
<td></td>
<td><img src="image" alt="Sketch" /></td>
<td>$\theta = 180^\circ$</td>
<td>$0.08$</td>
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<tr>
<td></td>
<td><img src="image" alt="Sketch" /></td>
<td>$0.20$</td>
<td>$0.42$</td>
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</tr>
<tr>
<td></td>
<td><img src="image" alt="Sketch" /></td>
<td>$0.40$</td>
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<td></td>
</tr>
<tr>
<td></td>
<td><img src="image" alt="Sketch" /></td>
<td>$0.80$</td>
<td>$0.20$</td>
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<tr>
<td></td>
<td><img src="image" alt="Sketch" /></td>
<td>$0.90$</td>
<td>$0.10$</td>
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<tr>
<td>Expansion</td>
<td><img src="image" alt="Sketch" /></td>
<td>$D_1/D_2$</td>
<td>$K_E$</td>
<td>(2)</td>
</tr>
<tr>
<td>$h_L = K_E V^2/2g$</td>
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<td>$\theta = 20^\circ$</td>
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<td><img src="image" alt="Sketch" /></td>
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<td>$0.25$</td>
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<td></td>
<td><img src="image" alt="Sketch" /></td>
<td>$0.60$</td>
<td>$0.41$</td>
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<tr>
<td></td>
<td><img src="image" alt="Sketch" /></td>
<td>$0.80$</td>
<td>$0.15$</td>
<td></td>
</tr>
<tr>
<td>90° miter bend</td>
<td><img src="image" alt="Sketch" /></td>
<td>Without vanes</td>
<td>$K_b = 1.1$</td>
<td>(37)</td>
</tr>
<tr>
<td></td>
<td><img src="image" alt="Sketch" /></td>
<td>With vanes</td>
<td>$K_b = 0.2$</td>
<td>(37)</td>
</tr>
<tr>
<td>90° smooth bend</td>
<td><img src="image" alt="Sketch" /></td>
<td>$r/d$</td>
<td>$K_b = 0.35$</td>
<td>(5) and (19)</td>
</tr>
<tr>
<td></td>
<td><img src="image" alt="Sketch" /></td>
<td>$2$</td>
<td>$0.19$</td>
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</tr>
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<td><img src="image" alt="Sketch" /></td>
<td>$4$</td>
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<td></td>
<td><img src="image" alt="Sketch" /></td>
<td>$6$</td>
<td>$0.21$</td>
<td></td>
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<td></td>
<td><img src="image" alt="Sketch" /></td>
<td>$10$</td>
<td>$0.32$</td>
<td></td>
</tr>
<tr>
<td>Globe valve—wide open</td>
<td>$K_e = 10.0$</td>
<td>(37)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Angle valve—wide open</td>
<td>$K_e = 5.0$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gate valve—wide open</td>
<td>$K_e = 0.2$</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Gate valve—half open</td>
<td>$K_e = 5.6$</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Return bend</td>
<td>$K_b = 2.2$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Straight-through flow</td>
<td>$K_e = 0.4$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Side-outlet flow</td>
<td>$K_e = 1.8$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>90° elbow</td>
<td>$K_b = 0.9$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>45° elbow</td>
<td>$K_b = 0.4$</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

If $\Delta h$ is defined as $h_1 - h_2$, then the final form of the discharge equation for an orifice reduces to

$$Q = KA_0 \sqrt{2g \Delta h} \quad (13.3a)$$

If a differential pressure transducer is connected across the orifice, it will sense a pressure change, which is equivalent to $\gamma \Delta h$ so the discharge equation becomes

$$Q = KA_0 \sqrt{2 \frac{\Delta \rho}{\rho}} \quad (13.3b)$$

Experimentally determined values of $K$ as a function of $d/D$ and Reynolds number based on orifice size are given in Fig. 13.13. If $Q$ is given, $Re_d$ is equal to

---

**Fig. 13.13**

Coefficient $K$ and $Re_d$ versus the Reynolds number for orifices, nozzles, and Venturi meters. [After (20) and ASME (1)].
### TABLE A.5 APPROXIMATE PHYSICAL PROPERTIES OF WATER* AT
### ATMOSPHERIC PRESSURE

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Density</th>
<th>Specific</th>
<th>Dynamic</th>
<th>Kinematic</th>
<th>Vapor</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>kg/m³</td>
<td>N/m³</td>
<td>N*s/m³</td>
<td>m²/s</td>
<td>N/m² abs.</td>
</tr>
<tr>
<td>0°C</td>
<td>1000</td>
<td>9810</td>
<td>1.79 × 10⁻³</td>
<td>1.79 × 10⁻⁶</td>
<td>611</td>
</tr>
<tr>
<td>5°C</td>
<td>1000</td>
<td>9810</td>
<td>1.51 × 10⁻³</td>
<td>1.51 × 10⁻⁶</td>
<td>872</td>
</tr>
<tr>
<td>10°C</td>
<td>1000</td>
<td>9810</td>
<td>1.31 × 10⁻³</td>
<td>1.31 × 10⁻⁶</td>
<td>1230</td>
</tr>
<tr>
<td>15°C</td>
<td>999</td>
<td>9800</td>
<td>1.14 × 10⁻³</td>
<td>1.14 × 10⁻⁶</td>
<td>1700</td>
</tr>
<tr>
<td>20°C</td>
<td>998</td>
<td>9790</td>
<td>1.00 × 10⁻³</td>
<td>1.00 × 10⁻⁶</td>
<td>2340</td>
</tr>
<tr>
<td>25°C</td>
<td>997</td>
<td>9781</td>
<td>8.94 × 10⁻⁴</td>
<td>8.94 × 10⁻⁷</td>
<td>3170</td>
</tr>
<tr>
<td>30°C</td>
<td>996</td>
<td>9771</td>
<td>7.97 × 10⁻⁴</td>
<td>7.97 × 10⁻⁷</td>
<td>4250</td>
</tr>
<tr>
<td>35°C</td>
<td>994</td>
<td>9751</td>
<td>7.20 × 10⁻⁴</td>
<td>7.20 × 10⁻⁷</td>
<td>5630</td>
</tr>
<tr>
<td>40°C</td>
<td>992</td>
<td>9732</td>
<td>6.53 × 10⁻⁴</td>
<td>6.53 × 10⁻⁷</td>
<td>7380</td>
</tr>
<tr>
<td>50°C</td>
<td>988</td>
<td>9693</td>
<td>5.47 × 10⁻⁴</td>
<td>5.47 × 10⁻⁷</td>
<td>12,300</td>
</tr>
<tr>
<td>60°C</td>
<td>983</td>
<td>9643</td>
<td>4.66 × 10⁻⁴</td>
<td>4.66 × 10⁻⁷</td>
<td>20,000</td>
</tr>
<tr>
<td>70°C</td>
<td>978</td>
<td>9594</td>
<td>4.04 × 10⁻⁴</td>
<td>4.04 × 10⁻⁷</td>
<td>31,200</td>
</tr>
<tr>
<td>80°C</td>
<td>972</td>
<td>9535</td>
<td>3.54 × 10⁻⁴</td>
<td>3.54 × 10⁻⁷</td>
<td>47,400</td>
</tr>
<tr>
<td>90°C</td>
<td>965</td>
<td>9467</td>
<td>3.15 × 10⁻⁴</td>
<td>3.15 × 10⁻⁷</td>
<td>70,100</td>
</tr>
<tr>
<td>100°C</td>
<td>958</td>
<td>9398</td>
<td>2.82 × 10⁻⁴</td>
<td>2.82 × 10⁻⁷</td>
<td>101,300</td>
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</table>

<table>
<thead>
<tr>
<th>Temperature</th>
<th>slugs/ft³</th>
<th>lb/ft³</th>
<th>lb·s/ft²</th>
<th>ft²/s</th>
<th>psia</th>
</tr>
</thead>
<tbody>
<tr>
<td>40°F</td>
<td>1.94</td>
<td>62.43</td>
<td>3.23 × 10⁻⁵</td>
<td>1.66 × 10⁻⁵</td>
<td>0.122</td>
</tr>
<tr>
<td>50°F</td>
<td>1.94</td>
<td>62.40</td>
<td>2.73 × 10⁻⁵</td>
<td>1.41 × 10⁻⁵</td>
<td>0.178</td>
</tr>
<tr>
<td>60°F</td>
<td>1.94</td>
<td>62.37</td>
<td>2.36 × 10⁻⁵</td>
<td>1.22 × 10⁻⁵</td>
<td>0.256</td>
</tr>
<tr>
<td>70°F</td>
<td>1.94</td>
<td>62.30</td>
<td>2.05 × 10⁻⁵</td>
<td>1.06 × 10⁻⁵</td>
<td>0.363</td>
</tr>
<tr>
<td>80°F</td>
<td>1.93</td>
<td>62.22</td>
<td>1.80 × 10⁻⁵</td>
<td>0.930 × 10⁻⁵</td>
<td>0.506</td>
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<tr>
<td>100°F</td>
<td>1.93</td>
<td>62.00</td>
<td>1.42 × 10⁻⁵</td>
<td>0.739 × 10⁻⁵</td>
<td>0.949</td>
</tr>
<tr>
<td>120°F</td>
<td>1.92</td>
<td>61.72</td>
<td>1.17 × 10⁻⁵</td>
<td>0.609 × 10⁻⁵</td>
<td>1.69</td>
</tr>
<tr>
<td>140°F</td>
<td>1.91</td>
<td>61.38</td>
<td>0.981 × 10⁻⁵</td>
<td>0.514 × 10⁻⁵</td>
<td>2.89</td>
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<tr>
<td>160°F</td>
<td>1.90</td>
<td>61.00</td>
<td>0.838 × 10⁻⁵</td>
<td>0.442 × 10⁻⁵</td>
<td>4.74</td>
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<tr>
<td>180°F</td>
<td>1.88</td>
<td>60.58</td>
<td>0.726 × 10⁻⁵</td>
<td>0.385 × 10⁻⁵</td>
<td>7.51</td>
</tr>
<tr>
<td>200°F</td>
<td>1.87</td>
<td>60.12</td>
<td>0.637 × 10⁻⁵</td>
<td>0.341 × 10⁻⁵</td>
<td>11.53</td>
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<tr>
<td>212°F</td>
<td>1.86</td>
<td>59.83</td>
<td>0.593 × 10⁻⁵</td>
<td>0.319 × 10⁻⁵</td>
<td>14.70</td>
</tr>
</tbody>
</table>

*Notes: (1) Bulk modulus Ε, of water is approximately 2.2 GPa (3.2 × 10⁶ psi); (2) Water-air surface tension is approximately 7.3 × 10⁻² N/m (5 × 10⁻³ lbf/ft) from 10°C to 50°C.

10.9

Roughness for kinds of pipe. (29).

With roughness from the
Eventually laminar but then changed from laminar to turbulent flow at a Reynolds number in the neighborhood of 2100. However, Reynolds found that if the fluid was initially completely motionless and if there was no vibration in the equipment while the flow was increased, it was possible to reach a much higher Reynolds number before the flow became turbulent. He also found that, when going from high-velocity turbulent flow to low-velocity flow, the change from turbulent flow always occurred at a Reynolds number of about 2000.

These experiments of Reynolds indicate that under carefully controlled conditions it is possible to have laminar flow in pipes at Reynolds numbers much higher than 2000. However, the slightest disturbances will trigger the onset of turbulence at high values of Re. Because most engineering applications involve some vibration or flow disturbance, it is reasonable to expect that pipe flow will be laminar for Reynolds numbers less than 2000 and turbulent for Reynolds numbers greater than 3000. When Re is between 2000 and 3000, the type of flow is very unpredictable and often changes back and forth between laminar and turbulent states. Fortunately, however, most engineering applications either are not in this range or are not significantly affected by the unstable flow.

**EXAMPLE 10.2** Oil (S = 0.85) with a kinematic viscosity of $6 \times 10^{-4}$ m$^2$/s flows in a 15-cm pipe at a rate of 0.020 m$^3$/s. What is the head loss per 100 m of length of pipe?

**Solution** First we determine whether the flow is laminar or turbulent by checking to see if the Reynolds number is below 2000 or above 3000.

\[
V = \frac{Q}{A} = \frac{0.020 \text{ m}^3/\text{s}}{\left(\pi/4\right)D^2 \text{ m}^2} = \frac{0.020 \text{ m}^3/\text{s}}{0.785(0.15^2 \text{ m}^2)} = 1.13 \text{ m/s}
\]

Then

\[
Re = \frac{VD}{\nu} = \frac{(1.13 \text{ m/s})(0.15 \text{ m})}{6 \times 10^{-4} \text{ m}^3/\text{s}} = 283
\]

Since the Reynolds number is less than 2000, the flow is laminar. The head loss per 100 m is obtained from Eq. (10.17):

\[
h_f = \frac{32\mu LV}{gD^2}
\]

Here $\mu/\gamma = \nu/\rho$; hence

\[
h_f = \frac{32\rho LV}{gD^2}
\]

Then

\[
h_f = \frac{32(6)(10^{-4} \text{ m}^2/\text{s})(100 \text{ m})(1.13 \text{ m/s})}{(9.81 \text{ m/s}^2)(0.15^2 \text{ m}^2)} = 9.83 \text{ m}
\]

The head loss is 9.83 m/100 m of length.
From Flygt BS-2060.390 Performance Data, at 50 GPM the discharge pressure is 78 feet.
C_v FACTORS — MP/MI 70-80 SERIES

C_v is defined as the number of U.S. gallons of water per minute of ambient temperature water that will flow through a valve at 1 psi pressure drop.

MP 70-80 SERIES C_v FACTORS (MEASURED IN GPM)

<table>
<thead>
<tr>
<th>Valve Size</th>
<th>C_p</th>
<th>C_v (GPM)</th>
<th>C_f</th>
<th>C_t</th>
<th>C_f</th>
<th>C_v (GPM)</th>
<th>C_f</th>
<th>C_t</th>
<th>C_f</th>
</tr>
</thead>
<tbody>
<tr>
<td>MP-72</td>
<td>1/2&quot;</td>
<td>.62&quot;</td>
<td>12</td>
<td>14</td>
<td>9</td>
<td>12</td>
<td>12</td>
<td>14</td>
<td>9</td>
</tr>
<tr>
<td>MP-73</td>
<td>3/4&quot;</td>
<td>.75&quot;</td>
<td>12</td>
<td>14</td>
<td>9</td>
<td>12</td>
<td>12</td>
<td>14</td>
<td>9</td>
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<td>33</td>
<td>38</td>
<td>24</td>
<td>29</td>
<td>33</td>
<td>38</td>
<td>24</td>
</tr>
<tr>
<td>MP-75</td>
<td>1-1/4&quot;</td>
<td>1.00&quot;</td>
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<td>36</td>
<td>24</td>
<td>27</td>
<td>31</td>
<td>36</td>
<td>24</td>
</tr>
<tr>
<td>MP-76</td>
<td>1-1/2&quot;</td>
<td>1.50&quot;</td>
<td>78</td>
<td>93</td>
<td>58</td>
<td>67</td>
<td>78</td>
<td>93</td>
<td>58</td>
</tr>
<tr>
<td>MP-77</td>
<td>2&quot;</td>
<td>2.00&quot;</td>
<td>148</td>
<td>176</td>
<td>108</td>
<td>124</td>
<td>148</td>
<td>176</td>
<td>108</td>
</tr>
<tr>
<td>MP-79</td>
<td>3&quot;</td>
<td>3.00&quot;</td>
<td>380</td>
<td>460</td>
<td>270</td>
<td>300</td>
<td>380</td>
<td>460</td>
<td>270</td>
</tr>
<tr>
<td>MP-80</td>
<td>4&quot;</td>
<td>4.00&quot;</td>
<td>680</td>
<td>820</td>
<td>490</td>
<td>530</td>
<td>680</td>
<td>820</td>
<td>490</td>
</tr>
<tr>
<td>MP-42</td>
<td>6&quot;</td>
<td>6.00&quot;</td>
<td>1541</td>
<td>1851</td>
<td>1111</td>
<td>1210</td>
<td>1541</td>
<td>1851</td>
<td>1111</td>
</tr>
</tbody>
</table>

NOTES:
1. Most values represent MP Series valves with 150# flanged end fittings.
2. MP Series valves with Female NPT end fittings.
3. Flanged end fittings are not available for MP-72 (1-1/4").
4. 1-1/4" and double angle port are not full-port design.

MI 70-80 SERIES C_v FACTORS (MEASURED IN GPM)

<table>
<thead>
<tr>
<th>Valve Size</th>
<th>C_p</th>
<th>C_v (GPM)</th>
<th>C_f</th>
<th>C_t</th>
<th>C_f</th>
<th>C_v (GPM)</th>
<th>C_f</th>
<th>C_t</th>
<th>C_f</th>
</tr>
</thead>
<tbody>
<tr>
<td>MI-72</td>
<td>1/2&quot;</td>
<td>0.37&quot;</td>
<td>3.5</td>
<td>5.3</td>
<td>3.0</td>
<td>3.5</td>
<td>2.9</td>
<td>3.7</td>
<td>2.6</td>
</tr>
<tr>
<td>MI-73</td>
<td>3/4&quot;</td>
<td>0.62&quot;</td>
<td>11</td>
<td>16</td>
<td>9.2</td>
<td>11</td>
<td>8.8</td>
<td>11</td>
<td>8.0</td>
</tr>
<tr>
<td>MI-74</td>
<td>1&quot;</td>
<td>0.87&quot;</td>
<td>22</td>
<td>33</td>
<td>16</td>
<td>22</td>
<td>18</td>
<td>23</td>
<td>17</td>
</tr>
<tr>
<td>MI-76</td>
<td>1-1/2&quot;</td>
<td>1.37&quot;</td>
<td>56</td>
<td>85</td>
<td>49</td>
<td>56</td>
<td>47</td>
<td>60</td>
<td>42</td>
</tr>
<tr>
<td>MI-77</td>
<td>2&quot;</td>
<td>1.87&quot;</td>
<td>110</td>
<td>160</td>
<td>93</td>
<td>110</td>
<td>90</td>
<td>110</td>
<td>79</td>
</tr>
<tr>
<td>MI-79</td>
<td>3&quot;</td>
<td>2.87&quot;</td>
<td>270</td>
<td>410</td>
<td>240</td>
<td>270</td>
<td>230</td>
<td>290</td>
<td>210</td>
</tr>
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<td>MI-80</td>
<td>4&quot;</td>
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<td>500</td>
<td>760</td>
<td>440</td>
<td>500</td>
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<td>540</td>
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<td>MI-42</td>
<td>6&quot;</td>
<td>Consult PBM</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

NOTES:
1. 6" and double angle port are not True-Bore design.

VACUUM AND CYCLE TESTS — MP/MI 70-80 SERIES

Vacuum Testing
PBM valves excel under vacuum conditions as well as under pressure conditions. Typical test results showing helium leakage at 10^-7 Torr are provided.

<table>
<thead>
<tr>
<th>Valve Size</th>
<th>PBM Code</th>
<th>Body Leakage (cc/sec)</th>
<th>Seat Leakage (cc/sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2&quot;</td>
<td>MPH-77-F152/POC1</td>
<td>1.8 x 10^-7</td>
<td>3.4 x 10^-7</td>
</tr>
<tr>
<td>2&quot;</td>
<td>MIH-77-TT3/POC1</td>
<td>3 x 10^-7</td>
<td>1 x 10^-7</td>
</tr>
</tbody>
</table>

Cycle Testing
The life of a ball valve is dependent upon service conditions and, therefore, impossible to predict. However, PBM cycle-tests valves using 100 psid of ambient temperature water pressure across the seats with the valve in the closed position. These test conditions represent a typical wear-causing force on the seats and packings. PBM also tests valves in a steam environment up to 380°F.

Replacement of valve gaskets or O-rings is recommended at each disassembly. Replacement of other non-moving parts is dictated only by the corrosion caused by the flow media. In most applications, PBM ball valves will operate trouble-free for many years.
12" RISER NOZZLE (11.937" I.D.)

SUBMERSIBLE PL

FLANGE SET-

1 0 5/16"
Objective:
This task order is to authorize Fluor Daniel Northwest to provide engineering support for identifying, supporting procurement, testing, and final design of a pump assembly for waste removal in the Double-Shell Tank Annulus.

Background/Introduction:
The objective is to provide a combination of two pumps capable of high flow removal of waste for the DST Annulus, and removal of the heel to the extent possible. The pumping scheme should follow that addressed in an ARES Report Number 9905303-001, March 1999, “Double-Shell Tank Annulus Pumping Alternative Evaluation” unless changed with LMHC concurrence. A spare pumping system will also be procured. These activities support Tasks 19DAPB “Prepare Procurement Specification & Procure Pump” and 19DAPC “Design, Procure, Fabricate, Receive & Store Jumpers & Pump Assemblies” of the schedule attached to correspondence LMHC-9954506R2 October 25, 1999.

Scope:
This Task Order allows Fluor Daniel Northwest to perform, as required, the following minimum activities:

- **Task 19DAPB**
  1. Review of piping system and prepare preliminary design (6 DST Farms transferring to 106-AP)
  2. Prepare procurement specification for pumps
  3. Support procurement activities
  4. Evaluate bids, and select vendor
  5. Prepare acceptance test procedure
  6. Evaluate run-in data for the tested pumps
  7. Develop Certified Vendor Information File

- **Task 19DAPC**
  8. Final design of pump assemblies and farm specific flanges
  9. Fabrication support of pump assemblies
  10. Identification of common spare jumper parts
  11. Prepare spare parts list

References:
Piping pressure drop calculations for the Cross-site transfer route to AP Tank Farm have been documented in Project W-058 files in calculation numbers W058-P-044 and 048. Schematics with transfer line lengths have been developed for most tank farm routings to AP farm and can be found in the Emergency Transfer procedures TO-001-181, 182, 183, 184 and TO-430-500 as excavation schematics.

Deliverables:
Design drawings, procurement specification, acceptance test procedure all prepared in accordance with LMHC approved procedures.

Acceptance Criteria:
Documentation with the appropriate LMHC and FDNW approvals as established in current procedures.

Period of Performance:
Activities associated with this SOW are expected to be initiated as soon as possible after receipt of the Task Order, with completion on or before April 11, 2000 for Task 19DAPB and June 2, 2000 for Task 19DAPC.

Technical Point of Contact:
The following personnel are assigned as liaison with Fluor Daniel Northwest for the scope of work described:

- Technical Contact: D. W Reberger, LMHC, Double Shell Tank Engineering
- Administrative Contact: A. B. Johnson, L.K. Martin LMHC, Financial Control
- Project Engineer: S. J. Lepka, LMHC, Operational Configuration Management
Applicable ES&H requirements:
Standard ES&H requirements (without ISMS) are warranted for this work.

Safety Requirements:
N/A

Requirements (Including Quality Assurance Requirements):
The subcontractor is subject to Title 10, Code of Federal Regulations, Part 830.120 (10 CFR 830.120), Quality Assurance Requirements, and the enforcement actions under 10 CFR 820, General Statement of Enforcement Policy.

Hold Points:
N/A

Configuration Management Requirements:
N/A

Work Location/Potential Access Requirements:
N/A

Training:
N/A

Qualifications:
Degreed Engineering support as required.

Special Requirements:
N/A

Reporting/Administration:
Status Meetings will be as requested by LMHC or FDNW. Any documentation computer files such as Supporting Documents will be prepared in Word Perfect or Microsoft Word.
This sheet shows the status and description of the attached Design Analysis sheets

**Discipline:** 454  **Project/Area/Unit:** 65100541/25/9  **Calculation No.:** DSTAP-P-003

**Project No. & Name:** Double Shell Tank Annulus Pumping

**Calculation Item:** DST Annulus Pump Transfer Line Pressure

These calculations apply to:

- **Drawing No.:** N/A  
- **Drawing 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  [X] No

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

**Original and Revised Calculation Approvals:**

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**INDEX**

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<th>Design Analysis Page No.</th>
<th>Description</th>
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<td>1</td>
<td>Objective, Design Input, Assumptions, Methods, References, Conclusions</td>
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<tr>
<td>2</td>
<td>Calculation</td>
</tr>
<tr>
<td>Appendix A</td>
<td>Attached References</td>
</tr>
<tr>
<td>A1</td>
<td>Dayton Air Compressor Cut-Sheet</td>
</tr>
<tr>
<td>A2</td>
<td>E-mail consisting of Design Parameters</td>
</tr>
<tr>
<td>A3</td>
<td>Instrumentation Northwest, Inc. Hydrostar System Air Motors</td>
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OBJECTIVE:
The objective of this calculation is to determine if the Hydrostar air motor/pump can pressurize a transfer line above its design pressure. An obstruction in the transfer line could prevent a flow of fluid. This would create a closed system in which the pressure in the air motor could be amplified and transmitted to the transfer line. The maximum design pressure of the lines is 230 psi. If the operating pressure exceeds the maximum design pressure, a pressure relief valve may be required to protect the transfer lines.

DESIGN INPUT:
1.) The design pressure of the piping is 230 psi. (Ref. 2, A2)
2.) The maximum air pressure produced by the air compressor is 135 psi. (Ref. 1, A1)
3.) A 2" air motor was recommended for use by the pump manufacturer. (Ref. 3, A3)
4.) The pump piston diameter is 1.5".

ASSUMPTIONS:
1.) The air compressor is able to pressurize the air motor to 135 psi.
2.) There is no "blow-by" of air past the piston seals used in the air motor.
3.) There is no "blow-by" of fluid past the piston seals used in the pump.

METHODS:
1.) Calculations are performed using Mathcad 6.0

The Hydrostar pump is a positive displacement, piston driven pump. The piston in the pump is driven by a rod, which is actuated by an air operated motor. The air motor cylinder is pressurized, causing the piston to move. The force of the motor piston is transferred to the actuating rod. The rod transmits the force to the piston in the pump. The force moves the pump piston, which positively displaces fluid. By fluid static principles of a closed system, a pressure change produced at one point in the system will be transmitted throughout the entire system. Thus, the pressure produced at the pump piston will be transmitted throughout the entire transfer line.

REFERENCES:
1.) Dayton Air Compressor cut-sheet, from Grainger 1995 General Catalog No. 386.
2.) E-mail dated 1/25/00 from Dan Reberger to Marshall Hauck consisting of Revised Design Criteria.
3.) Instrumentation Northwest, Inc. Hydrostar System Air Motors

CONCLUSION:
There is a possibility that the air motor can pressurize the transfer line to 240 psi. This is above the design pressure of 230 psi. A pressure relief valve should be installed in the piping.
DESIGN ANALYSIS

CALCULATION:

Air Motor Piston Diameter
\[ D_m = 2.0 \text{ in} \]

Air Motor Piston Surface Area
\[ A_m = D_m^2 \frac{\pi}{4} \]
\[ A_m = 3.142 \text{ in}^2 \]

Max Pressure Induced in Air Motor
\[ P_m = 135 \text{ psi} \]

Max Lifting Force of Air Motor / Rod
\[ F = P_m A_m \]
\[ F = 424.1 \text{ lb} \]

Pump Piston Diameter
\[ D_p = 1.5 \text{ in} \]

Pump Piston Surface Area
\[ A_p = D_p^2 \frac{\pi}{4} \]
\[ A_p = 1.767 \text{ in}^2 \]

Pump Piston Pressure
\[ P_p = \frac{F}{A_p} \]
\[ P_p = 240 \text{ psi} \]
CALCULATION NO: DSTAP-P-003, Rev. 0
APPENDIX A

References
EXCLUSIVE DAYTON DESIGN RELIABLY POWERS AIR TOOLS, PAINT SPRAYERS, SANDBLAST EQUIPMENT, AIR CYLINDERS, AND SMALL MACHINES

THE DAYTON CAST IRON DIFFERENCE
- Longer life—up to 100% longer than comparable air compressors
- Higher Air Flow—Up to 10% more CFM than comparable models
- Higher Pressure—Maximum 135 PSI for a broader range of application
- Higher Duty Cycle—Runs up to a 65% duty cycle vs. the standard 50/50 duty cycle

TANK MOUNT MODELS INCLUDE
- High flow air cooling system reduces pump temperature
- Copper discharge tube for improved durability and cooling
- Single and 3-phase open drip-proof motors with thermal protection
- NEMA 1 enclosure pressure switch with gauge
- 30 gallon stationary ASME air tank
- Pressure switch setting 95 PSI On and 135 PSI Off (Except Base Plate Models Nos. 48242 and 48243)
- Comply with State of California code 462 (L) (2)
- Charcoal gray metallic finish

PUMP SPECIFICATIONS

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<td>1400-1725</td>
<td>1000-1200</td>
<td>16.0</td>
<td>48246</td>
</tr>
</tbody>
</table>

BASE PLATE MODELS
- Suitable for fire sprinkler applications (verify local codes and regulations for compliance)
- Prestressed (240V) with pneumatically controlled package
- Pressure switch setting 30 PSI On and 45 PSI Off

NET PRICES, NOT SUBJECT TO DISCOUNTS
I forgot the criteria on Flammable Gas Controls and pressure.

In our recent meetings on annulus pumping, it was apparent that the pumping specifications previously provided were not adequate. I'm currently in the process of developing a technical rational for the Pump Design Criteria. The following is a draft of the criteria. Let me know if there are any questions or concerns.

**Heel Pump**

- **Total Flow**: 2 - 5 gpm
- **SpG**: 1.0 - 1.47
- **Viscosity**: 1.0 - 30 centipoise
- **Solids**: 0 - 20 Volume %
- **Temperature**: 65 - 140°F
- **Discharge Pressure**: 230 maximum *
- **Flammable Gas Controls**: Ignition Source Control Set #1 (Class 1 Division 1 Group B or equivalent)**
- **Dilution water Flow**: None Required

Note: It is assumed that the heel pump will be used just to remove the last few inches of liquid from the annulus. Repeated water flushes of the annulus may be performed to remove the residual radioactive components. So it is anticipated that the actual solution SpG will probably be significantly lower than the maximum stated above.

* Maximum design pressure for transfer lines in SY Farm (Spec B-101-C3) and A & AX Farms (Spec B-102-C1)

** Mineral insulated Cable meets requirements for equivalency. Series 300 stainless is acceptable as non-sparking.
**Introduction**

When sizing an air-driven system one must consider the air motor cylinder size being used, the stroke rate desired to produce a certain production rate (GPM) and the air consumption of the air motor.

**Air Cylinder Size**

Without going through the formulas, outlined below is a general guideline table for selecting the proper size air motor depending on the installation depth of the HydroStar. For each motor size a range of values is given: the Maximum Full Speed Depth (MFSD) and the Maximum Recommended Depth (MRD). The Maximum Full Speed Depth is the installation depth where some loss in air motor performance will begin to occur. The Maximum Recommended Depth is the deepest installation depth we would recommend using this size air motor.

<table>
<thead>
<tr>
<th>Cylinder size (in)</th>
<th>1.5</th>
<th>2.0</th>
<th>2.5</th>
<th>3.25</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>MFSD (ft)</td>
<td>76</td>
<td>146</td>
<td>240</td>
<td>392</td>
<td>617</td>
</tr>
<tr>
<td>MRD (ft)</td>
<td>106</td>
<td>205</td>
<td>337</td>
<td>549</td>
<td>865</td>
</tr>
</tbody>
</table>

**Production Due to Stroke Rate**

The HS-8000 and HS-8001 pumps are 1.5" diameter pump cylinders with a stroke rate of 12 inches. If we assume that the pumps operate at 90% efficiency the production factor of the pumps is 0.082 gallons per stroke. Note: Actual field studies rate the efficiency of the HydroStar pumps better than 90% at their rated operating depth capacity (see pump curves).

Example: If your pump is operating at 40 strokes per minute your production rate would be 40 * 0.082 = 3.29 gallons per minute.

**Air Consumption (at 80 PSI operation)**

Air consumption is a factor of the cylinder size you use and the stroke rate of the cylinder. The HydroStar system can operate up to 60 strokes per minute down to less than 1 stroke per minute so naturally the air consumption will vary depending on the desired operating speed.

Below is a table of factors one can use to determine the air consumption of your system in Standard Cubic Feet (SCF). (These factors are just guidelines since a number of additional variables can effect air consumption).

<table>
<thead>
<tr>
<th>Cylinder Size (in)</th>
<th>1.5</th>
<th>2.0</th>
<th>2.5</th>
<th>3.25</th>
<th>4</th>
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</thead>
<tbody>
<tr>
<td>Air consumption (SCF per stroke)</td>
<td>.10</td>
<td>.18</td>
<td>.30</td>
<td>.49</td>
<td>.76</td>
</tr>
</tbody>
</table>

Example: A HydroStar system operating at 40 strokes per minute using a 1.5 inch cylinder would need .1 * 40 = 4 SCFM of air.

(cont.)
**Fluor Federal Services, INC**

**CALCULATION IDENTIFICATION AND INDEX**

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

- **Discipline:** 27, Piping and Vessels
- **W/Job No.:** DSTAP-P-004
- **Project No. & Name:** TANK FARM PUMP PITS ANNULUS PUMPING
- **Calculation Item:** Annulus Jumper Piping Stress Analysis

These calculations apply to:

- **Dwg. No.:** H-14-104128 through H-14-104133
- **Rev. No.:** 0
- **Dwg. No.:** 
- **Rev. No.:** 
- **Other (Study, CDR):**

The status of these calculations is:

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

- Incorporation in Final Drawings? x Yes o No
- This calculation verified by independent "check" calculation? o Yes x No

**Design Analysis INDEX**

<table>
<thead>
<tr>
<th>Page No.</th>
<th>Description</th>
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<tbody>
<tr>
<td>1</td>
<td>Calculation Identification and Index</td>
</tr>
<tr>
<td>2</td>
<td>Objective, Design Criteria, Codes &amp; Standards and Design Parameters</td>
</tr>
<tr>
<td>3</td>
<td>Design loads and Acceptance criteria</td>
</tr>
<tr>
<td>4</td>
<td>Design Methodology</td>
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<tr>
<td>5</td>
<td>Assumptions, References, Calculation &amp; Conclusion</td>
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<th>Appdx-A</th>
<th>AutoPipe File: AY01F&amp;02F Stress Report</th>
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<td>AutoPipe File: AN01_07B Stress Report</td>
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<tr>
<td>Appdx-D</td>
<td>AutoPipe File: AP&amp;SY Stress Report</td>
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</table>
OBJECTIVE:

The objective of this calculation is to perform static & seismic analysis for Jumper piping for annulus pumping located in pump pits for Tanks AN, AP, AW, AY, AZ and SY in accordance with General Services requirements and be in compliance with ASME Code B31.3 requirements.

DESIGN CRITERIA:

The design and analysis of jumper piping is in accordance with the following criteria:

1. DOE Criteria 6430.1A

2. HNF-PRO-97, Rev-0. Engineering Design and Evaluation


DESIGN CODES & STANDARDS:

1. ASME Code B31.3a-1996 “Process Piping”

2. Piping Stress Analysis Software program “AUTOPIPE” Version-6.0 by Rebis Co.

3. SD-RE-DGS-002, Rev-3. Purex Connector Standards

DESIGN PARAMETERS:

1. Design Pressure: 300 psig
2. Design Temperature: 340°F
3. Ambient Temperature: 65°F
4. Corrosion Allowance: 0.4 mils/year
5. Project Life: 40 years
6. Waste fluid specific weight: 1.47
7. Seismic Safety Class: General Service
DESIGN LOADS:

DESIGN PRESSURE LOAD:
A design pressure of 300 psig is considered in the analysis to compute pressure stresses. AutoPipe (Ref:2) software program is used for stress analysis. AutoPipe program computes the "Hoop Stress" (pipe wall circumference stress) and longitudinal pressure stress as required by Code ASME B31.3 (Ref:1).

THERMAL EXPANSION LOADS:
Thermal expansion stress due to increase of pipe metal temperature from 65° F to 340° F is calculated in AutoPipe program to meet code criteria.

SUSTAINED LOADS:
The weight of pipe material, contents, pipe components and supporting dunnage steel are included in AutoPipe analysis. The AutoPipe program computes the mechanical stresses resulting from sustained loads.

SEISMIC LOADS:
Since the jumper piping is classified as General Service, in accordance with the requirements of HNF-PRO-97 (Ref:5), the UBC methodology to compute the Lateral earthquake forces is supposed to be used. However a dynamic analysis using Table D-4 (Ref:5) response spectra designated for Safety Significant PC3 structures is performed which is conservative for General Service.

ACCEPTANCE CRITERIA:

ASME Code B31.3 criteria for allowable pipe stresses is adopted as acceptance criteria. Allowable stress $S_h$ for given material at given design temperature are obtained from Appendix-A of the code.

1. Hoop stress $< S_h$  
   (Circumferential pressure stress)  
   Ref:1, Para 302.3.5(a)

2. Sustained Stress $< S_h$  
   (Longitudinal pressure + Gravity stress)  
   Ref:1, Para 302.3.5

3. Thermal (Displacement) stress $< f(1.25S_e + 0.25S_h)$  
   (Thermal expansion stress)  
   Ref:1, Eqn-1a

4. Seismic (Occasional) stress $< 1.33S_h$  
   (Sustained + Seismic stress)  
   Ref:1, Para 302.3.6
DESIGN METHODOLOGY:

The jumper piping analysis is performed using the Autopipe (Ref:2) software program which has been verified and validated in accordance with Fluor Daniel practice no: 134 200 0960.

The jumper piping assemblies basically consists of multiple jumper piping connected between tanks/ pit wall nozzles through Purex type jumper (Ref:6) connectors. Each jumper piping is attached to dunnage (supporting) steel and bail assembly. The Purex type connectors are welded to pipe at both ends. The jumper piping is remotely installed in the pit by using crane. When set in position, the Purex connectors are remotely connected to the existing nozzles in the pit.

The Purex type connectors (Ref:6) are modeled as a short radius elbows with a flexible joint on the nozzle side. The translation and rotational stiffness of ISB connectors (Ref:3) are used in the model since both ISB and Purex connectors are assumed to have similar rigidity. The weights of the Purex connectors, nozzles and kick plates are considered as concentrated loads at connector locations.

The three way valves are modeled as three different valves with 1/3 of weight of the valve, because of the in-ability of AutoPipe program to model a three way valve.

The jumper piping terminal attachments to Pump pit wall structure and Waste tanks risers are considered as rigid anchors in the model.

The function of structural (Dunnage) steel attached to jumper piping is to balance piping during jumper assembly installation in the pit. Hence the structural steel is subjected to dead weight of jumper piping assembly during installation only. The structural steel is reviewed for adequacy to withstand the weight of jumper assemblies and determined to be adequate by inspection.

Once installed the pipe will bear the weight of the steel. As such the weight of steel is calculated and imposed at appropriate node points (steel attachment to pipe) in the model.

The bail assembly and it’s welds are reviewed and found to be structurally adequate to carry the weight of the jumper piping assembly during installation.

PUREX CONNECTORS:
The Purex connectors application is acceptable based on historical precedence. The ASME B31.3 code paragraph 304.7.2(a) states that “unlisted components and elements may be utilized based on extensive, successful service experience under comparable conditions with similarly proportioned components of same or like material.” The PUREX connectors have been in service successfully for approximately 40 years. As such analytical qualification of the PUREX connectors is not required.
ASSUMPTIONS:

1. The stiffness factors used in the model for Purex type connectors are obtained from ISB connectors (Ref:3) data. Assumed that these stiffness factors are valid.

2. Pit wall structures and tank risers are structurally adequate to support piping loads.

3. A separate analysis will be performed for Pit wall Anchors for the combined piping loads from Jumper piping and buried transfer.

REFERENCES:


2. AutoPipe, Version 6.0 software program by Rebis Co.


CALCULATION:

The AutoPipe analysis results are documented in Appendices to this calculation as listed below. The Jumper piping assemblies with similar configuration are grouped for the purpose of analysis.

Appendix-A AutoPipe File:AY01&02F Pump Pits 241-AY-01F & -02F
Appendix-B AutoPipe File:AZ01&02F Pump Pits 241-AZ-01F & -02F
Appendix-C AutoPipe File:AN01-07B Pump Pits 241-AN-01B THRU -07B 241-AW-01B THRU -06B and 241-AP-01A, 03A, 06A & 08A
Appendix-D AutoPipe File:AP&SY Pump Pits 241-AP-02A, 04A, 05A & 07A 241-SY-01B, 02B & 03B

CONCLUSION:

The review of AutoPipe analysis indicates that the piping stresses meets Code B31.3a criteria as stated in Acceptance Criteria above.
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</tr>
<tr>
<td>POINT DATA LISTING</td>
<td></td>
</tr>
</tbody>
</table>
### Maximum Hoop Stress

<table>
<thead>
<tr>
<th>Load Combination</th>
<th>Stress psi</th>
<th>Point</th>
<th>Metal</th>
<th>Acceptable psi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max. Horsepower</td>
<td>29540</td>
<td>0.00</td>
<td>0.18</td>
<td>100000</td>
</tr>
</tbody>
</table>

### Maximum Axial Stress

<table>
<thead>
<tr>
<th>Load Combination</th>
<th>Stress psi</th>
<th>Point</th>
<th>Metal</th>
<th>Acceptable psi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max. Horsepower</td>
<td>4053</td>
<td>0.00</td>
<td>0.18</td>
<td>200000</td>
</tr>
</tbody>
</table>

### Maximum Bending Stress

<table>
<thead>
<tr>
<th>Load Combination</th>
<th>Stress psi</th>
<th>Point</th>
<th>Metal</th>
<th>Acceptable psi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max. Horsepower</td>
<td>1436</td>
<td>0.00</td>
<td>0.18</td>
<td>200000</td>
</tr>
</tbody>
</table>

### Summary

**Maximum Results**

- Max. Total: 386
- Max. Y: 96
- Max. X: 120
- Max. M: 0.129

**Maximum Displacements** (in)

<table>
<thead>
<tr>
<th>Component</th>
<th>Point</th>
<th>Metal</th>
<th>Acceptable Displacement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Axial</td>
<td>0.129</td>
<td></td>
<td>0.121</td>
</tr>
<tr>
<td>Torsion</td>
<td>0.129</td>
<td></td>
<td>0.121</td>
</tr>
<tr>
<td>Bending</td>
<td>0.129</td>
<td></td>
<td>0.121</td>
</tr>
</tbody>
</table>
**SYSTEM SUMMARY**

**For the selected options**

The system satisfies ASME B31.3 code requirements.

---

**Load Combination: Max**

- Ratio: 0.18
- Allowable psi: 31,240
- Stress psi: 29,920
- Point: 400

**Maximum hoop stress ratio**

- Load combination: Cool + Hot
- Ratio: 0.11
- Allowable psi: 21,725
- Stress psi: 23,825
- Point: 509

**Maximum occasional stress ratio**

- Load combination: Cold to Hot
- Ratio: 0.06
- Allowable psi: 22,960
- Stress psi: 20,812
- Point: 509

**Maximum displacement stress ratio**

- Load combination: G & P + Max
- Ratio: 0.14
- Allowable psi: 12,490
- Stress psi: 23,490
- Point: 400

**Maximum sustained stress ratio**

---
MODEL REVISION NUMBER: 10
MATERIAL LIBRARY: AUTO313
COMPONENT LIBRARY: Auto313
AMBIENT TEMPERATURE: 65.0øF
Y:
VERTICAL AXIS: B31.3
Piping Code:

CHECKED BY: M. Ahmad
PREPARED BY: M. Ahmad

Pump P11 Jumper Assembly Analysis
PROJECT ID: 241-A2-OFP-A-020 ANNUUS
SYSTEM NAME: AZ01020
<table>
<thead>
<tr>
<th>Load Case</th>
<th>X Specimen</th>
<th>Y Specimen</th>
<th>Combination Method</th>
<th>ZPA</th>
<th>Missing Mass</th>
<th>Response Spectrum Load Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.00</td>
<td>No</td>
<td>No</td>
<td>SASS</td>
<td>No</td>
<td>Yes</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**SS(y) Data**

<table>
<thead>
<tr>
<th>Load Case</th>
<th>X Specimen</th>
<th>Y Specimen</th>
<th>Combination Method</th>
<th>ZPA</th>
<th>Missing Mass</th>
<th>Response Spectrum Load Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.00</td>
<td>No</td>
<td>No</td>
<td>SASS</td>
<td>No</td>
<td>Yes</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Maximum Restraint Moments (ft-lb)

<table>
<thead>
<tr>
<th>Load Component</th>
<th>Max. Restraint Moment (ft-lb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOTAL</td>
<td>412</td>
</tr>
<tr>
<td>TOTAL</td>
<td>660</td>
</tr>
<tr>
<td>TOTAL</td>
<td>400</td>
</tr>
</tbody>
</table>

### Maximum Restraint Forces (lb)

<table>
<thead>
<tr>
<th>Load Component</th>
<th>Max. Restraint Force (lb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOTAL</td>
<td>0.480</td>
</tr>
<tr>
<td>TOTAL</td>
<td>660</td>
</tr>
<tr>
<td>TOTAL</td>
<td>388.0</td>
</tr>
</tbody>
</table>

### Maximum Displacements (in)

<table>
<thead>
<tr>
<th>Load Component</th>
<th>Max. Displacement (in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOTAL</td>
<td>0.125</td>
</tr>
<tr>
<td>TOTAL</td>
<td>0.950</td>
</tr>
</tbody>
</table>

---

### System Summary

- Maximum Load: 640 kips
- Maximum Deflection: 0.125 in
- Maximum Moment: 660 ft-lb
Maximum hoop stress ratio

Load combination: Max P
Ratio: 0.18
Allowable psi: 16480
Stress psi: 16780
Point: 0.00

Maximum axial stress ratio

Load combination: Max P
Ratio: 0.11
Allowable psi: 17325
Stress psi: 16402
Point: 0.00

Maximum displacement stress ratio

Load combination: Max P
Ratio: 0.14
Allowable psi: 16400
Stress psi: 15280
Point: 0.00

Maximum sustained stress ratio

Load combination: Max P
Ratio: 0.14
Allowable psi: 16400
Stress psi: 15280
Point: 0.00

FOR THE SELECTED OPTIONS

* * *

THE SYSTEM SATISFIES ANSI B31.3 CODE REQUIREMENTS

SYSTEM SUMMARY

Load combination: Max P
Ratio: 0.18
Allowable psi: 16480
Stress psi: 16780
Point: 0.00

Load combination: Max P
Ratio: 0.11
Allowable psi: 17325
Stress psi: 16402
Point: 0.00

Load combination: Max P
Ratio: 0.14
Allowable psi: 16400
Stress psi: 15280
Point: 0.00

Load combination: Max P
Ratio: 0.14
Allowable psi: 16400
Stress psi: 15280
Point: 0.00
**Calculation of Load on Piping**

### Minor Diameter of Pipe

1. **Design Pressure:** 1000 psi
   - Apply code-based pressure
   - Include pressure
   - Include axial force in code design
   - Include correction in code design
   - Include correction in stress calculations

2. **Factors:**
   - Number of stress points per span: 0.08
   - Welding factor: 0.8
   - Pipe factor: 0.9
   - Y-factor: 0.9

### Code Compliance

<table>
<thead>
<tr>
<th>Code</th>
<th>Compliant</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Compliant</td>
</tr>
</tbody>
</table>

### Remarks

- Application of piping analysis
- Flange pressure: 1200 psi
- User-defined factors
- Code compliance

### User Defined Factors

- Seismic: 1.00
- Response 1: 1.00
- Response 2: 1.00
- Thermal: 1.00
- Gravity: 1.00
- Response 3: 1.00
- Default: 1.00
- Response 4: 1.00
- Default: 1.00
- Response 5: 1.00
- Default: 1.00
- Thermal: 1.00
- Default: 1.00
- Gravity: 1.00
- Default: 1.00

### Load Factor

- Combination: Method 3

---

**Appendix C**

Page 43 of 48

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**Appendix C**

Page 43 of 48

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**Appendix C**

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**Appendix C**

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**Appendix C**

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**Appendix C**

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**Appendix C**

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**Appendix C**

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---

**Appendix C**

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---

**Appendix C**

Page 43 of 48
### Calculation Modeling - 004 Rev.0

<table>
<thead>
<tr>
<th>A17</th>
<th>210</th>
<th>020</th>
<th>000</th>
<th>000</th>
<th>000</th>
<th>000</th>
</tr>
</thead>
<tbody>
<tr>
<td>A20</td>
<td>200</td>
<td>020</td>
<td>000</td>
<td>000</td>
<td>000</td>
<td>000</td>
</tr>
<tr>
<td>A41</td>
<td>060</td>
<td>020</td>
<td>000</td>
<td>000</td>
<td>000</td>
<td>000</td>
</tr>
</tbody>
</table>

### Appendix C

<table>
<thead>
<tr>
<th>A12</th>
<th>100</th>
<th>010</th>
<th>000</th>
<th>000</th>
<th>000</th>
<th>000</th>
</tr>
</thead>
<tbody>
<tr>
<td>A13</td>
<td>100</td>
<td>010</td>
<td>000</td>
<td>000</td>
<td>000</td>
<td>000</td>
</tr>
<tr>
<td>A19</td>
<td>060</td>
<td>020</td>
<td>000</td>
<td>000</td>
<td>000</td>
<td>000</td>
</tr>
</tbody>
</table>

---

### Displacements

<table>
<thead>
<tr>
<th>Name</th>
<th>Displacement (in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Z</td>
<td>X</td>
</tr>
<tr>
<td>A</td>
<td>X</td>
</tr>
</tbody>
</table>

---

### Appendix E: Result Page 06

<table>
<thead>
<tr>
<th>A02</th>
<th>060</th>
<th>010</th>
<th>000</th>
<th>000</th>
<th>000</th>
<th>000</th>
</tr>
</thead>
<tbody>
<tr>
<td>A03</td>
<td>060</td>
<td>010</td>
<td>000</td>
<td>000</td>
<td>000</td>
<td>000</td>
</tr>
</tbody>
</table>

---

### Appendix F: Result Page 06

<table>
<thead>
<tr>
<th>A05</th>
<th>060</th>
<th>010</th>
<th>000</th>
<th>000</th>
<th>000</th>
<th>000</th>
</tr>
</thead>
<tbody>
<tr>
<td>A06</td>
<td>060</td>
<td>010</td>
<td>000</td>
<td>000</td>
<td>000</td>
<td>000</td>
</tr>
</tbody>
</table>
**System Summary**

Maximum Sustained Stress Ratio

Load combination: 1.1
Ratio: 0.14
Allowable psi: 16400
Stress psi: 2855
Point: A00

Maximum Sustained Stress Ratio

Load combination: 1.1
Ratio: 0.14
Allowable psi: 16400
Stress psi: 2855
Point: A00

Maximum Displacement Stress Ratio

Load combination: 1.1
Ratio: 0.55
Allowable psi: 27198
Stress psi: 1311
Point: A00

Maximum Occasional Stress

Load combination: 0.11
Ratio: 0.10
Allowable psi: 16400
Stress psi: 978
Point: A00

Maximum hoop stress

Load combination: Max p
Ratio: 0.15
Allowable psi: 16400
Stress psi: 978
Point: A00
<table>
<thead>
<tr>
<th>Calculation No.</th>
<th>Rating Pts.</th>
<th>IllegalArgumentException</th>
</tr>
</thead>
<tbody>
<tr>
<td>A16</td>
<td>6.09</td>
<td>2.35</td>
</tr>
<tr>
<td>A17</td>
<td>3.75</td>
<td>1.5</td>
</tr>
<tr>
<td>A18</td>
<td>5.60</td>
<td>3.29</td>
</tr>
<tr>
<td>A19</td>
<td>6.00</td>
<td>2.60</td>
</tr>
<tr>
<td>A20</td>
<td>2.60</td>
<td>1.19</td>
</tr>
</tbody>
</table>

**Notes:**
- No cut-offs.
- N/A.

---

**Number of Points in the System:**

<table>
<thead>
<tr>
<th>Normal Movements</th>
<th>Name</th>
<th>X</th>
<th>Y</th>
<th>Z</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00</td>
<td>NAME</td>
<td>X</td>
<td>Y</td>
<td>Z</td>
</tr>
</tbody>
</table>

**Normal Movements:**

- MOVEMENT 12 ANCHOR RIGID
- MOVEMENT 12 ANCHOR RIGID
- MOVEMENT 12 ANCHOR RIGID
- MOVEMENT 12 ANCHOR RIGID
- MOVEMENT 12 ANCHOR RIGID

**Articulated Points:**

<table>
<thead>
<tr>
<th>X</th>
<th>Y</th>
<th>Z</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.09</td>
<td>2.35</td>
<td>1.5</td>
</tr>
<tr>
<td>3.75</td>
<td>1.5</td>
<td>0.00</td>
</tr>
<tr>
<td>5.60</td>
<td>3.29</td>
<td>1.19</td>
</tr>
<tr>
<td>6.00</td>
<td>2.60</td>
<td>1.19</td>
</tr>
<tr>
<td>2.60</td>
<td>1.19</td>
<td>0.00</td>
</tr>
</tbody>
</table>

---

**Component Data Listing:**

- Name: PUMP P03 49-AF-702
- Type: "0.00 ANCHOR RIGID"

---

**Component Data Listing:**

- Name: PUMP P03 49-AF-702
- Type: "0.00 ANCHOR RIGID"

---

**Component Data Listing:**

- Name: PUMP P03 49-AF-702
- Type: "0.00 ANCHOR RIGID"
__. . --...
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000

...

000
000

. -. . . . -:;
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x 8 z::
a

4

1 "

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0
0

0

0

I

7

P
VI


<table>
<thead>
<tr>
<th>Width</th>
<th>Depth</th>
<th>Moment</th>
<th>Stress</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5 ft</td>
<td>1 ft</td>
<td>-1000 lb ft</td>
<td>-500 psi</td>
</tr>
<tr>
<td>1 ft</td>
<td>2 ft</td>
<td>-2000 lb ft</td>
<td>-1000 psi</td>
</tr>
<tr>
<td>1.5 ft</td>
<td>2.5 ft</td>
<td>-3000 lb ft</td>
<td>-1500 psi</td>
</tr>
</tbody>
</table>

**Note:** The above table provides a simplified representation of the data found in the provided document. Further details and calculations may be present in the original document but are not included here due to space constraints.
### Calculation: Moment at I-12,000 ft. of Load, Revised

<table>
<thead>
<tr>
<th>Load</th>
<th>Moment</th>
<th>Load</th>
<th>Moment</th>
<th>Load</th>
<th>Moment</th>
<th>Load</th>
<th>Moment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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<tr>
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<td>5</td>
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<tr>
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<td>5</td>
<td>1</td>
<td>1</td>
<td>5</td>
<td>5</td>
</tr>
</tbody>
</table>

### Notes:

- **Load:** The load is applied at various points along the structure, indicated by the table entries.
- **Moment:** The moment at each load point is calculated, showing the effect of the load on the structure.

---

**Appendix C**

- **3.7:** This section likely contains additional details or supporting information related to the calculations.
Appendix D

Calculation of DTAP-004 Rev. 0

<table>
<thead>
<tr>
<th>Load Case</th>
<th>TOTAL Load Case</th>
<th>MAX Load Case</th>
</tr>
</thead>
<tbody>
<tr>
<td>Point A</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Point B</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Point C</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Point D</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Point E</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Maximum Reactions (lb)

- Maximum Reactions (lb)
- Maximum Reactions (kip)
- Maximum Reactions (kN)
- Maximum Reactions (MPa)

Maximum Moments (ft-lb)

- Maximum Moments (in-ft)
- Maximum Moments (m-m)
- Maximum Moments (kN-m)
- Maximum Moments (N-m)

System Summary

**SYSTEM SUMMARY**

For the selected options:

- The system satisfies ASME B1.3 code requirements.

### Load Combinations

<table>
<thead>
<tr>
<th>Ratio</th>
<th>Allowable Psl</th>
<th>Stress psi</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.10</td>
<td>16400</td>
<td>900</td>
</tr>
<tr>
<td>0.18</td>
<td>16400</td>
<td>900</td>
</tr>
</tbody>
</table>

### Maximum Hoop Stress Ratio

Load combination: Gus. + A1

<table>
<thead>
<tr>
<th>Ratio</th>
<th>Allowable Psl</th>
<th>Stress psi</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.13</td>
<td>2172</td>
<td>111</td>
</tr>
</tbody>
</table>

### Maximum Occasional Stress Ratio

Load combination: Cold to 11

<table>
<thead>
<tr>
<th>Ratio</th>
<th>Allowable Psl</th>
<th>Stress psi</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.55</td>
<td>2940</td>
<td>111</td>
</tr>
</tbody>
</table>

### Maximum Displacement Stress Ratio

Load combination: Gus. + A1

<table>
<thead>
<tr>
<th>Ratio</th>
<th>Allowable Psl</th>
<th>Stress psi</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.15</td>
<td>1540</td>
<td>111</td>
</tr>
</tbody>
</table>

### Maximum Sustained Stress Ratio

Load combination: Gus. + A1

<table>
<thead>
<tr>
<th>Ratio</th>
<th>Allowable Psl</th>
<th>Stress psi</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.16</td>
<td>1540</td>
<td>111</td>
</tr>
</tbody>
</table>
Mo,

On the annulus pumping calculation number-

Start with DSTAP-P-004 and sequentially increase the number if needed. Please let me know what numbers you use and the title of the calculation:

Paul M. Dorsh
Fluor Federal Services
(509) 372-0289
Ahmed, Mohammed M

From: Dorsh, Paul M
Sent: Tuesday, May 02, 2000 8:16 AM
To: Ahmed, Mohammed M
Subject: FW: Annulus Pump Pit Jumper Analysis

Mo,

Attached are references to the annulus jumper design criteria. The second has a revision to the SpG.

Design Pressure - 300 psi
Design Temperature - 340 F
Ambient Temperature - 65 F (assumed)
Fluid Specific Gravity - 1.47 (in Draft Design Criteria)
Safety Classification - General Service

The torque required to operate a 2" 3-way ball valve is not nearly as much as the torque needed to operate the 3" valves. Therefore, I don't believe it is necessary to include torque in the analysis.

FW Design Procedures Draft Design Criteria for Annulus...

---Original Message-----
From: Hauck, Frank M (Marshall)
Sent: Tuesday, May 02, 2000 6:59 AM
To: Dorsh, Paul M
Subject: FW: Annulus Pump Pit Jumper Analysis

Paul,

Can you gather up this information and send it back to Mo?

Thanks,

Marshall

---Original Message-----
From: Ahmed, Mohammed M
Sent: Monday, May 01, 2000 8:36 AM
To: Hauck, Frank M (Marshall)
Cc: Ahmed, Mohammed M
Subject: Annulus Pump Pit Jumper Analysis

Marshall,

I have received AZ-01B & -02B Jumper drawings from Gary Cleveland. What I need from you is Design specifications such as:

Design Pressure
Design Temperature
Ambient Temperature
Fluid Specific weight
Would there be any torque applied to Valve for opening & closing. If so how much torque?
Jumper piping Safety Category?
Any other data you think is pertinent.

Mohammed M. Ahmed
Fluor Federal Services
376-9120
The design of any jumper or pump piping assembly for annulus pumping, is expected to have Design Pressure, Thermal Expansion, Sustained and Seismic load calculations performed and documented. The calculation documentation should be issued as a Supporting Document. The preferred material for the pump assembly is stainless steel. All materials for trailer racks and instrument skids can be carbon steel.

**Design Criteria:**
The design and analysis of jumper/pump piping shall be in accordance with the following criteria:
1. HNF-PRO-097, Rev-0 Engineering Design and Evaluation
2. WHC-SD-W236A-DA-002, Rev-0 Stress Analysis of Single port Jumper Connectors

**Design Codes & Standards:**
1. ASME Code B31.3a 1996 “Process Piping”
2. WHC-SD-RE-DGS-002 Rev -3 Jumper Design Standard

**Design Parameters:**
1. Design Pressure 300 psig
2. Design Temperature 340° F
3. Corrosion Allowance 1.0 mils/yr.
4. Waste Specific Gravity 1.30
5. Classification General Service
In our recent meetings on annulus pumping, it was apparent that the pumping specifications previously provided were not adequate. I'm currently in the process of developing a technical rational for the Pump Design Criteria. The following is a draft of the criteria. Let me know if there are any questions or concerns.

**Submersible Centrifugal**

- Total Flow: 50 - 300 gpm
- SpG: 1.0 - 1.47
- Viscosity: 1.0 - 30 centipoise
- Solids: 0 - 20 Volume %
- Temperature: 65 - 140°F
- Discharge Pressure: 230 maximum
- Flammable Gas Controls: Ignition Source Control Set #1 (Class 1 Division 1 GroupB or equivalent)
- Waste Flow: 33 - 200 gpm
- Dilution water Flow: 17 - 100 gpm

* The maximum flow rate of 300 gpm is based on an accident in the Tank Farm FSAR 3.4.2.7 Surface Leak Resulting in a Pool.

** Maximum design pressure for transfer lines in SY Farm (Spec B-101-C3) and A & AX Farms (Spec B-102-C1)

*** Mineral insulated Cable meets requirements for equivalency. Series 300 stainless is acceptable as non-sparking.

**** The dilution water flow may be required to be as high as 50% of the waste flow. It’s recognized that design constraints may prevent reaching dilution water flows above 40 gpm. In this case throttling existing waste line valves will be used to set the proper dilution. The design constraints anticipated are water supply pressure, pressure drop through hose connections, and the limiting pipe diameter that can be coupled with the pump assemblies.

**Heel Pump**
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
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<tbody>
<tr>
<td>Total Flow</td>
<td>2 - 5 gpm</td>
</tr>
<tr>
<td>SpG</td>
<td>1.0 - 1.47</td>
</tr>
<tr>
<td>Viscosity</td>
<td>1.0 - 30 centipoise</td>
</tr>
<tr>
<td>Solids</td>
<td>0 - 20 Volume %</td>
</tr>
<tr>
<td>Temperature</td>
<td>65 - 140°F</td>
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<tr>
<td>Discharge Pressure</td>
<td>230 maximum*</td>
</tr>
<tr>
<td>Flammable Gas Controls</td>
<td>Ignition Source Control Set #1 (Class 1 Division 1 GroupB or equivalent)**</td>
</tr>
<tr>
<td>Dilution water Flow</td>
<td>None Required</td>
</tr>
</tbody>
</table>

Note: It is assumed that the heel pump will be used just to remove the last few inches of liquid from the annulus. Repeated water flushes of the annulus may be performed to remove the residual radioactive components. So it is anticipated that the actual solution SpG will probably be significantly lower than the maximum stated above.

* Maximum design pressure for transfer lines in SY Farm (Spec B-101-C3) and A & AX Farms (Spec B-102-C1)

** Mineral insulated Cable meets requirements for equivalency. Series 300 stainless is acceptable as non-sparking.
### Calculation Model VXP-004 Rev 0

#### Number of Points in the System:

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<thead>
<tr>
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#### Thermal Movements:

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<td>Z</td>
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### Gap Set Movements

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### Pin Set Movements

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<td>Z</td>
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</tr>
</tbody>
</table>

### Component Data Listing

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<thead>
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<th>Point</th>
<th>DATA</th>
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<tr>
<td>Y</td>
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This sheet shows the status and description of the attached Design Analysis sheets.

**Discipline:** 454  
**Project/Area/Unit:** 65100541/25/9  
**Calculation No.:** DSTAP-P-005

**Project No. & Name:** Double Shell Tank Annulus Pumping  
**Calculation Item:** DST Annulus Pump Test Piping Line Loss

These calculations apply to:

- **Drawing No.:** N/A  
- **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  
- [X] No

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

**Original and Revised Calculation Approvals:**

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<th>Rev. 2</th>
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<tr>
<td>Checked by</td>
<td><a href="Signature">Jennifer Williamson</a></td>
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**INDEX**

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<th>Description</th>
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<tbody>
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<td>Objective, Design Criteria, Methods, Assumptions</td>
</tr>
<tr>
<td>2</td>
<td>Assumptions Cont, References, Conclusions</td>
</tr>
<tr>
<td>3-10</td>
<td>Calculations</td>
</tr>
<tr>
<td>Appendix A</td>
<td>Attached References</td>
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<tr>
<td>A1-A6</td>
<td>Crane Technical Paper No. 410</td>
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<td>A7-A8</td>
<td>Engineering Fluid Mechanics</td>
</tr>
<tr>
<td>A9</td>
<td>Engineering Sketch ES-259-001, Rev. 0</td>
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<tr>
<td>Appendix B</td>
<td>Test System Curve</td>
</tr>
<tr>
<td>B1</td>
<td>DST Annulus Pumping Test System Curve</td>
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OBJECTIVE:
The objective of this calculation is to determine the line loss, at various flow rates, of the piping used to test the Double Shell Tank Annulus Pumps and develop a system curve from this information.

DESIGN INPUT:
1.) Test Skid Submersible Pump Arrangement, Engineering Sketch ES-259-001, Rev. 0.

METHODS:
1.) The Darcy-Weisbach equation is used in determining the friction pressure losses.
2.) Friction losses due to standard fittings are calculated using the pipe resistance coefficients (K factors) found in Crane Technical Paper No. 410.
3.) For this calculation, a flow rate value of 90 GPM was arbitrarily chosen to show how the line losses were determined. This value was then varied throughout the range of 0 to 160 GPM and the corresponding line loss value recorded. These points were then used to develop a system curve.

ASSUMPTIONS:
1.) The test fluid will be water and the temperature will not be above 80 degrees F during the testing.
2.) There are no losses through the magnetic flow meter.
3.) The equivalent roughness of the pipe is 0.00015 ft.

REFERENCES:
3.) Test Skid Submersible Pump Arrangement, Engineering Sketch ES-259-001, Rev. 0.

All References are located in Appendix A.

CONCLUSIONS:
The head required by the test piping at 90 GPM is 50.9 ft. A chart of the head required by the test piping at various flow rates is seen on page 4. A Test System Curve can be seen in Appendix B.
Fluid Characteristics

Flow Rate

\[ Q = 90 \text{ GPM} \]

Density of Water

\[ \rho = 62.22 \text{ lb/ft}^3 \] (Ref. 2, A8)

Dynamic Viscosity

\[ \mu = 0.85 \text{ cp} \] (Ref. 1, A2)

Pipe Roughness

\[ k_s = 0.00015 \text{ ft} \] (Assum. 3)

Resistance Coefficients - 3" sch 40 Pipe

Pipe Inside Diameter

\[ D_2 = 3.068 \text{ in} \]

Inside Area

\[ A = \frac{\pi D_2^2}{4} \quad A = 7.393 \text{ in}^2 \]

Fluid Velocity

\[ V = \frac{Q}{A} \quad V = 3.906 \text{ ft/sec} \]

3" Complete Turbulence Friction Factor

\[ f_t = 0.018 \] (Ref. 1, A3)

90 Degree Elbow

\[ K_1 = 30 f_t \quad K_1 = 0.54 \] (Ref. 1, A6)

Reynolds Number

\[ \text{Re} = \frac{V D_2^2 \rho}{\mu} \quad \text{Re} = 1.1 \times 10^5 \]

Friction Factor

\[ f = \frac{0.25}{\log \left( \frac{k_s}{3.7 D_2} + \frac{5.74}{\text{Re}^{0.9}} \right)^2} \quad f = 0.021 \] (Ref. 2, A7)

Approximate Length of 3" Pipe

\[ L = 3 \text{ ft} \]

3" Friction Head Loss

\[ h_1 = \left( K_1 + f \cdot \frac{L}{D_2} \right) \frac{V^2}{2g} \quad h_1 = 0.185 \text{ ft} \] (Ref. 1, A1)
Resistance Coefficients - 1-1/2" sch 40 Pipe

Pipe Inside Diameter

\[ D_1 = 1.61\text{ in} \]

Inside Area

\[ A = \frac{\pi D_1^2}{4} \]

Fluid Velocity

\[ V = \frac{Q}{A} \]

1-1/2" Complete Turbulence Friction Factor

\[ f_t = 0.021 \]

3" to 1-1/2" Contraction (Sudden)

\[ \beta = \frac{D_1}{D_2} \]

\[ \beta = 0.525 \] (Ref. 1, A3)

\[ K_1 = \frac{0.5 \left(1 - \beta^2\right) \left(\frac{\sin 180\degree}{2}\right)}{\beta^4} \]

\[ K_1 = 4.777 \] (Ref. 1, A3)

Tee - Run Flow

\[ K_2 = (20 f_t)^2 \]

\[ K_2 = 0.84 \] (Ref. 1, A6)

Tee - Branch Flow

\[ K_3 = 60 f_t \]

\[ K_3 = 1.26 \] (Ref. 1, A6)

Globe Valve

\[ K_4 = 340 f_t \]

\[ K_4 = 7.14 \] (Ref. 1, A4)

Ball Valve

\[ K_5 = 3 f_t \]

\[ K_5 = 0.063 \] (Ref. 1, A5)

Pipe Exit

\[ K_6 = 1 \] (Ref. 1, A6)

Total Resistance Coefficients

\[ K = \sum_{i=1}^{6} K_i \]

\[ K = 15.08 \]

Reynolds Number

\[ Re = \frac{V D_1 \rho}{\mu} \]

\[ Re = 2.1 \times 10^5 \]
FLUOR FEDERAL SERVICES

DESIGN ANALYSIS

Client: CH2M HILL Hanford Group
Subject: DOUBLE SHELL TANK ANNULUS PUMPING
Location: 200 E AREA HANFORD

Friction Factor
\[ f = \frac{0.25}{\log \left( \frac{k_s}{3.7\cdot D} + \frac{5.74}{Re^{0.8}} \right)^{1/2}} \]

Approximate Length of 1-1/2" Pipe
\[ L = 7 \text{ ft} \]

1-1/2" Friction Head Loss
\[ h_2 = \left( K + \frac{f}{D} \right) \frac{V^2}{2g} \]
\[ h_2 = 50.669 \text{ ft} \]

Total Friction Head Loss
\[ h_L = h_1 + h_2 \]
\[ h_L = 50.854 \text{ ft} \]

The following is a chart of the test piping head requirements at various flow rates. The Test System Curve can be seen in Appendix B.

<table>
<thead>
<tr>
<th>Flow Rate (GPM)</th>
<th>Head (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>30</td>
<td>5.7</td>
</tr>
<tr>
<td>60</td>
<td>22.6</td>
</tr>
<tr>
<td>90</td>
<td>50.9</td>
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<tr>
<td>120</td>
<td>90.3</td>
</tr>
<tr>
<td>140</td>
<td>122.9</td>
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<tr>
<td>160</td>
<td>160.4</td>
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</tbody>
</table>
CALCULATION NO: DSTAP-P-005, Rev. 0
APPENDIX A

References
Summary of Formulas

- Head loss and pressure drop through valves and fittings

Head loss through valves and fittings is generally given in terms of resistance coefficient \( K \) which indicates static head loss through a valve in terms of "velocity head", or, equivalent length in pipe diameters \( L/D \) that will cause the same head loss as the valve.

From Darcy's formula, head loss through a pipe is:

\[
h_L = f \frac{L}{D} \frac{v^2}{2g}
\]

and head loss through a valve is:

\[
h_L = K \frac{v^2}{2g}
\]

therefore:

\[
K = f \frac{L}{D}
\]

To eliminate needless duplication of formulas, the following are all given in terms of \( K \). Whenever necessary, substitute \((fL/D)\) for \((K)\).

\[
h_L = 0.005 \frac{KQ^2}{d^4}
\]

\[
\Delta P = \frac{0.001}{270} \frac{KB^2}{d^4} = 0.000 \frac{KQ\sqrt{V}}{d^4}
\]

\[
\Delta P = 0.000 \frac{KQ^2}{d^4} = 0.000 \frac{KQ}{d^4}
\]

\[
\Delta P = 0.000 \frac{KQ^2}{d^4}
\]

\[
\Delta P = 0.000 \frac{KQ^2}{d^4}
\]

For compressible flow with \( h_L \) or \( \Delta P \) greater than approximately 10% of inlet absolute pressure, the denominator should be multiplied by \( Y^2 \). For values of \( Y \), see page A-22.

- Pressure drop and flow of liquids of low viscosity using flow coefficient

\[
\Delta P = \left( \frac{Q}{C_v} \right)^2 \frac{\rho}{62.4}
\]

\[
Q = C_v \sqrt{\frac{\Delta P}{62.4}} = 7.90 C_v \sqrt{\frac{\Delta P}{\rho}}
\]

\[
C_v = Q \sqrt{\frac{\rho}{\Delta P (62.4)}} = \frac{19.9 d^3}{\sqrt{fL/D}} = \frac{19.9 d^2}{\sqrt{K}}
\]

\[
K = \frac{891 d^4}{(C_v)^3}
\]

- Resistance coefficient, \( K \), for sudden and gradual enlargements in pipes

If, \( \theta \geq 45^\circ \),

\[
K_1 = 2.6 \sin \frac{\theta}{2} \sum (1 - \theta^2)^2
\]

Equation 3-17

If, \( 45^\circ < \theta < 180^\circ \),

\[
K_1 = (1 - \theta^2)^2
\]

Equation 3-17.1

- Resistance coefficient, \( K \), for sudden and gradual contractions in pipes

If, \( \theta \geq 45^\circ \),

\[
K_1 = 0.8 \sin \frac{\theta}{2} \sum (1 - \theta)
\]

Equation 3-18

If, \( 45^\circ < \theta < 180^\circ \),

\[
K_1 = 0.5 \sqrt{\sin \frac{\theta}{2} \sum (1 - \theta)}
\]

Equation 3-18.1

\* Note: The values of the resistance coefficients \((K)\) in equations 3-17, 3-17.1, 3-18, and 3-18.1 are based on the velocity in the small pipe. To determine \( K \) values in terms of the greater diameter, divide the equations by \( \theta^2 \).

- Discharge of fluid through valves, fittings, and pipe; Darcy's formula

Liquid flow:

\[
q = 0.0438 d^3 \frac{h_L}{K} = 0.525 d^3 \sqrt{\frac{\Delta P}{k_p}}
\]

\[
Q = 19.65 d^3 \sqrt{\frac{h_L}{K}} = 236 d^3 \sqrt{\frac{\Delta P}{k_p}}
\]

\[
w = 0.0438 d^2 \sqrt{\frac{h_L}{K}} = 0.525 d^3 \sqrt{\frac{\Delta P}{k_p}}
\]

\[
W = 157.6 d^2 \sqrt{\frac{h_L}{K}} = 189.1 d^2 \sqrt{\frac{\Delta P}{k_p}}
\]

Compressible flow:

\[
q' = 40.700 Y d^3 \sqrt{\frac{\Delta P}{k_p}}
\]

\[
q' = 24.700 Y d^3 \sqrt{\frac{\Delta P}{k_p}}
\]

\[
q' = 678 Y d^3 \sqrt{\frac{\Delta P}{k_p}}
\]

\[
q' = 11.30 Y d^3 \sqrt{\frac{\Delta P}{k_p}}
\]

\[
w = 0.525 d^3 \sqrt{\frac{\Delta P}{k_p}}
\]

Values of \( Y \) are shown on page A-22. For \( K \), \( Y \), and \( \Delta P \) determination, see examples on pages 4-13 and 4-14.
# Viscosity of Water and Liquid Petroleum Products

![Graph showing viscosity vs temperature for various fluid types.](image)

1. Ethane (C₂H₆)
2. Propane (C₃H₈)
3. Butane (C₄H₁₀)
4. Natural Gasoline
5. Gasoline
6. Water
7. Kerosene
8. Distillate
9. 48 Deg. API Crude
10. 40 Deg. API Crude
11. 35.6 Deg. API Crude
12. 32.6 Deg. API Crude
13. Salt Creek Crude
14. Fuel 3 (Max.)
15. Fuel 5 (Min.)
16. SAE 10 Lube (100 V.I.)
17. SAE 30 Lube (100 V.I.)
18. Fuel 5 (Max.) or Fuel 6 (Min.)
19. SAE 70 Lube (100 V.I.)
20. Bunker C Fuel (Max.) and M.C. Residue
21. Asphalt

Data extracted in part by permission from the Oil and Gas Journal.

---

**Example:** The viscosity of water at 125°F is 0.51 centipoise (Curve No. 6).
"K" FACTOR TABLE—SHEET 1 of 4

Representative Resistance Coefficients (K) for Valves and Fittings

("K" is based on use of schedule pipe as listed on page 2-10)

PIPE FRICTION DATA FOR CLEAN COMMERCIAL STEEL PIPE
WITH FLOW IN ZONE OF COMPLETE TURBULENCE

<table>
<thead>
<tr>
<th>Nominal Size</th>
<th>⅛&quot;</th>
<th>¼&quot;</th>
<th>⅜&quot;</th>
<th>½&quot;</th>
<th>¾&quot;</th>
<th>1&quot;</th>
<th>1⅛&quot;</th>
<th>1½&quot;</th>
<th>2&quot;</th>
<th>2½&quot;, 3&quot;</th>
<th>4&quot;</th>
<th>5&quot;</th>
<th>6&quot;</th>
<th>8-10&quot;</th>
<th>12-16&quot;</th>
<th>18-24&quot;</th>
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<tbody>
<tr>
<td>Friction Factor ((f_t))</td>
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<td>.025</td>
<td>.023</td>
<td>.022</td>
<td>.021</td>
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<td>.013</td>
<td>.012</td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

---

FORMULAS FOR CALCULATING "K" FACTORS* FOR VALVES AND FITTINGS WITH REDUCED PORT
(Ref. Pages 2-11 and 3-4)

- **Formula 1**
  \[ K_1 = \left( \frac{0.8 \sin \frac{\theta}{2} (1 - \beta^2)}{\beta^4} \right) - \frac{K_1}{\beta^4} \]

- **Formula 2**
  \[ K_2 = \frac{0.5 (1 - \beta^2) \sqrt{\sin \frac{\theta}{2}}}{\beta^4} - \frac{K_1}{\beta^4} \]

- **Formula 3**
  \[ K_3 = \frac{2.6 \left( \sin \frac{\theta}{2} \right) (1 - \beta^2)^2}{\beta^4} - \frac{K_1}{\beta^4} \]

- **Formula 4**
  \[ K_4 = \frac{(1 - \beta^2)^2}{\beta^4} - \frac{K_1}{\beta^4} \]

- **Formula 5**
  \[ K_5 = \frac{K_1}{\beta^4} - \text{Formula 1 + Formula 3} \]

- **Formula 6**
  \[ K_6 = K_1 \text{ + Formula 2 + Formula 4} \]

- **Formula 7**
  \[ K_7 = K_1 + \beta \text{ (Formula 2 + Formula 4)} \text{ when } \theta = 180^\circ \]

\[ K_8 = \frac{K_1 + \beta \left[ 0.5 (1 - \beta) + (1 - \beta^2) \right]}{\beta^4} \]

\[ \beta = \frac{d_1}{d_2} \]

\[ \beta^4 = \left( \frac{d_1}{d_2} \right)^{\frac{1}{2}} \frac{d_1}{d_2} \]

Subscript 1 defines dimensions and coefficients with reference to the smaller diameter.

Subscript 2 refers to the larger diameter.

*Use "K" furnished by valve or fitting supplier when available.

---

SUDDEN AND GRADUAL CONTRACTIONS

<table>
<thead>
<tr>
<th>( \theta )</th>
<th>Formula</th>
<th>( \theta )</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>(&lt; 45^\circ)</td>
<td>( K_2 \text{ - Formula 1} )</td>
<td>( \geq 45^\circ )</td>
<td>( K_2 \text{ - Formula 2} )</td>
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SUDDEN AND GRADUAL ENLARGEMENTS

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<th>( \theta )</th>
<th>Formula</th>
<th>( \theta )</th>
<th>Formula</th>
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<tbody>
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<td>( K_3 \text{ - Formula 3} )</td>
<td>( \geq 45^\circ )</td>
<td>( K_3 \text{ - Formula 4} )</td>
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</table>
"K" FACTOR TABLE—SHEET 2 of 4

Representative Resistance Coefficients (K) for Valves and Fittings

(for formulas and friction data, see page A-26)

("K" is based on use of schedule pipe as listed on page 2-10)

GATE VALVES
Wedge Disc, Double Disc, or Plug Type

If: \( \beta = 1, \theta = 0 \) \( K_1 = 8 \frac{f}{t} \)
\( \beta < 1 \) and \( \theta < 45^\circ \) \( K_2 = \text{Formula } 5 \)
\( \beta < 1 \) and \( 45^\circ < \theta < 180^\circ \) \( K_3 = \text{Formula } 6 \)

GLOBE AND ANGLE VALVES

If: \( \beta = 1 \) \( K_1 = 340 \frac{f}{t} \)
If: \( \beta = 1 \) \( K_1 = 55 \frac{f}{t} \)
If: \( \beta = 1 \) \( K_1 = 150 \frac{f}{t} \)

All globe and angle valves, whether reduced seat or throttled,
If: \( \beta < 1 \) \( K_3 = \text{Formula } 7 \)

SWING CHECK VALVES

\( K = 100 \frac{f}{t} \) Minimum pipe velocity (fps) for full disc lift
\( -35 \sqrt{V} \) except U/L listed = 100 \( \sqrt{V} \)

LIFT CHECK VALVES

If: \( \beta = 1 \) \( K_1 = 50 \frac{f}{t} \)
\( \beta < 1 \) \( K_2 = \text{Formula } 7 \)
Minimum pipe velocity (fps) for full disc lift
\( = 60 \sqrt{V} \)

TILTING DISC CHECK VALVES

\( K = \frac{d}{4} \) Minimum pipe velocity (fps) for full disc lift
\( = 140 \beta^2 \sqrt{V} \)

<table>
<thead>
<tr>
<th>Sizes</th>
<th>2 to 8&quot;</th>
<th>10 to 14&quot;</th>
<th>16 to 24&quot;</th>
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<tr>
<td>K</td>
<td>40 f/t</td>
<td>30 f/t</td>
<td>20 f/t</td>
</tr>
<tr>
<td>( \theta = 5^\circ )</td>
<td>120 f/t</td>
<td>90 f/t</td>
<td>60 f/t</td>
</tr>
<tr>
<td>( \theta = 15^\circ )</td>
<td>80 ( \sqrt{V} )</td>
<td>30 ( \sqrt{V} )</td>
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</table>
### STOP-CHECK VALVES
(Globe and Angle Types)

- **Poppet Disc**
  - If: \( \beta = 1 \ldots K_1 = 400 \text{ ft} \)
  - \( \beta < 1 \ldots K_3 = \text{Formula } 7 \)
  - Minimum pipe velocity for full disc lift:
    \[ = 55 \beta^2 \sqrt{V} \]

- **Hinged Disc**
  - If: \( \beta = 1 \ldots K_1 = 200 \text{ ft} \)
  - \( \beta < 1 \ldots K_3 = \text{Formula } 7 \)
  - Minimum pipe velocity for full disc lift:
    \[ = 75 \beta^2 \sqrt{V} \]

### FOOT VALVES WITH STRAINER
- **Poppet Disc**
  - Minimum pipe velocity (fps) for full disc lift:
    \[ = 15 \sqrt{V} \]
- **Hinged Disc**
  - Minimum pipe velocity (fps) for full disc lift:
    \[ = 35 \sqrt{V} \]

### BALL VALVES
- If: \( \beta = 1 \ldots K_1 = 300 \text{ ft} \)
  - \( \beta < 1 \ldots K_3 = \text{Formula } 7 \)
  - Minimum pipe velocity (fps) for full disc lift:
    \[ = 60 \beta^2 \sqrt{V} \]

### BUTTERFLY VALVES
- Sizes 2 to 8"... \( K = 45 \text{ ft} \)
- Sizes 10 to 14"... \( K = 35 \text{ ft} \)
- Sizes 16 to 24"... \( K = 25 \text{ ft} \)
"K" FACTOR TABLE—SHEET 4 of 4

Representative Resistance Coefficients (K) for Valves and Fittings

(for formulas and friction data, see page A.26)

("K" is based on use of schedule pipe as listed on page 2-10)

PLUG VALVES AND COCKS

STANDARD ELBOWS

MITRE BENDS

90° PIPE BENDS AND
FLANGED OR BUTT-WELDING 90° ELBOWS

The resistance coefficient, $K_B$, for pipe bends other than 90° may be determined as follows:

$$K_B = (n - 1) \left( 0.25 \pi \frac{f}{d} + 0.5 K \right) + K$$

$n$ = number of 90° bends
$K$ = resistance coefficient for one 90° bend (per table)

CLOSE PATTERN RETURN BENDS

PIPE ENTRANCE

For $K$, see table

PIPE EXIT

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</tr>
<tr>
<td>Sharp-Edged</td>
<td>1.0</td>
</tr>
<tr>
<td>Rounded</td>
<td>1.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Type</th>
<th>$K$</th>
</tr>
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<tbody>
<tr>
<td>Projecting</td>
<td>0.78</td>
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<tr>
<td>Sharp-Edged</td>
<td>0.78</td>
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<tr>
<td>Rounded</td>
<td>0.78</td>
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</tbody>
</table>

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Colebrook–White formula, from which the Moody diagram was developed, Swamee and Jain (39) developed explicit formulas relating $f$, $h_f$, $Q$, and $D$. It is reported that their formulas yield results that deviate no more than 3% from those obtained from the Moody diagram for the following ranges of $k_s/D$ and Re: $10^{-5} < k_s/D < 2 \times 10^{-2}$ and $4 \times 10^{3} < Re < 10^{4}$. The formulas for $f$ and $Q$ are

$$f = \left[ \log \left( \frac{k_s}{3.7D} + \frac{5.74}{Re^{0.8}} \right) \right]^{0.25}$$  \hspace{1cm} (10.26)

$$Q = -2.22D^{5.2} \sqrt{gh_f/L} \log \left( \frac{k_s}{3.7D} + \frac{1.78\nu}{D^{5.2} \sqrt{gh_f/L}} \right)$$  \hspace{1cm} (10.27)

They also developed a formula for the explicit determination of $D$. A modified version of that formula, given by Streeter and Wylie (38), is

$$D = 0.66 \left[ k_s^{1.25} \left( \frac{LQ^2}{gh_f} \right)^{4.75} + \nu Q^{0.4} \left( \frac{L}{gh_f} \right)^{4.7} \right]^{0.04}$$  \hspace{1cm} (10.28)

If you want to solve for head loss given $Q$, $L$, $D$, $k_s$, and $\nu$, simply solve for $f$ by Eq. (10.26) and compute $h_f$ with the Darcy–Weisbach equation, Eq. (10.22). Straightforward calculations for $Q$ and $D$ can also be made if $h_f$ is known. However, for problems involving head losses in addition to $h_f$, an iterative solution is required. For computing $Q$, you can assume an $f$ and solve for $Q$ from the energy equation after substituting $Q/A$ in that equation. Then compute Re and use the result in Eq. (10.26) to get a better estimate of $f$, and so on, until $Q$ converges analogous to the procedure for determining $Q$ using the Moody diagram. In this case, however, Eq. (10.26) is substituted for the Moody diagram. Similarly, you can determine $D$ if you are given $Q$, $\nu$, the change in pressure or head, and the geometric configuration.

**Example 10.8** Solve Example 10.5 using Eq. (10.27).

**Solution** From Fig. 10.8, $k_s$ for asphalted cast-iron pipe is given as $1.2 \times 10^{-4}$ m. From the given conditions, $h_f/L = 0.0122$. Assume $T = 20^\circ$C, so $\nu = 10^{-6}$ m$^2/$s. Then, using Eq. (10.27), we have

$$Q = -2.22(0.20 \text{ m})^{5.2} \sqrt{9.81 \text{ m/s}^2 \times 0.0122} \times \log \left( \frac{1.2 \times 10^{-4} \text{ m}}{3.7 \times 0.20 \text{ m}} + \frac{1.78 \times 10^{-6} \text{ m}^2/\text{s}}{(0.20 \text{ m})^{5.2} \sqrt{9.81 \text{ m/s}^2 \times 0.0122}} \right)$$

$$= 0.050 \text{ m}^3/\text{s}$$
### Table A.5 Approximate Physical Properties of Water* at Atmospheric Pressure

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<thead>
<tr>
<th>Temperature</th>
<th>Density</th>
<th>Specific weight</th>
<th>Dynamic viscosity</th>
<th>Kinematic viscosity</th>
<th>Vapor pressure</th>
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<tr>
<td></td>
<td>kg/m³</td>
<td>N/m³</td>
<td>N ⋅ s/m²</td>
<td>m²/s</td>
<td>N/m³ abs.</td>
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<tr>
<td>0°C</td>
<td>1000</td>
<td>9810</td>
<td>1.79 × 10⁻¹</td>
<td>1.79 × 10⁻⁵</td>
<td>611</td>
</tr>
<tr>
<td>5°C</td>
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<td>9810</td>
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<td>1.51 × 10⁻⁵</td>
<td>872</td>
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<tr>
<td>10°C</td>
<td>1000</td>
<td>9810</td>
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<td>15°C</td>
<td>999</td>
<td>9800</td>
<td>1.14 × 10⁻¹</td>
<td>1.14 × 10⁻⁵</td>
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<td>20°C</td>
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<tr>
<td>25°C</td>
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<tr>
<td>30°C</td>
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<td>9632</td>
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<td>7380</td>
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<tr>
<td>45°C</td>
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<td>5.53 × 10⁻⁴</td>
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<td>50°C</td>
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<tr>
<td>60°C</td>
<td>972</td>
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<tr>
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<td>40°F</td>
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<td>62.43</td>
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<td>1.17 × 10⁻²</td>
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<td>0.726 × 10⁻²</td>
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<td>140°F</td>
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<td>60.12</td>
<td>0.637 × 10⁻²</td>
<td>0.341 × 10⁻⁵</td>
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<td>212°F</td>
<td>1.86</td>
<td>59.83</td>
<td>0.593 × 10⁻²</td>
<td>0.319 × 10⁻⁵</td>
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</tbody>
</table>

*Notes: (1) Bulk modulus $K$ of water is approximately 2.2 GPa (3.2 × 10⁷ psi); (2) Water–air surface tension is approximately 73 × 10⁻² N/m (5 × 10⁻³ lbf/ft) from 10°C to 50°C.

CALCULATION NO: DSTAP-P-005, Rev. 0
APPENDIX B

Test System Curve
DST Annulus Pumping - Test System Curve

Flow Rate (GPM)

Head (ft)
This sheet shows the status and description of the attached Design Analysis sheets.

**Discipline:** 454  
**Project/Area/Unit:** 65100541/25/9  
**Calculation No.:** MISC.

**Project No. & Name:** Double Shell Tank Annulus Pumping  
**Calculation Item:** DST Annulus Pump Miscellaneous Calculations

These calculations apply to:

- **Drawing No.:** N/A  
- **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  
- [X] No

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

---

**Table: Calculation Identification and Index**

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<th>Description</th>
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<td>Appendix B</td>
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<td>Weep Hole Sizing</td>
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APPENDIX A

Air Compressor Sizing
OBJECTIVE:
The objective of this calculation is to determine the air requirements of the Double Shell Tank Annulus air driven pump. The air requirements will be used to properly size and select an air compressor, which will be used to drive the air motor attached to the pump.

INPUT:
1.) A 2" air motor has been recommended by the manufacturer to operate the air pump.
2.) All other input was obtained from manufacturer's published data on Hydrostar System Air Motors.

REFERENCES:
1.) Instrumentation Northwest, Inc. Hydrostar System Air Motors

CALCULATION:

Air Motor Cylinder Size \( M := 2.0 \text{-in} \)

Air Consumption \( C := 0.18 \frac{SCF}{stroke} \) \((\text{Ref 1, A1})\)

Maximum Stroke Rate \( V := 60 \frac{stroke}{min} \) \((\text{Ref 1, A1})\)

Amount of Air Required \( A := C \cdot V \)
\( A = 10.8 \text{-SCFM} \)

CONCLUSION:
The air motor attached to the pump will require a flow rate of 10.8 SCFM. This value considers an operation pressure of 80 psi and a maximum stroke rate of 60 strokes per minute. An air compressor with this capability should be chosen. However, according to the manufacturer, a compressor with less performance will not harm anything. The pump will be unable to operate at higher speeds.
Introduction

When sizing an air-driven system one must consider the air motor cylinder size being used, the stroke rate desired to produce a certain production rate (GPM) and the air consumption of the air motor.

Air Cylinder Size

Without going through the formulas, outlined below is a general guideline table for selecting the proper size air motor depending on the installation depth of the HydroStar. For each motor size a range of values is given: the Maximum Full Speed Depth (MFSD) and the Maximum Recommended Depth (MRD). The Maximum Full Speed Depth is the installation depth where some loss of air motor performance will begin to occur. The Maximum Recommended Depth is the deepest installation depth we would recommend using this size air motor.

<table>
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<th>Cylinder size (in)</th>
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<th>2.0</th>
<th>2.5</th>
<th>3.25</th>
<th>4</th>
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<tr>
<td>MFSD (ft)</td>
<td>76</td>
<td>146</td>
<td>240</td>
<td>392</td>
<td>617</td>
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<tr>
<td>MRD (ft)</td>
<td>106</td>
<td>205</td>
<td>337</td>
<td>549</td>
<td>865</td>
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Production Due to Stroke Rate

The HS-8000 and HS-8001 pumps are 1.5" diameter pump cylinders with a stroke rate of 12 inches. If we assume that the pumps operate at 90% efficiency the production factor of the pumps is .082 gallons per stroke. Note: Actual field studies are the efficiency of the HydroStar pumps better than 90% at their rated operating depth capacity (see pump curves).

Example: If your pump is operating at 40 strokes per minute your production rate would be 40 * .082 = 3.29 gallons per minute.

Air Consumption (at 80 PSI operation)

Air consumption is a factor of the cylinder size you use and the stroke rate of the cylinder. The HydroStar system can operate up to 60 strokes per minute down to less than 1 stroke per minute so naturally the air consumption will vary depending on the desired operating speed.

Below is a table of factors one can use to determine the air consumption of your system in Standard Cubic Feet (SCF). These factors are just guidelines since a number of additional variables can effect air consumption.

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<th>Cylinder Size (in)</th>
<th>1.5</th>
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<th>2.5</th>
<th>3.25</th>
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<tr>
<td>Air consumption (SCF per stroke)</td>
<td>.10</td>
<td>.18</td>
<td>.30</td>
<td>.49</td>
<td>.76</td>
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</table>

Example: A HydroStar system operating at 40 strokes per minute using a 1.5 inch cylinder would need .1 * 40 = 4 SCFM air.
APPENDIX B

Desiccant Filler Replacement
OBJECTIVE:
The objective of this calculation is to determine when the desiccant filter, used to trap moisture in the air line from the compressor to the air motor, should be replaced. The air motor is used to drive the Hydrostar piston pump.

INPUT:
1.) The total volume of air that can be dried before desiccant must be replaced is 11,000 ft³.
2.) The free air from the air compressor at 40 psi is 11.0 CFM.

REFERENCES:
1.) Wilkerson Desiccant Dryers cut-sheet, from Grainger 1995 General Catalog No. 386.
2.) Dayton Air Compressor cut-sheet, from Grainger 1995 General Catalog No. 386.

CALCULATION:
Assume that the air compressor is operating at 40 psi (most conservative)

Capacity of Desiccant Filter \[ C = 11000 \text{ ft}^3 \] (Ref. 1, B2)

Free Air at 40 psi \[ A = 11.0 \text{ CFM} \] (Ref. 2, B3)

Operation Life of Filter \[ L = \frac{C}{A} \] \[ L = 16.7 \text{ hr} \]

CONCLUSION:
The desiccant filter should be replaced approximately every 16.5 hours of operation. The desiccant material also contains 25% cobalt blue coloring which turns pink to indicate saturation.
REGENERATIVE DESICCANT COMPRESSED AIR DRYERS

PREVENT LIQUID WATER FROM FORMING IN AIR SYSTEMS EXPOSED TO TEMPERATURES BELOW FREEZING. ADJUSTABLE FOR -40°F OR -100°F PRESSURE DROP.

APPLICATIONS: ADDED PROTECTION WHERE AIR IS USED FOR AIR TOOLS, PUMPS, CYLINDERS AND VALVES, ELECTRIC CIRCUITS AND INSTRUMENTATION, AIRPLANE AND ANTIENNA PRESSURIZATION, DUST COLLECTORS, DUST BLASTING AND PAINTING. ULTRA-DRY COMPRESSED AIR FOR CRITICAL APPLICATIONS SUCH AS AIR AGITATION, AIR BEARINGS, AIR BLANKETING, AIR CONVEYING AND FLUIDISATION, FINISH GRIT BLASTING, NITROGEN REPLACEMENT FOR ELECTRONIC CHIP MANUFACTURING, FEEDBACK FOR CONVECTION GENERATORS.

- LARGE DESICCANT BEDS PROVIDE CONSISTENT OUTLET PRESSURE DROP POINTS
- TOWER REPRESSURIZATION PROMOTES LONG DESICCANT LIFE
- BED DESIGN MINIMIZES PURGE AIR USAGE
- SOLID STATE TIMER ACCURATELY CONTROLS TOWER CYCLING
- HEAVY DUTY PURGE EXHAUST MUFFLER FOR QUIET OPERATION
- USES EASILY REPLACED BULK DESICCANT—NO SPECIAL CARTRIDGES REQUIRED
- REMOVABLE, CLEANABLE STAINLESS STEEL FLOW DIFFUSERS
- NON-LUBRICATED, SOFT SEATED CONTROL VALVES
- ENCLOSED IN DURABLE METAL CABINET FOR EASY WALL MOUNTING
- FRONT-MOUNTED CONTROL PANEL WITH POWER-ON RIGHT, TOWER PRESSURE GAUGES AND ON/OFF SWITCH

DESICCANT AIR DRYER ORDERING DATA

<table>
<thead>
<tr>
<th>Flow Capacity SCFM @ 100 PSIG (–40°F P.D.P.)</th>
<th>In/Out Connection NPTF</th>
<th>Dimensions H x W x D</th>
<th>Hankison Stock No.</th>
<th>Stock List No.</th>
<th>Shpg. Wt.</th>
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<td>5 4</td>
<td>1/2</td>
<td>30 20 6</td>
<td>DHW-5</td>
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<td>10 8</td>
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<td>30 30 8</td>
<td>DHW-25</td>
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Note: Electrical: 115VAC 10-60 Hz, NEMA 1. Includes 6" power cord & plug. Minimum/Maximum Operating Pressure: 50/150 PSI. Minimum Operating Temperature: 32°F if inlet temp. exceeds 120°F, use aftercooler to precool incoming air—see index under Aftercoolers.

DESICCANT DRYERS

- REMOVE HARMFUL MOISTURE FROM COMPRESSED AIR SYSTEMS THROUGH DIRECT ADSORPTION
- USEFUL FOR SMALL SYSTEMS AND MOISTURE SENSITIVE POINT-OF-USE APPLICATIONS
- USED WITH AIR TOOLS, INSTRUMENTS, AND PAINT SPRAYING EQUIPMENT, OR WHERE AIR LINES MUST BE PROTECTED FROM FREEZE-UP

Desiccant dryers provide -45°F atmospheric dewpoint (95% relative humidity at 78°F). Units rated to 150 PSI at 125°F.

NOS. SZ610 and SZ611 have quick-release polycarbonate bowls for easy inspection and replacement of saturated desiccant.

No. SZ610 has quick-disconnect aluminum bowl with desiccant saturation indicator.

Silica gel desiccant material contains 25% cobalt blue coloring which turns pink to indicate saturation. When desiccant becomes saturated, replace with new desiccant, or regenerate at 350°F. Replacement desiccant material also available. See table below. Wilkerson brand.

DESICCANT DRYER ORDERING DATA

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(*) Total volume of air that can be dried before desiccant must be replaced or regenerated.

REPLACEMENT DESICCANT

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WHOLESALE PRICES—GRAINGER
STATIONARY TANK MOUNTED AND BASE PLATE AIR COMPRESSORS

EXCLUSIVE DAYTON DESIGN RELIABLY POWERS AIR TOOLS, PAINT SPRAYERS, SANDBLAST EQUIPMENT, AIR CYLINDERS, AND SMALL MACHINES

THE DAYTON CAST IRON DIFFERENCE
- Longer life—up to 100% longer pump life than comparable air compressors
- Higher Air Flow—Up to 10% more CFM than comparable models
- Higher Pressure—Maximum 135 PSI for a broader range of applications
- Higher Duty Cycle—Runs up to a 65% duty cycle vs. the standard 50/50 duty cycle

TANK MOUNT MODELS INCLUDE
- High flow air cooling system reduces pump temperature
- Copper discharge line for improved durability and cooling
- Single and 3-phase open dripproof motors with thermal protection
- NEMA 1 enclosure pressure switch with gauge
- 30 gallon stationary ASME air tank
- Pressure switch setting 95 PSI On and 135 PSI Off (Except Base Plate Nos. 48242 and 48243)
- Comply with State of California code 462 (L) (2)
- Charcoal gray metallic finish

HI-PERFORMANCE CAST IRON PUMP DESIGN
- Improved head design with flow reed valves
- Solberg paper element filter for clean operation
- One piece connecting rod for maximum reliability
- Solid cast iron cylinders for longer life
- Cast iron & crankshaft crankcase for extended life
- Rear oil sight glass for easy inspection
- Quick stick and switch for better oil control

PUMP SPECIFICATIONS

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BASE PLATE MODELS
- No. 48242 and 48243
- Perfect for fire sprinkler applications (verify local codes and regulations for compliance)
- Prewired (230V) with pneumatically controlled package
- Pressure switch setting 30 PSI On and 40 PSI Off

With Magnetic Starters

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APPE-414 Rev. 0

*For specific HP rating explanations, see page 2214. (1) ASME code air tanks. (2) As rated by the standard 60 Hz bearing life of the pump. Individual reservoir life will vary depending on duty cycle, ambient temperature, maintenance performed, air intake quality, and manufacturing part tolerances. (3) Magnetic starters not mounted and wired, provided separately.

(2226) **Net Prices. Not Subject To Discounts**
APPENDIX C

Test Tank Modification Analysis
OBJECTIVE:
The objective of this calculation is to do a "quick check" on the adequacy of the testing equipment and the legs used on the DST Annulus Pumping Test Tank.

DESIGN INPUT:
1.) Test Skid Submersible Pump Sketch, ES-259-001, Rev. 0
2.) Stress allowables are based on the Allowable Stress Design, Ninth Edition.

ASSUMPTIONS:
As stated in the calculation.

REFERENCES:
1.) Pump Sketch, ES-259-001, Rev. 0

CONCLUSION:
The tank and its components are more than adequate for use.
Inside Diameter of Tank \[ D_j = 59 \text{ in} \]

Depth of Tank \[ L = 55 \text{ in} \]

Volume of Tank \[ V = \frac{\pi D_j^2}{4} L \]

Density of Water @ 50 F \[ \rho = 62.4 \frac{\text{lb}}{\text{ft}^3} \]

Weight of Water \[ W_w = V \rho \]

Weight of Equipment \[ W_e = 300 \text{ lb} \]

Total Weight \[ W = W_w + W_e \]

Check 4" x 4" x 1/4" Tubing Leg Bracing

Assume that only one center beam takes the load and the ends are fixed. (Ultra conservative)

Area of Tubing \[ A = 3.59 \text{ in}^2 \]

Section Modulus \[ S = 4.11 \text{ in}^3 \]

Moment of Inertia \[ I = 8.22 \text{ in}^4 \]

Yield Strength \[ S_y = 36000 \text{ psi} \]

Allowable Shear \[ \tau_{all} = 0.4 \cdot S_y \]

\[ \tau_{all} = 14400 \text{ psi} \]
Shear Stress \[ \tau := \frac{W}{A} \quad \tau = 1596.1 \text{ psi} \]

Factor of Safety \[ FS := \frac{\tau_{all}}{\tau} \quad FS = 9.022 \]

Allowable Bending \[ \sigma_{all} := 0.6 \cdot S_y \quad \sigma_{all} = 21600 \text{ psi} \]

Bending Moment \[ M := \frac{W \cdot 44 \cdot \text{in}}{8} \quad M = 2626.2 \text{ lb-ft} \]

Bending Stress \[ \sigma := \frac{M}{S} \quad \sigma = 7667.8 \text{ psi} \]

Factor of Safety \[ FS := \frac{\sigma_{all}}{\sigma} \quad FS = 2.817 \]

Welds

Assume only the 1/4" fillet weld on the end of one of the center beams takes the load. This is ultra conservative.

Dimensions of Weld \[ b := 4 \cdot \text{in} \quad d := 4 \cdot \text{in} \]

Line Area \[ A_w := 2 \cdot d \quad A_w = 8 \cdot \text{in} \]

Bending Area \[ S_w := \frac{d^2}{3} \quad S_w = 5.333 \cdot \text{in}^2 \]

Force on Weld \[ f := \frac{W}{A_w} + \frac{M}{2 \cdot S_w} \quad f = 3670.8 \cdot \frac{\text{lb}}{\text{in}} \]

Allowable Weld Stress (assume E60 electrode) \[ S := 0.3 \cdot 60000 \cdot \text{psi} \quad S = 18000 \text{ psi} \]

Required Weld Size \[ w := \frac{f}{0.707 \cdot S} \quad w = 0.288 \cdot \text{in} \]

1/4" fillet welds are used. There is another welded cross beam under the tank, which will distribute the load and greatly stiffen the bracing. Therefore, by judgment, the welds are more than adequate for the load.
**Pump Support Channel - C4 x 5.4**

Area of Channel

\[ A = 1.59 \text{ in}^2 \]

Moment of Inertia

\[ I = 3.85 \text{ in}^4 \]

Section Modulus

\[ S = 1.93 \text{ in}^3 \]

Length

\[ L = 5.56 + 4.5 - \text{in} \]

Moment

\[ M = \frac{W_e L}{28} \]

\[ M = 100.8 \text{ lb-ft} \]

Shear Stress

\[ \tau = \frac{W_e}{2.4 A} \]

\[ \tau = 94.3 \text{ psi} \]

Factor of Safety

\[ FS = \frac{\tau_{all}}{\tau} \]

\[ FS = 152.6 \]

Bending Stress

\[ \sigma = \frac{M}{S} \]

\[ \sigma = 626.6 \text{ psi} \]

Factor of Safety

\[ FS = \frac{\sigma_{all}}{\sigma} \]

\[ FS = 34.471 \]

**Pump Plate**

Width

\[ w = 6 \text{ in} \]

Length

\[ l = 16.1875 \text{ in} \]

Thickness

\[ t = 0.5 \text{ in} \]

Shear Stress

\[ \tau = \frac{W_e}{t \cdot w} \]

\[ \tau = 100 \text{ psi} \]

Factor of Safety

\[ FS = \frac{\tau_{all}}{\tau} \]

\[ FS = 144 \]

Bending Stress

\[ \sigma = \frac{12 \, W_e \cdot L}{(8 \cdot w \cdot t^2)} \]

\[ \sigma = 19350 \text{ psi} \]

Factor of Safety

\[ FS = \frac{\sigma_{all}}{\sigma} \]

\[ FS = 1.116 \]
APPENDIX D

Test Tank Sizing
OBJECTIVE:
The objective of this calculation is to size a test tank that will be used to perform run-in and maintenance tests on the DST submersible annulus pumps.

INPUT:
1.) The submersible pump has a rating of 3.6 HP. (Ref 1, D2)

ASSUMPTIONS:
1.) A 20 degree rise in temperature over an 8 hour test period is acceptable.
2.) Tandem pumps (2 pumps in series) will be tested. Therefore, assume that 7.2 HP is dissipated as heat into the test water.

REFERENCES:
1.) Performance data of Flygt BS-2060 submersible pump.

CALCULATION:
The Flygt submersible pump to be used for annulus pumping has a power rating of 3.6 HP. Two pumps will be tested in tandem. Therefore, assume that 7.2 HP is lost to heat which is dissipated into the test tank. Also, assume that the test will last a period of 8 consecutive hours, 20 degrees F rise in temperature is acceptable, and the initial temperature of the water is 50 degrees F.

By the First Law of Thermodynamics, Q - W = ΔU, where Q is heat transferred into the system, W is work out of the system and ΔU is the change of internal energy. In this case, no work is going into or out of the system, thus W = 0. For solids and incompressible liquids, the change in internal energy can be determined by the relation ΔU = mc(T₂ - T₁), where m is the mass, C is the specific heat, T₁ is the initial temperature, and T₂ is the final temperature. Thus, the First Law equation becomes Q = mC(T₂ - T₁), or m = Q/(ΔT*C).

Heat Transfer to Water
Q = 7.2 hp
Q = 18319.49 BTU/hr

Density of Water @ 50 F
ρ = 62.4 lb/ft³

Specific Heat of Water
C = 1 BTU/(lb·F)
DESIGN ANALYSIS

Client: CH2M HILL Hanford Group
Subject: DOUBLE SHELL TANK ANNULUS PUMPING
Location: 200 E AREA HANFORD

Change in Temperature
\[ \Delta T = \frac{20 \text{ F}}{8 \text{ hr}} \]
\[ \Delta T = 2.5 \cdot \frac{\text{F}}{\text{hr}} \]

Required Mass of Water
\[ m = \frac{Q}{\Delta T \cdot C} \]
\[ m = 7.328 \times 10^3 \cdot \text{lb} \]

Volume of Water for Given Mass
\[ V = \frac{m}{\rho} \]
\[ V = 117.43 \cdot \text{ft}^3 \]
\[ V = 878.5 \cdot \text{gal} \]

Tank Sizing

<table>
<thead>
<tr>
<th>Volume (ft^3)</th>
<th>Depth (ft)</th>
<th>Diameter (ft)</th>
<th>Length (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>117.5</td>
<td>1</td>
<td>12.23</td>
<td>10.84</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>8.65</td>
<td>7.66</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>7.06</td>
<td>6.26</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>6.12</td>
<td>5.42</td>
</tr>
<tr>
<td>5</td>
<td>1</td>
<td>5.47</td>
<td>4.85</td>
</tr>
<tr>
<td>6</td>
<td>1</td>
<td>4.99</td>
<td>4.43</td>
</tr>
<tr>
<td>7</td>
<td>1</td>
<td>4.62</td>
<td>4.10</td>
</tr>
<tr>
<td>8</td>
<td>1</td>
<td>4.32</td>
<td>3.83</td>
</tr>
<tr>
<td>9</td>
<td>1</td>
<td>4.08</td>
<td>3.61</td>
</tr>
<tr>
<td>10</td>
<td>1</td>
<td>3.87</td>
<td>3.43</td>
</tr>
<tr>
<td>11</td>
<td>1</td>
<td>3.69</td>
<td>3.27</td>
</tr>
<tr>
<td>12</td>
<td>1</td>
<td>3.53</td>
<td>3.13</td>
</tr>
<tr>
<td>13</td>
<td>1</td>
<td>3.39</td>
<td>3.01</td>
</tr>
<tr>
<td>14</td>
<td>1</td>
<td>3.27</td>
<td>2.90</td>
</tr>
<tr>
<td>15</td>
<td>1</td>
<td>3.16</td>
<td>2.80</td>
</tr>
</tbody>
</table>
**FLUOR FEDERAL SERVICES**

**DESIGN ANALYSIS**

Client: CH2M HILL Hanford Group  
Subject: DOUBLE SHELL TANK ANNULUS PUMPING  
DST ANNULUS PUMP MISCELLANEOUS CALCULATIONS  
Location: 200 E AREA HANFORD

**Submersible Pump Run-In Test**

![Diagram of submersible pump run-in test setup]

**CONCLUSION:**

Considering that 7.2 HP is lost to heat, an allowable temperature increase of 20° over an eight hour period, 117.5 ft³ of 880 gallons of water is required. This number is conservative since it is unlikely that all power will be dissipated as heat into the water. A chart showing relative tank sizes for the required volume is seen in the chart above.
From Flygt BS-2060.390 Performance Data, per the Imp. Code of 232, the pump is rated at 3.6 HP.
APPENDIX E

Radiation Resistance of Flygt Submersible Pump Elastomers
OBJECTIVE:
The objective of this calculation is to explore the elastomers used in the Flygt submersible pump and verify their adequacy in the radiation environment.

INPUT:
1.) The expected radiation dose is $8.8 \times 10^6$ Rad. (Ref. 1, E3)
2.) The maximum temperature is 140$^\circ$ F. (Ref. 1, E3)

REFERENCES:
1.) Annulus Pump Submersible Pump Specification 4975-59-P1, Rev. 0
2.) Flygt Pump Material/Component List

CALCULATION:
See table on next page (E2).

CONCLUSION:
The radiation resistance of the elastomers used in the Flygt submersible pump are higher than the expected radiation dose. Therefore, the elastomers used in the Flygt pump will be sufficient for use in the design life of the pump.
<table>
<thead>
<tr>
<th>Pump Component</th>
<th>Trade Name</th>
<th>Material</th>
<th>Radiation Exposure (Rad)</th>
<th>Radiation Resistance (Rad)</th>
<th>Maximum Service Temperature</th>
<th>Acceptable?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluorocarbon Rubber, FPM</td>
<td>Viton</td>
<td>O-ring</td>
<td>$8.8 \times 10^6$</td>
<td>$1 \times 10^8$</td>
<td>$+90 , ^\circ C / +194 , ^\circ F$</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Seal Sleeve</td>
<td>$8.8 \times 10^6$</td>
<td>$1 \times 10^8$</td>
<td>$+90 , ^\circ C / +194 , ^\circ F$</td>
<td>Yes</td>
</tr>
<tr>
<td>Nitrile Rubber, NBR</td>
<td>BUNA-N</td>
<td>Diffuser Coating</td>
<td>$8.8 \times 10^6$</td>
<td>$8 \times 10^8$</td>
<td>$+90 , ^\circ C / +194 , ^\circ F$</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>O-ring</td>
<td>$8.8 \times 10^6$</td>
<td>$9 \times 10^8$</td>
<td>$+70 , ^\circ C / +158 , ^\circ F$</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Oil Housing Coating</td>
<td>$8.8 \times 10^6$</td>
<td>$10 \times 10^8$</td>
<td>$+90 , ^\circ C / +194 , ^\circ F$</td>
<td>Yes</td>
</tr>
<tr>
<td>Chloroprene Rubber, CR</td>
<td>Neoprene</td>
<td>Motor Cable</td>
<td>$8.8 \times 10^6$</td>
<td>$3.5 \times 10^7$</td>
<td>$+70 , ^\circ C / +158 , ^\circ F$</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Seal Sleeve</td>
<td>$8.8 \times 10^6$</td>
<td>$3.5 \times 10^7$</td>
<td>$+70 , ^\circ C / +158 , ^\circ F$</td>
<td>Yes</td>
</tr>
</tbody>
</table>
3.1.5 These pumps will be stored in a warehouse and installed only in the case of a leak into the tank annulus. During the time in storage it is anticipated that they will be periodically performance tested to ensure the availability of reliable pumps should there be a leak.

3.1.6 The maximum weight of the pump assembly, including motor and water, shall not exceed 1,000 lbs. The Seller shall specify both wet and dry weights of the equipment furnished.

3.2 Environmental Conditions

3.2.1 The transfer pump shall be able to withstand the following conditions inside the pump pit and in the annulus area:

<table>
<thead>
<tr>
<th>LOCATION</th>
<th>TEMPERATURE</th>
<th>% RELATIVE HUMIDITY</th>
<th>RADIATION EXPOSURE IN RAD</th>
</tr>
</thead>
<tbody>
<tr>
<td>PUMP PIT</td>
<td>15 to 150 °F</td>
<td>0 to 100</td>
<td>50</td>
</tr>
<tr>
<td>TANK VAPOR SPACE</td>
<td>50 to 140 °F</td>
<td>0 to 100</td>
<td>400</td>
</tr>
<tr>
<td>ANNULUS LIQUID</td>
<td>65 to 140 °F</td>
<td>N/A</td>
<td>500</td>
</tr>
</tbody>
</table>

3.3 Fluid Pumped

3.3.1 The radioactive sludge settled in the tanks consists mainly of insoluble oxides and/or hydroxides of aluminum, iron, manganese, and zirconium.

3.3.2 Fluid Properties

<table>
<thead>
<tr>
<th>Specific Gravity</th>
<th>1.47</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absolute Viscosity, Centipoise</td>
<td>1.0 to 30 cP</td>
</tr>
<tr>
<td>Solids Content (vol.%)</td>
<td>0 to 20.0</td>
</tr>
<tr>
<td>Particle Size, Micron</td>
<td>0.5 to 4000μ</td>
</tr>
<tr>
<td>Abrasiveness, Miller Number (ASTM G75-82)</td>
<td>less than 100</td>
</tr>
<tr>
<td>Temperature (transfer)</td>
<td>65 to 140 °F</td>
</tr>
<tr>
<td>Temperature (flush or dilution)</td>
<td>35 to 150 °F</td>
</tr>
<tr>
<td>PH</td>
<td>7 – 14</td>
</tr>
</tbody>
</table>

* Although 50-micron particle size is the nominal design point, the pump must be fully capable of operating with the full range of particle sizes. The number of larger (500 to 4000 micron) particles will be relatively small (less than 1% of the total particles). Particles in the range of 50 to 500 micron will constitute less than 5% of the total particles. Particles ranging in size from 0.5 to 50 micron will constitute approximately 95% of the total particles.
## Chemical Resistance Table

**Product:** 2060 390 Stainless Steel  
**Liquid:** Aluminium Hydroxide  
**Concentration:** All  
**Chemical Denomination:** Al(OH)₃ or AlO(OH)

<table>
<thead>
<tr>
<th>Material</th>
<th>Component</th>
<th>°F</th>
<th>°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>STAINLESS STEEL, AISI 316L</td>
<td>Bearing Cover</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Connection Housing</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Cover</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Data Plate</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Diffuser Uncoupled</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Entrance Cover</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Gland Screw</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Jacket</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Lifting Handle</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Metallising</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Nipple Pipe</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Oil Housing</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Outer Casing</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Screw</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Sleeve</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Stator Housing</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Strainer Bottom</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>STAINLESS STEEL, AISI 329</td>
<td>Impeller</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Shaft</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>SINTERED ALUMINIUM OXIDE</td>
<td>Mechanical Seal</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Seal Ring</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>CEMENTED CARBIDE, WCRR</td>
<td>Seal Ring</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>SILICON CARBIDE, RIGS</td>
<td>Mechanical Seal</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>FLUOR. ETHYLENE PROPYLENE, FEP</td>
<td>Motor Cable</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>FLUOROCARBON RUBBER, FPM</td>
<td>O-ring</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Seal Sleeve</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>NITRILE RUBBER, NBR</td>
<td>Diffuser Coat.</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>O-ring</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Oil Housing Coated</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>ARAMID FIBRE, RUBBER BONDED</td>
<td>Pipe</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>CHLOROPRENE RUBBER, CR</td>
<td>Motor Cable</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Seal Sleeve</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
APPENDIX F

Weep Hole Sizing
OBJECTIVE:
The objective of this calculation is to determine the effects of placing a "weep hole" in the discharge piping of the air pump. A 1/16" weep hole will be drilled into the 3/4" discharge piping just after the pump discharge. The hole will allow the discharge column to drain once pumping is complete.

INPUT:
1.) The pump piston is 1.5" in diameter and has a stroke of 12". (Ref. 1, F4)
2.) The pump displaces fluid at a maximum rate of 60 strokes/min. (Ref. 1, F4)

METHODS:
1.) Calculations are performed using Mathcad 6.0, MathSoft Inc.
2.) Bernoulli's equation is used to determine the velocity of fluid at the weep hole.
   For ease of calculation, the velocity at the weep hole is determined by considering a constant elevation head and neglecting the effects of the pump discharge.

ASSUMPTIONS:
1.) The highest elevation of the discharge fluid is 50 feet above the elevation of the weep hole.
2.) The air pump is operating at its maximum speed of 60 fluid displacement strokes/min.
3.) Losses due to friction are negligible.
4.) The pump is 88% efficient.
5.) The entrance of the weep hole has a resistance coefficient of K = 0.5.

REFERENCES:
1.) Instrumentation Northwest, Inc. Hydrostar System Air Motors

CONCLUSIONS:
A 1/16" weep hole placed near the pump discharge will have a flow rate of 0.362 gal/min. Since the pump displaces 4.86 gal/min, this is a minor loss. A weep hole of this size would effectively drain the air pump discharge piping and would not greatly effect the pumping flow rate.
**FLUOR FEDERAL SERVICES**

**DESIGN ANALYSIS**

**Client:** CH2M HILL Hanford Group  
**Subject:** DOUBLE SHELL TANK ANNULUS PUMPING  
**Location:** 200 E AREA HANFORD

**Client:**  
**Project/Area/Unit:** 65100541 / 25 / 9

**Subject:**  
**Date:** 05 / 03 / 00

**Location:**  
**Checked:** By: P. M. DORSH

**Duration:**  
**By:**

---

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Calculation</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length of Pump Stroke</td>
<td>$L := 12 \text{ in}$</td>
<td></td>
</tr>
<tr>
<td>Pump Piston Diameter</td>
<td>$D := 1.5 \text{ in}$</td>
<td></td>
</tr>
<tr>
<td>Pump Piston Surface Area</td>
<td>$A := \frac{\pi}{4} D^2$</td>
<td></td>
</tr>
<tr>
<td>Pump Efficiency</td>
<td>$e := 0.88$</td>
<td></td>
</tr>
<tr>
<td>Volume of Fluid Displaced by Pump</td>
<td>$V := A \cdot L \cdot e$</td>
<td>$V = 18.661 \text{ in}^3$</td>
</tr>
<tr>
<td>Maximum Stroke Rate</td>
<td>$R := 60 \cdot \frac{\text{stroke}}{\text{min}}$</td>
<td></td>
</tr>
<tr>
<td>Pump Flow Rate</td>
<td>$Q_p := 18.7 \cdot \frac{\text{in}^3}{\text{stroke}} \cdot R$</td>
<td>$Q_p = 18.7 \frac{\text{in}^3}{\text{sec}}$</td>
</tr>
<tr>
<td></td>
<td>$Q_p = 4.857 \frac{\text{gal}}{\text{min}}$</td>
<td></td>
</tr>
<tr>
<td>Weep Hole Diameter</td>
<td>$D_w := \frac{1}{16} \text{ in}$</td>
<td></td>
</tr>
<tr>
<td>Weep Hole Area</td>
<td>$A_w := \frac{\pi}{4} D^2_w$</td>
<td>$A_w = 0.003 \text{ in}^2$</td>
</tr>
<tr>
<td>Highest Elevation of Discharge Fluid</td>
<td>$z_a := 50 \text{ ft}$</td>
<td></td>
</tr>
<tr>
<td>Elevation of Weep Hole</td>
<td>$z_b := 0 \text{ ft}$</td>
<td></td>
</tr>
</tbody>
</table>

*Assumption 1*

*Assumption 4*
Considering Bernoulli's equation, \( P_a/\gamma + V_a^2/2g + z_a = P_b/\gamma + V_b^2/2g + z_b + h_L \), with position "a" located at the highest elevation point and position "b" located at the weep hole, we find the velocity at the weep hole to be:

\[ V_b^2/2g = (P_a/\gamma - P_b/\gamma) + (V_a^2/2g) + (z_a - z_b) - h_L \]

or, with zero terms canceled out (both pressures are atmospheric and \( V_a = 0 \)) and \( h_L = KV_b^2/2g \) (assuming \( K = 0.5 \)):

\[ 1.5V_b^2/2g = z_a \]

Velocity of Fluid Exiting Weep Hole

\[ V = \sqrt{\frac{z_a (2g)}{1.5}} \quad V = 37.815 \text{ ft/sec} \]

Flow Rate of Fluid at Weep Hole

\[ Q_w = V \cdot A_w \quad Q_w = 1.392 \text{ in}^3/\text{sec} \]

\[ Q_w = 0.362 \text{ gal/min} \]

Flow Rate

\[ Q = Q_p - Q_w \quad Q = 4.496 \text{ gal/min} \]

Efficiency

\[ e = \frac{Q}{Q_p} \quad e = 0.926 \]
Introduction

When sizing an air-driven system one must consider the air motor cylinder size being used, the stroke rate desired to produce a certain production rate (GPM) and the air consumption of the air motor.

Air Cylinder Size

Without going through the formulas, outlined below is a general guideline table for selecting the proper size air motor depending on the installation depth of the Hydrostar. For each motor size a range of values is given: the Maximum Full Speed Depth (MFS&D) and the Maximum Recommended Depth (MRD). The Maximum Full Speed Depth is the installation depth where some loss in air motor performance will begin to occur. The Maximum Recommended Depth is the deepest installation depth we would recommend using this size air motor.

<table>
<thead>
<tr>
<th>Cylinder size (in)</th>
<th>1.5</th>
<th>2.0</th>
<th>2.5</th>
<th>3.25</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>MFS&amp;D (ft)</td>
<td>76</td>
<td>146</td>
<td>240</td>
<td>392</td>
<td>617</td>
</tr>
<tr>
<td>MRD (ft)</td>
<td>106</td>
<td>205</td>
<td>337</td>
<td>549</td>
<td>865</td>
</tr>
</tbody>
</table>

Production Due to Stroke Rate

The HS-8000 and HS-8001 pumps are 1.5" diameter pump cylinders with a stroke rate of 12 inches. If we assume that the pumps operate at 90% efficiency the production factor of the pumps is .082 gallons per stroke. Note: Actual field studies rate the efficiency of the Hydrostar pumps better than 90% at their rated operating depth capacity (see pump curves).

Example: If your pump is operating at 40 strokes per minute your production rate would be 40 * .082 = 3.29 gallons per minute.

Air Consumption (at 80 PSI operation)

Air consumption is a factor of the cylinder size you use and the stroke rate of the cylinder. The Hydrostar system can operate up to 60 strokes per minute down to less than 1 stroke per minute so naturally the air consumption will vary depending on the desired operating speed.

<table>
<thead>
<tr>
<th>Cylinder Size (in)</th>
<th>1.5</th>
<th>2.0</th>
<th>2.5</th>
<th>3.25</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air consumption (SCF per stroke)</td>
<td>.10</td>
<td>.18</td>
<td>.30</td>
<td>.49</td>
<td>.76</td>
</tr>
</tbody>
</table>

Example: A Hydrostar system operating at 40 strokes per minute using a 1.5 inch cylinder would need .1 * 40 = 4 SCFM air.

(cont.)
APPENDIX G

Annulus Pump Assembly
The objective of this calculation is to verify the adequacy of a typical annulus pump assembly flange and lifting bails. A typical balance of the entire pump assembly is also included.

**INPUT:**
1.) The weight of the pump assembly is 1300 lbs.

**METHODS:**
1.) Calculations are performed using Mathcad 6.0, MathSoft Inc.
2.) Standard engineering practices are used to calculate stresses in the components and welds.

**ASSUMPTIONS:**
1.) As stated in the calculation.

**REFERENCES:**
1.) Drawing H-2-90161, Standard Rigid Lifting Bails.
2.) Drawing H-14-104134, Rev. 0, Pumps Assembly Annulus Pump Pit 241-AN-01B Thru -07B (typical).

**CONCLUSIONS:**
The bails and associated components are adequate for vertical lifts. However, in a worst case scenario, the capacity of the bails for lateral lifts are exceeded. The bending stresses in the bail created by a lateral lift surpasses the allowable stress, but are still below the yield stress for the material. It is unknown how the assembly will actually be lifted from the horizontal position. Any additional bracing or lifting points will lower the bending stresses to the allowable level.

Pump Assembly Balance Calculation performed by Roger Schroeder is located on page G6.
Lifting Bail Capacity

Lifting Bail Capacity (vertical capacity) = 795 lbs^2 = 1590 lbs (per H-2-90161-15) (Ref. 1, G7)

Assembly Weight = 1300 lbs

Lifting Bail Support Welds

Weight of Assembly  \( W := 1300 \text{ lb} \)

Diameter of Weld  \( D := 3.068 \text{ in} \)

Length of Weld  \( L := \pi D - 2 \)  \( L = 19.277 \text{ in} \)

Strength of Weld  \( S_w := 60000 \text{ psi} \)

(Assuming E60 electrodes)

Allowable Weld Force  \( f_{all} := 0.3 \cdot S_w \)  \( f_{all} = 1.8 \cdot 10^8 \text{ psi} \)

Horizontal Shear on Weld  \( f_w := \frac{W}{L} \)  \( f_w = 67.439 \frac{\text{lb}}{\text{in}} \)

Minimum Allowable Fillet Weld Required by Design  \( t := \frac{f_w}{0.707 \cdot f_{all}} \)  \( t = 0.005 \text{ in} \)

Factor of Safety  \( FS := \frac{1875 \text{ in}}{t} \)  \( FS = 35.382 \)

Lifting the Pump Assembly

It is assumed that the pump assembly will be lifted from a horizontal position to the vertical position (for insertion into the annulus riser) via the 2 lifting bails. The stresses in the bail will be checked for this lift. Note: only half the weight of the pump assembly will be lifted since one end is still in contact with the ground.

Weight of Assembly on each bail  \( W := \frac{650 \text{ lb}}{2} \)  \( W = 325 \text{ lb} \)
Moment on Weld on each Bail \[ M := W \cdot 10 \cdot \text{in} \]

Diameter of Weld \[ D := 0.875 \cdot \text{in} \]

Length of Weld \[ L := \pi D \cdot 2 \]

Bending \[ S_w := \left( \frac{\pi D^2}{4} \right)^2 \]

Force on Weld \[ f_w := \frac{W + M}{L} S_w \]

Strength of Weld (Assuming E60 electrodes) \[ S_w := 60000 \cdot \text{psi} \]

Allowable Weld Force \[ f_{all} := 0.3 \cdot S_w \]

Minimum Allowable Fillet Weld Required by Design \[ t := \frac{f_w}{0.707 \cdot f_{all}} \]

Factor of Safety \[ FS := \frac{3125 \cdot \text{in}}{t} \]

Bending Stress in Bail \[ \sigma := \frac{M \cdot c}{I} \]

Moment of Inertia \[ I := \left( \frac{\pi D^4}{64} \right) \cdot 2 \]

Radius \[ c := \frac{7}{16} \cdot \text{in} \]

Yield Stress \[ S_y := 36000 \cdot \text{psi} \]

Allowable Bending Stress \[ S_o := S_y \cdot 0.6 \]

The bending stress of the lifting bail is slightly higher than the allowable stress, but is much lower than yield stress.
Bending Stress in Bail Support

Diameter

\[ D = 3.068 \text{ in} \]

Moment of Inertia

\[ I = \frac{\pi D^4}{64} \cdot 2 \]

\[ I = 8.698 \cdot \text{in}^4 \]

Radius

\[ c = \frac{D}{2} \]

\[ c = 1.534 \cdot \text{in} \]

Bending Moment

\[ M = W \cdot 22 \cdot \text{in} \]

Bending Stress

\[ \sigma = \frac{M \cdot c}{I} \]

\[ \sigma = 1261 \cdot \text{psi} \]

Yield Stress

\[ S_y = 25000 \cdot \text{psi} \]

Allowable Bending Stress

\[ S_\sigma = S_y \cdot 0.6 \]

\[ S_\sigma = 15000 \cdot \text{psi} \]

Based on the low stresses in the bail support pipe, the support welds are still acceptable.

Pump Flange

The Pump Flange is under the most stress during installation. For conservatism and ease of calculation assume that the plate is 8" wide, and simply supported at the lifting bails.

Width of Plate

\[ w = 8 \cdot \text{in} \]

Thickness of Plate

\[ t = 0.875 \cdot \text{in} \]

Moment of Inertia

\[ I = \frac{w \cdot t^3}{12} \]

\[ I = 0.447 \cdot \text{in}^4 \]

Length of Plate

\[ L = \sqrt{(7.375 \cdot 2)^2 + (6.75 \cdot 2)^2} \cdot \text{in} \]

\[ L = 19.995 \cdot \text{in} \]
FLUOR FEDERAL SERVICES

DESIGN ANALYSIS

Client: CH2M HILL Hanford Group
Subject: DOUBLE SHELL TANK ANNULUS PUMPING
Location: DST ANNULUS PUMP MISCELLANEOUS CALCULATIONS
Location: 200 E AREA HANFORD

Client: CH2M HILL Hanford Group
Subject: DOUBLE SHELL TANK ANNULUS PUMPING
Location: DST ANNULUS PUMP MISCELLANEOUS CALCULATIONS
Location: 200 E AREA HANFORD

Modulus of Elasticity

\[ E = 30 \times 10^6 \text{ psi} \]

Weight of Assembly

\[ W = 1300 \text{ lb} \]

Plate Deflection

\[ \delta = \frac{W \cdot L^3}{48 \cdot E \cdot I} \]
\[ \delta = 0.016 \text{ in} \]

Moment

\[ M = \frac{W \cdot L}{2} \]
\[ M = 1083.1 \text{ lb ft} \]

Bending Stress

\[ \sigma = \frac{M \cdot t}{I/2} \]
\[ \sigma = 12731.7 \text{ psi} \]

Shear Stress

\[ \tau = \frac{W}{w \cdot t} \]
\[ \tau = 185.714 \text{ psi} \]

Yield Stress

\[ S_y = 25000 \text{ psi} \]

Allowable Bending Stress

\[ S_{\sigma} = S_y \times 0.6 \]
\[ S_{\sigma} = 15000 \text{ psi} \]

Allowable Shear Stress

\[ S_{\tau} = S_y \times 0.4 \]
\[ S_{\tau} = 10000 \text{ psi} \]

Both stresses are well below the allowable. Therefore, the plate is acceptable.
### JUMPER CALCULATION

**JOB NO.**
AZ FARM

**DRAWING NO.**
H-14-104-13B

**DATE**
5/8/00

**PAGE**

---

<table>
<thead>
<tr>
<th>PART</th>
<th>DESCRIPTION</th>
<th>WEIGHT (LBS)</th>
<th>X - X AXIS</th>
<th>Y - Y AXIS</th>
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<tbody>
<tr>
<td>A</td>
<td>PL 25&quot; THK 6&quot; TRIM</td>
<td>288</td>
<td>16.75</td>
<td>4889</td>
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<tr>
<td>B</td>
<td>NOZZ A'</td>
<td>7</td>
<td>28.42</td>
<td>16</td>
</tr>
<tr>
<td>C</td>
<td>NOZZ B'</td>
<td>6.5</td>
<td>5</td>
<td>133.25</td>
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<tr>
<td>D</td>
<td>A' PL</td>
<td>13</td>
<td>5.278</td>
<td>10</td>
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<tr>
<td>E</td>
<td>B' PL</td>
<td>3.25</td>
<td>18.06</td>
<td>58.7</td>
</tr>
<tr>
<td>F</td>
<td>B PL</td>
<td>3.25</td>
<td>15.75</td>
<td>51.2</td>
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<td>G</td>
<td>8' PIPE</td>
<td>3.25</td>
<td>9.38</td>
<td>30.3</td>
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<tr>
<td>H</td>
<td>3/4&quot; PIPE</td>
<td>1.4</td>
<td>20</td>
<td>28.7</td>
</tr>
<tr>
<td>J</td>
<td>BIG PUMP</td>
<td>140</td>
<td>14.69</td>
<td>2056.6</td>
</tr>
<tr>
<td>K</td>
<td>3&quot; PIPE &amp; COUPLING</td>
<td>440</td>
<td>14.69</td>
<td>1461.03</td>
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<tr>
<td>L</td>
<td>Std PUMP &amp; MCH</td>
<td>320</td>
<td>10.5</td>
<td>3560</td>
</tr>
<tr>
<td>M</td>
<td>3/4&quot; FLUSH</td>
<td>42</td>
<td>18.5</td>
<td>888</td>
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<tr>
<td>K</td>
<td>1/2 FLUSH</td>
<td>3</td>
<td>18.5</td>
<td>55.5</td>
</tr>
<tr>
<td>P</td>
<td>CABLE</td>
<td>3</td>
<td>14.69</td>
<td>110.10</td>
</tr>
<tr>
<td>Q</td>
<td>1.672</td>
<td>16.612</td>
<td>21.87</td>
<td>2108.53</td>
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</tbody>
</table>

\[ \Sigma W = \] 
\[ \Sigma M_x = \] 
\[ \Sigma M_y = \]

\[ x = \frac{\Sigma M_x}{\Sigma W} = \] 
\[ y = \frac{\Sigma M_y}{\Sigma W} = 1.45 \] 

---

<table>
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<tr>
<th>COEFF. OF</th>
<th>EXP. 1°F</th>
<th>ΔL</th>
<th>ΔX</th>
<th>ΔY</th>
<th>ΔZ</th>
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<tr>
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<tr>
<td>VESSEL</td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>DUNNAGE</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>TOLERANCE</td>
<td></td>
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---

**FAX NO.:** 313-571-1530

**PHONE:** 313-572-3211

**CABLE NO.**

---

**FAX NO.:** 313-571-1530

**PHONE:** 313-572-3210

---

**DATE:** 05/22/00

**NOTES:**

---

**TRANSPORTATION:**

---

**HANDHECKER:** 7611
This sheet shows the status and description of the attached Design Analysis sheets.

**Discipline:** STRUCTURAL  
**WOJOB No.:**  
**Calculation No.:** DST-C-001

**Project No. & Name:** DST TANK ANNULUS PUMP SYSTEM  
**Calculation Item:** PORTABLE DST TANK SKID

These calculations apply to:

- **Dwg. No.:** H-14-104141  
  **Rev. No.:**

- **Dwg. No.:**
  **Rev. No.:**

- **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?

- [x] Yes  
- [ ] No

This calculation verified by independent "check" calculations?

- [ ] Yes  
- [x] No

**Original and Revised Calculation Approvals:**

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<th></th>
<th>Rev. 0</th>
<th>Rev. 1</th>
<th>Rev. 2</th>
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<td><strong>Originator</strong></td>
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<td><strong>Checked by</strong></td>
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<td></td>
<td></td>
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<tr>
<td><strong>Approved by</strong></td>
<td></td>
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</tr>
<tr>
<td><strong>Checked Against</strong></td>
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<td></td>
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<tr>
<td><strong>Approved Vendor Date</strong></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Design Analysis Page No.:** 1-5
- **Description:** GENERAL & CALC BODY
- **Attach:** A-1 THRU A-4 EQUIP CUT SHEETS
**DESIGN ANALYSIS**

**Fluor Federal Services**

**Subject:** PORTABLE DST TANK SKID

**Originated By:** DST

**Checked By:** G.A. Lisle

**Date 4/18/00**

**Date 7/21/00**

**Location:**

---

**OBJECTIVE:** TO CHECK THE PORTABLE SKID STRUCTURE. SEE NEXT PG FOR LAYOUT.

**CRITERIA:** THE SKID IS A GENERAL SERVICE CLASSIFICATION.

**REFERENCES:** USE HNF-PRO-97. WISTRUT GENERAL ENGINEERING CATALOG NO. 12.

**DESIGN INPUT:** SEE THE ATTACHMENT A FOR ELECTRICAL PANEL AIR COMPRESSOR (TANK) DATA.

**WIND LOAD** ASCE 7-95, EXPOSURE C, PC 2.

\[
F = \frac{g_v G_c f_A f}{(0.6)^2} = 16.82 \times 0.85 \times 1.2 A f \text{ (TABLE 6-1, OTHER STRUCTURES)}
\]

\[
= 17.2 A f \text{ (TABLE 6-8)}
\]

\[
= 16.82 \text{ PSF}
\]

**SEISMIC LOAD** PC 2, UBC 97, ZONE 2B, FOR ESSENTIAL FACILITY (169N.1.2, FORMULA 3.2.2, \( w / h \times = 0 \))

\[
F_p = \frac{g_p C_p f_w}{R_p} w_p
\]

\[
= 2.5 \times 0.28 \times 1.5 \text{ WP = 0.35 WP}
\]

**ASSUME S_p SOIL PROFILE** USE SIGNS & BILLBOARD TYPE
### DEAD LOADS

**Air Compressor** \( (40\frac{1}{6} \times 21\frac{1}{8} \times 3\frac{3}{8}) \)  
\[ DL = 180 \text{ LBS} \]

**Electric Panel** \( (30 \times 25.4 \times 9.0) \)  
**Assume**  
\[ 100 \text{ LBS} \]

**Base Frame**

- \( W8 \times 28 \)  
  \[ 28 \text{ PLE} \times (4.3 \times 2 \text{ EA} + 3.5') = 339 \]
- \( W5 \times 16 \)  
  \[ 16 \times 3.5' \times 2 \text{ EA} = 112 \]
- **Unistrut**  
  \[ 0.8 \text{ PLE} \times 5' \times 2 \text{ EA} = 38 \]
  \[ 2.0 \text{ PLE} \times 4' \times 3 \text{ EA} = 24 \]
  **Connection & Misc.**  
\[ = 7 \]

\[ \text{Total} = 830 \text{ LBS} \]

### STABILITY ANALYSIS

**Wind Load**

\[ 17.2 \text{ PSE} \times (94'' \times 30'' / 44) = 122 \text{ LBS} \times (3.8'' + 0.7') = 549 \]

\[ 2.5' \times 2.5' \times 3.5' = 151 \text{ LBS} \times (13'' + 0.7') = 302 \]

\[ 2.73 \]

**Seismic**

\[ F_P = 0.35 \times 800 = 280 \text{ LBS} \]
DESIGN ANALYSIS

OVERTURNING:

\[ M_R = 180 \text{ lbs} \times 1.3 + 451 \times 2.2 \\
+ (100 + 69) \times 2.8 \]

= 1700 \text{ ft-lb}

\[ F.S. = \frac{M_R}{M_0} = 2.0 > 1.1 \quad \text{OK} \]

WIND GOVERNS

SLIDING:

ASSUME FRICTION COEFFICIENT STEEL/ SOIL = 0.35

RESISTANCE = 800 \text{ lbs} \times 0.95 = 280 \text{ lbs}

\[ F.S. = \frac{280}{280} = 1.0 \quad \text{OK} \]

SEISMIC GOVERNS \quad \text{(AN IMPORTANCE FACTOR OF 1.5 APPLIED TO THE SEISMIC LOAD)}
ELECTRICAL PANEL RACK

\[ E_{\text{SEISMIC}} = (100 + 71)(0.85) = 60 \text{#} \]
\[ W_{\text{WIND}} = 122 \text{#} \] (PG.3)

BY INSPECTION:
- VERT COLS USE P1001
- HORIZ BM USE P1000
- VERT BRACE USE P1000
passive pressures in cohesionless material for steady seepage beneath the wall consists of.

Note: Numbers shown are ultimate values and require sufficient movement for failure to occur.
Where friction factor only is shown, the effect of adhesion is included in the friction factor.
For data on adhesion on bearing piles, see Chapter 13.

of resultant uplift force on failure wedge for various inclinations of failure plane, to be used in analysis of the active wedge.

d. Seepage Beneath Wall. See bottom panel of Figure 10-5 for correction to be applied to active and passive pressures in cohesionless material for steady seepage beneath a wall.

e. Consolidation Pore Pressures. Where impervious clay behind a wall is loaded by backfill, hydrostatic excess pore pressures can develop in the clay. Estimate such pore pressures by methods of Chapter 6 and include them in uplift on the failure surface.

5. SURCHARGE LOADING. For the effect of surcharge loading, see Figures 10-1 and 10-2.

a. Area Loads. Where surcharge behind a wall consists of area load, include the weight of surcharge with forces acting on the trial failure wedges.

---

**TABLE 10.1**

Friction Factors and Adhesion for Dissimilar Materials

<table>
<thead>
<tr>
<th>Interface materials</th>
<th>Friction factor, ( \tan \delta )</th>
<th>Friction angle, ( \delta ), degrees</th>
<th>Adhesion, ( C_A ), psf</th>
</tr>
</thead>
<tbody>
<tr>
<td>Masonry on masonry, igneous and metamorphic rocks:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dressed soft rock on dressed soft rock</td>
<td>0.70</td>
<td>35</td>
<td></td>
</tr>
<tr>
<td>Dressed hard rock on dressed soft rock</td>
<td>0.65</td>
<td>33</td>
<td></td>
</tr>
<tr>
<td>Dressed hard rock on dressed hard rock</td>
<td>0.60</td>
<td>29</td>
<td></td>
</tr>
<tr>
<td>Masonry on wood (cross grain)</td>
<td>0.50</td>
<td>26</td>
<td></td>
</tr>
<tr>
<td>Steel on steel at sheet pile interlocks</td>
<td>0.30</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td>Steel concrete on the following foundation materials:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clean gravel</td>
<td>0.40</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td>Clean sand</td>
<td>0.30</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td>Silty sand, gravel or sand mixed with silt or clay</td>
<td>0.25</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Very stiff and hard residual or preconsolidated clay</td>
<td>0.20</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>Medium stiff and stiff clay and silty clay</td>
<td>0.30 to 0.55</td>
<td>17 to 19</td>
<td></td>
</tr>
<tr>
<td>Steel sheet piles against the following soils:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clean gravel, gravel-sand mixtures, coarse sand</td>
<td>0.35 to 0.60</td>
<td>29 to 31</td>
<td></td>
</tr>
<tr>
<td>Clean fine to medium sand, silty medium to coarse sand, silty or clayey gravel</td>
<td>0.45 to 0.55</td>
<td>24 to 29</td>
<td></td>
</tr>
<tr>
<td>Clean fine sand, silty or clayey fine to medium sand</td>
<td>0.35 to 0.45</td>
<td>19 to 24</td>
<td></td>
</tr>
<tr>
<td>Fine sandy silt, nonplastic silt</td>
<td>0.30 to 0.35</td>
<td>17 to 19</td>
<td></td>
</tr>
<tr>
<td>Very stiff and hard residual or preconsolidated clay</td>
<td>0.40 to 0.50</td>
<td>22 to 26</td>
<td></td>
</tr>
<tr>
<td>Medium stiff and stiff clay and silty clay</td>
<td>0.30 to 0.55</td>
<td>17 to 19</td>
<td></td>
</tr>
<tr>
<td>(Masonry on foundation materials has same friction factors.)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stiff and hard clay and clayey silt</td>
<td>0.65</td>
<td>30 to 35</td>
<td></td>
</tr>
</tbody>
</table>
For Type 4 and Type 12 Enclosures for Flange-Mounted Disconnects, the electrical Engineer called the supplier, Hoffman Engineering Company, for the WT:

Enclosure = 61#
Panel = 18#
Switches, etc=21# (assumed)
----
100#  DTC 4/17/00

These enclosures are designed to house Square D Class 9422 disconnect switches with flange mounted variable depth operating mechanisms or cable mechanisms.
### Accessories

- Bank Adapter Plate page 5.49
  - See also General Accessories index page 9.04
- Corrosion Inhibitors
- Electric Heater
- Electrical Interlocks
- Floor Stand Kit
- Lighting Kit
- Panels (See table)
- Terminal Kit Assembly
- Touch-Up Paint (A-TPPY61)
- Window Kit

**Air conditioners and heat exchangers for this enclosure can be found in Hoffman's Specifier's Guide for Thermal Management Products.**

**Product also available in stainless steel.**

**Contact your local Hoffman Sales Representative for information on modifications to this product.**

### Cross Reference

- Stainless Steel Type 4X Enclosures for Flange-Mounted Disconnects (page 6.26)
- CONCEPT™ Stainless Steel Disconnect Wall-Mount Enclosures (page 6.32)
- Type 12 and Type 13 Enclosures for Flange-Mounted Disconnects (page 5.01)

### Standard Sizes Type 4 and Type 12 Enclosures for Flange-Mounted Disconnects

<table>
<thead>
<tr>
<th>Enclosure</th>
<th>Catalog Number</th>
<th>Panel Size (D x E)</th>
<th>Number of Clamps</th>
<th>Stiffener Door/Body</th>
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<tbody>
<tr>
<td>A-304SP210LP</td>
<td>A-304SP201LP</td>
<td>A-304SP210LP</td>
<td>A-304SP201LP</td>
<td>A-304SP210LP</td>
</tr>
<tr>
<td>33.00 x 20.32 x 5.00</td>
<td>9.00 x 20.32 x 5.00</td>
<td>9.00 x 20.32 x 5.00</td>
<td>9.00 x 20.32 x 5.00</td>
<td>9.00 x 20.32 x 5.00</td>
</tr>
<tr>
<td>A-424SP310LP</td>
<td>A-424SP301LP</td>
<td>A-424SP310LP</td>
<td>A-424SP301LP</td>
<td>A-424SP310LP</td>
</tr>
<tr>
<td>43.00 x 30.32 x 10.00</td>
<td>9.00 x 30.32 x 10.00</td>
<td>9.00 x 30.32 x 10.00</td>
<td>9.00 x 30.32 x 10.00</td>
<td>9.00 x 30.32 x 10.00</td>
</tr>
<tr>
<td>63.00 x 50.32 x 15.00</td>
<td>9.00 x 50.32 x 15.00</td>
<td>9.00 x 50.32 x 15.00</td>
<td>9.00 x 50.32 x 15.00</td>
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**Dimensions (inch) are for reference only; do not convert metric dimensions to inch.**

* Panels must be ordered separately. Optional stainless steel or aluminum panels are available. See General Accessories.
AIR COMPRESSORS

EXCLUSIVE DAYTON DESIGN RELIABLY PROVIDES AIR TOOLS, PAINT SPRAYERS, SANDBLAST EQUIPMENT, AIR CYLINDERS, AND SMALL MACHINES

THE DAYTON CAST IRON DIFFERENCE
- Longer life—up to 100% longer pump life than comparable air compressors
- Higher Air Flow—Up to 10% more CFM than comparable models
- Higher Pressure—Maximum 135 PSI for a broader range of applications
- Higher Duty Cycle—Runs up to 63% duty cycle vs. the standard 50/50 duty cycle

TANK MOUNT MODELS INCLUDE
- High flow air cooling system reduces pump temperature
- Copper discharge tube for improved durability and cooling
- Single and 3-phase open dripproof motors with thermal protection
- NEMA 1 enclosure pressure switch with gauge
- 30 gallon stationary ASME air tank
- Pressure switch setting 95 PSI On and 125 PSI Off (Except Base Plate Nos. 48242 and 48243)
- Comply with State of California code 462 (L) 7
- Charcoal gray metallic finish

PUMP SPECIFICATIONS

<table>
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<td>11.5 lbs</td>
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ORDERING DATA

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<th>Pump No.</th>
<th>Running Motor Type</th>
<th>Tank Capacity</th>
<th>Volts</th>
<th>Phase</th>
<th>Amp Draw</th>
<th>NPT Outlet</th>
<th>Dimensions L W H</th>
<th>Stock No.</th>
<th>Weight</th>
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<tr>
<td>1</td>
<td>1.00</td>
<td>301 Horizontal</td>
<td>120/240</td>
<td>1</td>
<td>17.8/8.8</td>
<td>1-1/4</td>
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<td>2</td>
<td>2.00</td>
<td>301 Vertical</td>
<td>120/240</td>
<td>1</td>
<td>34.0/2.0</td>
<td>1-1/4</td>
<td>26 1/16 8 3/8</td>
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<td>48241-2</td>
</tr>
<tr>
<td>3</td>
<td>2.00</td>
<td>301 Vertical</td>
<td>208/240</td>
<td>3</td>
<td>5.82/3.5</td>
<td>1-1/4</td>
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<td>301 Horizontal</td>
<td>208/240</td>
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<tr>
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<td>Base Plate</td>
<td>120/240</td>
<td>1</td>
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*With Magnetic Starters*

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<th>Tank Capacity</th>
<th>Volts</th>
<th>Phase</th>
<th>Amp Draw</th>
<th>NPT Outlet</th>
<th>Dimensions L W H</th>
<th>Stock No.</th>
<th>Weight</th>
</tr>
</thead>
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<td>1.00</td>
<td>301 Horizontal</td>
<td>120/240</td>
<td>1</td>
<td>17.8/8.8</td>
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<td>2.00</td>
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<td>26 1/16 8 3/8</td>
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<td>2.00</td>
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<td>3</td>
<td>8.0/4.0</td>
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<td>48241-2</td>
</tr>
<tr>
<td>5</td>
<td>2.00</td>
<td>Base Plate</td>
<td>120/240</td>
<td>1</td>
<td>15.0/5.5</td>
<td>1-1/2</td>
<td>22 3/16 1 1/4 25</td>
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<tr>
<td>6</td>
<td>3.00</td>
<td>Base Plate</td>
<td>208/240</td>
<td>3</td>
<td>8.0/4.0</td>
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<td>45 3/4 1 3/4 25</td>
<td>48241-2</td>
<td>48241-2</td>
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</tbody>
</table>

*For specific HP rating explanations, see page 222. (1) ASME code air tanks. (2) As rated by the standard D-10 bearing life of the pump. Individual component life will vary depending on duty cycle, ambient temperature, maintenance performed, air filter quality, and manufacturing part tolerances. (3) Magnetic Starters not included. GB pump mounted and wired, provided separately.

2228 ▲Net Prices, Not Subject To Discounts
Fluor Federal Services

CALCULATION IDENTIFICATION AND INDEX

Status and description of the attached Calculation Sheets.

Discipline: **STRUCTURAL**

Project No. & Title: **DST ANNULAR PUMP SYSTEM**

Calculations: **FUSED DISCONNECT SKID**

These calculations apply to:

<table>
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Date: 6/20/00

Rev. 0

Originator

Checked By

Approved By

Checked Against

Approved Vendor Data

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<tr>
<td>Orig.</td>
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<td>June 6/20/00</td>
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</table>

Were calculations incorporated into the final drawings? **✓** Yes

Were calculations verified by independent "check" calculations? **✓** Yes

INDEX

<table>
<thead>
<tr>
<th>Calculation Sheet Page No.</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>1-4</td>
<td><strong>GENERAL CALCULATIONS, ATTACHMENTS</strong></td>
</tr>
</tbody>
</table>

E-NW-128 (03/00)
OBJECTIVE
CHECK THE SKID STRUCTURE
SEE FOLLOWING PG FOR SKID LAYOUT.

CRITERIA
GENERAL SERVICE.

REFERENCES - HNF - PRO-97.
- UNISTRUT GENERAL ENGINEERING CATALOG NO. 12.
- CALC DST-C-001, DST TANK SKID.

WIND LOAD - ASCE-7-95, EXPOSURE C, PC 2
USE P = 20 PSF (CONSERVATIVE).

SEISMIC LOAD - SKID LESS THAN 400 LBS (SEE P. 2), DO NOT NEED ANALYSIS (PRO-97).

STABILITY ANALYSIS.
UNISTRUT
WIND = 20 PSF x 1' x (10" + 2" x 2) / 144 = 35 # SMALL.
BY INSPECTION, SKID OVERTURNING & SLIDING IS ADEQUATE.

ELECTRICAL PANEL RACK

THE RACK & UNISTRUTS IS SIMILAR TO THE DST TANK SKID,
THE RACK IS ADEQUATE.
SKID WEIGHT

**ELEC PANEL**: (17.5" x 9" x 6.4") (SEE P. 4). \( \frac{30^\#}{(\text{ASSUMED})} \)

- **UNISTRUT**: P1001 3.8 PLF \( \times 4' \times 2 = 30\)
  - P1000 2.0 \( \times 2' \times (2+2) = 16\)
  - CONNECTIONS \( = 4\)

- **BASE FRAME**: W8x2S 28 PLF \( \times (3.5' \times 2 + 1.5') = 22.7\)
  - W5x16 16 \( \times 2.0' = 32\)

- **ELEC. CORD**: 4- #4 AWG 1.4 PLF \( \times 3.0' \) \( \approx 45\)
  - ~ 385
Heavy Duty Safety Switches:

Typical NEMA Type 3R

Catalog # H362NRB,RB Series F5:

- Height = 17.50 inches
- Width = 9.00 inches
- Depth = 6.38 inches
- W/H = 10.50 inches
APPENDIX I
ANNULUS PUMP CRITERIA LETTERS
MEMORANDUM

ANNULUS PUMP DESIGN CRITERIA

TO: M. J. Sutey S5-07

COPIES: D. G. Baida S5-05

FROM: DST Engineering

DATE: February 8, 2000

References:


Criteria is required to support the design of a new style of Annulus Pumps for the Double–Shell Tank System. Reference 1 recommended a change in design from the deep-well turbines to a smaller submersible style pump. Significantly lower maintenance and disposal costs were several of the factors that made the submersible pump attractive. The following is a discussion of the factors that influence the pumping of the DST waste, and used to derive the pump criteria. Attached in Table 1 is a compilation of the design criteria developed for the new annulus pump.

The old style annulus turbine pumps were designed to handle flowrates of 100 gpm at a head of 150 feet in the normal DST's to 100 gpm at a head of 80 feet in the aging waste tank farms. The submersible pumps will approach similar flowrates, approximately 40 gpm at a head of 160 feet. The 40 gpm @ 160 feet equates to approximately 85 gpm at a head of 100 feet. The fewer stages and size constraints are partially compensated for by using two pumps in series, as dictated by piping pressure drop between farms. The reduced flow is due to fewer stages and size constraints, but the pumps are still capable of performing the transfers required, as discussed in more detail below.

New Generation Pump Considerations

The new generation transfer pump is a submersible two-stage design. This pump could be used for the annulus pumping. Its compact design allows it to fit down a twelve-inch riser, the same size as the annulus riser. The pump is a two-stage pump and delivers a flow of 140
the same size as the annulus riser. The pump is a two-stage pump and delivers a flow of 140 gpm at a head of 450 feet. The pump is designed for an extended service life. The cost of the new generation pump approaches one million dollars. An annulus pump would not be required for an extended period of operation. Nor are the pumping distances for which the new generation pump was designed, such as Cross-Site, required for annulus pumping. So a new generation pump style is not warranted for the annulus service.

**Flow Vs Solids Suspension Considerations**

The amount of solids reaching the suction of an annulus pump is not expected to be significant. Solids entrainment into the annulus from a leak in the primary would depend on the leak location. The settling and accumulation of solids, which would occur on the path around the perimeter of the annulus, would limit the amount reaching the pump.

Reference 2 provides the basis for evaluating flow rates required to suspend solids through transfer lines. The reference states that “much of the available characterization data for Hanford particulate solids indicate mass distributions typically in a range less than 50 microns”. The reference also states that “typical insoluble solids in Hanford waste are identified as aluminum hydroxide, iron hydroxides and phosphate salts. The solid density of these particles range from 2.5 to 3.5 kg/L”. Correlation’s sited in the reference were used to calculate the flow velocities required to overcome solids settling tendencies. The following is an extremely conservative example:

Assuming a 50 micron mean particle diameter, 3.0 kg/L particle density, 1.0 kg/L liquid phase density, 1.0 centi-poise liquid phase viscosity – a velocity of 3.0 ft/sec or a flow of 70 gpm in a 3-inch pipe would be required to suspend the solids.

If some of the conservatism is removed by assuming a 50 micron mean particle diameter, 3.0 kg/L particle density, 1.35 kg/L liquid phase density, 15 centi-poise liquid phase viscosity – a velocity of 2.4 ft/sec or a flow of 55 gpm in a 3-inch pipe would be required to suspend the solids.

It should be recognized that solids accumulations in piping would tend to be a self-correcting problem. As the solids accumulate in a location in the pipe the fluid velocity would increase and tend to re-suspend the particles. Due to the relatively low quantity of insoluble solids in the DST system, the favorable solids characteristics for suspension in solutions, and the unlikely distribution of a significant quantity in the annulus, lower flowrates are considered acceptable for annulus pumping.

**Dilution vs. Solution Density & Viscosity Considerations**

The solutions in the double shell tank system are very fluid and pumpable. Most of the DST wastes were never concentrated to the final stage originally planned. Tank 103-AN contains the only dilute waste that went through the final stage of evaporation to reach the classification of Double-Shell Slurry. The rest of the dilute wastes were concentrated less through the evaporator and are classified as Double-Shell Slurry Feed. Tank 101-SY was the
only complex waste tank concentrated to such a high level and is atypical as can be seen from table 2. Viscosity of the supernate rarely exceeds 30 centi-poise.

The capability to dilute the DST waste with water however is felt to be a prudent design consideration to ensure the waste is well below the saturation point. The quantity of dilution water is a hard design criteria to establish. Saltwell operations are currently using a range of 2:1 to a 1:1 dilution ratio for saturated solutions.

The initial 101-SY transfer in December 1999 was diluted in a 1:1 ratio with water. One factor influencing this high dilution ratio was the dissolved gases, which were desired to be kept in solution.

Flowsheets are being developed for the pumping of the more concentrated wastes in AN Farm to the Vitrification Plant. The Reference 3 flowsheet dilutes the DST waste in AN-104 to a density of 1.30, which represents a 2:1 waste to water dilution. Discussions with the author indicate that a 1.35 density was determined to be adequate (3:1 dilution) but further conservatism was added. Reference 4 also supports the 1.35 density. The 1.35 density is used as a pluggage criteria in the Waste Compatibility Program. Reference 4 compiled several years of evaporator slurry data and no solids were ever noted above a 1.35 density.

Table 2 shows that not many waste tanks are above the 1.30 density and current waste concentration practices require a density of < 1.40 in the evaporator product to prevent flammable gas accumulations.

Dilution of the more concentrated DST wastes by a 2:1 waste to water ratio is definitely adequate to prevent transfer line pluggage, a 3:1 ratio is determined to be sufficiently adequate however. Diluting the highest DSSF waste from a 1.47 density to a 1.35 requires a 3:1 ratio. Diluting a 1.47 density to a 1.30 requires a 2:1 ratio. Diluting a 1.40 density to a 1.30 requires a 3:1 ratio.

The design criteria for the annulus dilution system will be specified as a 2:1 waste to water ratio for conservatism.

Flammable Gas Considerations

The Tank Farms Final Safety Analysis Report (FSAR) for Double-Shell Tanks contains an Administrative Control – 5.10 Ignition Controls, that applies to annulus pump operation. Annulus pumping is considered Waste Intrusive and therefore for all DST’s Ignition Source Control Set # 1 applies at all times.

Service Life Considerations

The service life for an annulus pump is expected to be short. A readily available commercial grade pump is desirable. The service life specified allows the use of normal elastomers used in the pump industry, to meet the radiation resistance requirement. The radiation field data used was developed for the W-211 project.
Table 1 – Pump Design Criteria

<table>
<thead>
<tr>
<th>Submersible Centrifugal</th>
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<tr>
<td>Total Flow</td>
<td>40 - 140 gpm (300' gpm maximum)</td>
</tr>
<tr>
<td>SpG</td>
<td>1.0 - 1.47</td>
</tr>
<tr>
<td>Viscosity</td>
<td>1.0 - 30 centi-poise</td>
</tr>
<tr>
<td>Solids</td>
<td>0 - 20 Volume %</td>
</tr>
<tr>
<td>Temperature</td>
<td>65 - 140°F</td>
</tr>
<tr>
<td>Discharge Pressure</td>
<td>230 psig maximum</td>
</tr>
<tr>
<td>Flammable Gas Controls</td>
<td>Ignition Source Control Set #1 (Class 1 Division 1 Group B or equivalent)***</td>
</tr>
<tr>
<td>Waste Flow</td>
<td>26 - 93 gpm ****</td>
</tr>
<tr>
<td>Dilution water Flow</td>
<td>14 - 47 gpm ****</td>
</tr>
<tr>
<td>Chemical Resistance</td>
<td>All parts exposed to liquids must be resistant to the basic solutions (pH of 13) found in the DST Tanks</td>
</tr>
<tr>
<td>Life Expectancy</td>
<td>2,000 hours in a 2 year period</td>
</tr>
</tbody>
</table>

* The allowable envelope of operation for flow is specified as 40 to 140 gpm. However, higher flowrates are acceptable for the shorter distance transfers as long as 300 gpm is not exceeded. The maximum flow rate of 300 gpm is based on an accident in the Tank Farm FSAR 3.4.2.7 Surface Leak Resulting in a Pool.

** Maximum design pressure for transfer lines in SY Farm (Spec B-101-C3) and A & AX Farms (Spec B-102-C1)

*** Mineral insulated Cable meets requirements for equivalency. Series 300 stainless is acceptable as non-sparking.

**** The dilution water flow may be required to be as high as 50% of the waste flow. It's recognized that design constraints may prevent reaching dilution water flows above 40 gpm. In this case throttling existing waste line valves will be used to set the proper dilution. The design constraints anticipated are water supply pressure, pressure drop through hose connections, and the limiting pipe diameter that can be coupled with the pump assemblies.
Table 1 - Pump Design Criteria (Continued)

<table>
<thead>
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<th>Heel Pump</th>
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<td>2 - 5 gpm</td>
</tr>
<tr>
<td>SpG</td>
<td>1.0 - 1.47</td>
</tr>
<tr>
<td>Viscosity</td>
<td>1.0 - 30 centi-poise</td>
</tr>
<tr>
<td>Solids</td>
<td>0 - 20 Volume %</td>
</tr>
<tr>
<td>Temperature</td>
<td>65 - 140°F</td>
</tr>
<tr>
<td>Discharge Pressure</td>
<td>230 psig maximum*</td>
</tr>
<tr>
<td>Flammable Gas Controls</td>
<td>Ignition Source Control Set #1 (Class 1 Division 1 Group B or equivalent)**</td>
</tr>
<tr>
<td>Dilution water Flow</td>
<td>None Required</td>
</tr>
<tr>
<td>Chemical Resistance</td>
<td>All parts exposed to liquids must be resistant to the basic solutions (pH of 13) found in the DST Tanks</td>
</tr>
<tr>
<td>Life Expectancy</td>
<td>2,000 hours in a 2 year period</td>
</tr>
</tbody>
</table>

Note: It is assumed that the heel pump will be used just to remove the last few inches of liquid from the annulus. Repeated water flushes of the annulus may be performed to remove the residual radioactive components. So it is anticipated that the actual solution SpG will probably be significantly lower than the maximum stated above.

* Maximum design pressure for transfer lines in SY Farm (Spec B-101-C3) and A & AX Farms (Spec B-102-C1)

** Mineral insulated Cable meets requirements for equivalency. Series 300 stainless is acceptable as non-sparking.
Table 2 – Double-Shell Tank Contents

<table>
<thead>
<tr>
<th>Tank</th>
<th>Waste Type</th>
<th>Sludge</th>
<th>Salt Cake</th>
<th>SpG</th>
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<tr>
<td>AN-101</td>
<td>DN</td>
<td>0</td>
<td>12&quot;</td>
<td>1.23</td>
</tr>
<tr>
<td>AN-102</td>
<td>CC</td>
<td>0</td>
<td>32&quot;</td>
<td>1.39</td>
</tr>
<tr>
<td>AN-103</td>
<td>DSS</td>
<td>0</td>
<td>0&quot;</td>
<td>1.46</td>
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<tr>
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<td>DSSF</td>
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<td>163&quot;</td>
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<td>AP-102</td>
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<td>0</td>
<td>0</td>
<td>1.20</td>
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<td>DSSF</td>
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<td>1.29</td>
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<td>1.15</td>
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<td>AW-102</td>
<td>DC</td>
<td>0</td>
<td>13&quot;</td>
<td>1.19</td>
</tr>
<tr>
<td>AW-103</td>
<td>DN</td>
<td>115&quot;</td>
<td>17&quot;</td>
<td>1.01</td>
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<td>AW-104</td>
<td>DN</td>
<td>0</td>
<td>84&quot;</td>
<td>1.00</td>
</tr>
<tr>
<td>AW-105</td>
<td>DN</td>
<td>93&quot;</td>
<td>0</td>
<td>1.02</td>
</tr>
<tr>
<td>AW-106</td>
<td>CC</td>
<td>0</td>
<td>82&quot;</td>
<td>1.30</td>
</tr>
<tr>
<td>AY-101</td>
<td>DC</td>
<td>34&quot;</td>
<td>0</td>
<td>1.08</td>
</tr>
<tr>
<td>AY-102</td>
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</tr>
<tr>
<td>AZ-101</td>
<td>Aging</td>
<td>17&quot;</td>
<td>0</td>
<td>1.21</td>
</tr>
<tr>
<td>AZ-102</td>
<td>Aging</td>
<td>32&quot;</td>
<td>0</td>
<td>1.11</td>
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<td>1.62</td>
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<tr>
<td>SY-103</td>
<td>CC</td>
<td>0</td>
<td>0</td>
<td>1.47</td>
</tr>
</tbody>
</table>

References: HNF-IP-0482-140 Waste Tank Summary Report for Month Ending November 30, 1999
Should you have any questions regarding the above information please contact me on 373-3926.

D. W. Reberger
DST Engineering
March 23, 2000

Ms. L. N. Cortez
CH2M HILL Hanford Group, Inc.
P. O. Box 1500
Richland, Washington 99352-1505

Dear Ms. Cortez:

CONTRACT NO. 4975, RELEASE NO. 59, DST ANNULUS PUMPING (L-02)

Response Requested By: N/A
Responds To: N/A

One of the deliverables Fluor Federal Services (FFS) has for this task is to prepare procurement specifications for a submersible and an air operated pump that will be used for pumping the Double Shell Tank (DST) Annulus. During the course of preparing the specifications, we researched different pump manufacturers and conducted telephone discussions with more than six different manufacturers reviewing at least seven different designs.

Taking the various design criteria into account, transfer routes, riser diameter, material etc., FFS engineering has concluded that the best choice for the submersible pump is the Flygt Model BS-2060.390, operated in tandem. Operation in tandem means, where necessary, there will be two pumps in series in the same line. This model pump has already been approved by the Hanford Flammable Gas Review Board (Report No: FGEAB-00-002, Rev. 0) for use in this application.

The Flygt pump has materials that are compatible with the waste characteristics for the relatively short mission of this project (2000 hours of operation over a two-year period) and will provide the operating characteristics necessary to pump waste from the annulus to other DSTs.

This submersible pump is commercially available for approximately $6,500 a piece. It will have a side discharge as received from the vendor. The discharge will be modified to a top discharge at the Hanford site in accordance with existing Hanford drawings prepared specifically for this pump (H-2-72507), after the dimensions on the Hanford drawing are checked against the latest drawings of the pump.

The air driven pump that should be used is a Hydrostar positive displacement pump that can be installed alongside the submersible pump. This pump will be used to remove the heel down to the last three inches in the Annulus. This is the only pump identified to meet all criteria identified for this operating condition. It has a Teflon seal that may be affected by radiation, however conservative calculations show that it will exceed the needed design life.
Thus, the ultimate life of this pump will be a function of the exposure the pump has to radiation. It may be as low as 500 hours in a very high radiation field. This pump has been reviewed and approved by the Board also at the same meeting as the submersible pump. This pump is also commercially available.

FFS originally prepared specifications for both pumps, with one (#4975-59-P1) transmitted to CH2M HILL Hanford Group, Inc. (CHG) via letter No. CO-00-RPP-228, dated February 22, 2000. The second specification (#4975-59-P2) has been completed and was signed off by both FFS and CHG personnel as of February 28, 2000, and was transmitted to CHG via letter No. CO-00-RPP-250, dated March 14, 2000. FFS received an e-mail from Mr. Dan Reberger, the Technical Representative on this task, stating that the classification of these pumps is "General Service." Because both pumps are commercially available, they may be purchased without a specification by identifying the model number desired. Therefore, the specifications prepared for this task are not required. FFS Quality Assurance (QA) (Mr. Lanny Hall) has reviewed the information above, and agrees that since the pumps are commercially available and they are classified as "General Service," a specification is not required, and we do not need to review the QA plan of the selected vendors. In addition, the only receipt inspection required is to verify that what was shipped matches the requisition and enclosed paperwork is for the requested pump. (Check for shipping damage, also).

Procurement of these pumps was originally a part of the FFS scope. On, or about February 3, 2000, Mr. Reberger notified Mr. Rarig that Mr. Shipler stated that CHG would perform the procurement using the specifications for the submersible and air driven pump. Procurement was discussed at each weekly status meeting thereafter and we were told that CHG would perform the procurement in order to save money, since funding had been cut. FFS continued to offer to do the procurement, but the offer was declined.

Therefore, in order for CHG to do the procurement, we are providing here the following information on the Flygt Submersible Pump and the Hydrostar Pump, which meet the requirements contained in the specifications. The specifications were given to CHG on February 8, 2000 for review and approval.

Finally, here is the information and quantities needed to procure the pumps for DST Annulus Pumping:

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Description</th>
<th>Address</th>
<th>Phone</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>ITT Flygt Small Dewatering pump - Stainless Steel Product Code - BS-2060.390/232 460 V with 100 feet electrical cable</td>
<td>Whitney Equipment Company 14636 N. E. 95th Street Redmond, WA 98052 (425) 556-1750</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>INW HYDROSTAR Pump HS8001-1 Part Number 3A001</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Ms. L. N. Cortez  
LMHC96WO-0006  
March 23, 2000  
Page 3, CO-00-RPP-237

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Description</th>
<th>Address</th>
<th>Phone</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>2&quot; Air Motor</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Part Number 3B020</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>2&quot; Well Completion Assembly</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Part Number 3E502</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20*</td>
<td>Actuating rod (5 ft. sections w/coupling and nut)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Part Number 2B095</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Subject to further engineering review to determine the exact discharge column configuration

Procurement of 50' of discharge pipe must come from a source other than the pump vendors.

On March 6, 2000, Mr. Dan Reberger, CHG, Technical Representative, requested that FFS review the compatibility of a Gorman Rupp submersible pump to the requirements in the specification. This pump has a mine Safety and Health Approved rating. After extensive review and numerous discussions with the vendor, the pump was presented to the Flammable Gas Review Board for consideration on March 14, 2000. On March 21, 2000, Mr. Reberger notified FFS that the Board did not approve the Gorman Rupp pump due to the lack of a UL rating or equivalent. Therefore, we have reverted back to the Flygt pump as the only viable submersible pump for this application. However, the Board added a stipulation to the approval of the Flygt pump. That is: it must have a Class I, Division 1, Group B power cable. Mr. Ray Merriman, FFS, is currently evaluating cables to satisfy this requirement. Ray has suggested using a conduct for the power cable and intrinsically safe thermal sensor circuit as a possible option for the cable.

FFS has been told that CHG will procure the pumps. However, FFS is offering to procure these pumps. The formal hold placed on FFS procurement activities by CHG applies only to Safety Class components. These pumps, as mentioned earlier, are General Services and therefore are not affected by this HOLD. Should CHG desire FFS procurement support, please notify us via e-mail from CHG Contract Administration (Ms. Kathy McLerran) and we will immediately proceed with procurement activities.

All other activities in support of Release No. 59 are proceeding as identified in weekly status meetings. If there are any questions regarding this information, please contact Mr. Bradley Rarig at 373-2673 or Mr. Marshall Hauck at 376-9339.

Sincerely,

Bradley Rarig  
Project Manager

BKR:rdp

c: D. W. Reberger, CHG, w/attachments
APPENDIX J
SKETCHES FOR PUMP TEST TANK
APPENDIX K
FABRICATION
## Site Fabrication Services (SFS) Fabrication Request

### For SFS Use Only

1. **Engineer Tracking Number:** DLR-002
2. **CAGN or Change No. (Required):** 11D-77
3. **COA (Required):** E410
4. **Tining Organization Code:** 74100

### Contact Information

- **Release Date:** 3-3926
- **Location:**

### Requested Completion Date

- **5/31/00**

### Quality Level of Component

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Identify Facility Service Use For Fabrication

- **Check one only:**
  - [X] Nuclear
  - [ ] Non-Nuclear

### SSC Designation

- **Check one only:**
  - [ ] GS
  - [ ] SS
  - [ ] SC
  - [ ] E
  - [ ] S
  - [ ] Q
  - [ ] N/A

### Authorization Amount

- **$5,000**

### Title/Description of Work

- **Annulus pumps**

### Originator

- **Name:** C.E. Shepherd
- **Date:** 5/10/00
- **Phone:** 3-3880

### Notes

- **NOTE:** All items above marked N/A will default to General Shop Standard (SFS 05-107 - Copy available at SFS Planner/Scheduler/Supervisor Office).

### NEC Inspection Required on All Electrical Fabrication

### Material Procurement Requirements

- **Check applicable Safety Class/Quality Level designations for this fabrication request:**
  - [ ] P-Card GS/NA – QL-0
  - [ ] Passport GS/NA – QL-0
  - [X] GS (Procurement/Receiving QC Inspection) – QL-3
  - [ ] SS (CGI Dedication) – QL-2
  - [ ] SC (CGI Dedication) – QL-1
  - [ ] SS (EOL Procurement) – QL-2
  - [ ] SC (EOL Procurement) – QL-3

### Customer Approval Signatures

- **PLEASE PRINT OR TYPE NAME, SIGN AND DATE**

- **Customer Approval Signatures according to MRP 5.43:**

  - 21. **CAG Responsible Engineer:** [Signature]
    - **Date:** 5/10/00
    - **Phone:** 3-3580
  - 22. **CAG Responsible Engineer’s Manager:** [Signature]
    - **Date:** 5/10/00
    - **Phone:** 3-3490
  - 23. **Quality Assurance:** [Signature]
    - **Date:** 5/11/00
    - **Phone:** 3-3633
DynCorp

SITE FABRICATION SERVICES
FABRICATION ESTIMATE

Tracking No: 2H-0004706
Job Title: FAB/ASSEMBLE CONNECTORS PERS H-2-32420/30 & J-10 GS QL 3
Drawing(s)/Rev.: Customer: Todd Black
Estimator: Signature: PARSONS Date: 05/22/00

MATERIALS/ CONTRACTS CONSUMABLES LABOR TOTALS

SITE FAB SERVICES LABOR AND MATERIALS
TAB SERVICES PROVIDED MATERIALS 62 10 3,564 3,564
SITE TAB SERVICES LABOR 0 0 432 432
OTHER TAB SERVICES SUPPORT 0 0 0 0
TOTAL S.F.S. SUPPORT 62 10 3,996 4,057

NON FAB SERVICES REQUIRED SUPPORT
OTHER REQUIRED ONSITE SUPPORT 0 0 108 108
OFFSITE TAB SUPPORT 0 0 0 0
CONTRACT SUPPORT 0 0 0 0
TOTAL NON S.F.S. SUPPORT 0 0 108 108

GRAND TOTAL 4,166

10 ASSUMPTIONS & REMARKS

1. This Estimate represents the estimated costs for the on-site E/C "Site Fabrication Services" and associated support personnel or services to perform the task set forth in the reference documents. Included are all known costs identifiable at this time with the exception of HII adders (G&A/SS) which is not included in this estimate.

2. All documents and drawings are assumed to be correct and to current site standards unless otherwise noted. No fabrication engineering time has been included for changes or revisions to the fabrication documents. Three complete sets of full size drawings shall be provided by the Customer with the Work Request. Incomplete design's, ECN's, changes to design, materials, requirements, or other alterations to the original design, work scope, or fabrication process may result in increased costs or schedule delays.

3. It is assumed that the work scope (including schedule) will remain the same for the duration of the effort. Any modifications to the work scope or agreed upon schedule could result in re-estimating and/or rescheduling of the activity.

4. Scheduled dates provided at the time of this estimate are for estimating purposes only. A firm schedule will be agreed to at the time the order is issued.

5. This estimate assumes all costs for this effort to be identified and approved by the requester and that sufficient funding will be provided within five working days of the initial request for work. No activities related to this fabrication effort will begin until full (or negotiated partial) funding has been provided.

6. F.O.D. point will be the appropriate Site Fabrication facility unless otherwise specified.

7. This is only an Estimate of the fabrication cost, actual fabrication or material costs may be more or less than the estimate.
SITE FABRICATION SERVICES (SFS) FABRICATION REQUEST

FOR SFS USE ONLY

1. Servicing Task No.: 2H-000-4768/F

2. Originator Tracking Number: DWR-003

3. CAGN or Change No. (Required): 111273

4. COA (Required): EL10

5. Issuing Organization Code: 74100

6. Deliver to: Contact Dan Reberger @ 373-3926 for location

7. Delivery Location: Contact Dan Reberger @ 373-3926 for location

8. Requested Completion Date: July 5, 2000

9. Quality Level of Component: X

10. Identify Facility Service Use For Fabrication (Check one only): X

11. SSC Designation: GS

12. Approval Designation: S

13. Equipment Identification No.: 0

14. Application/Project: Annulus Pumping

15. Authorized Amount: $20,000

16. Originator: Dan Reberger

17. Funding Approval: C E Shively

18. Title/Description of Work — List all required drawings, ECNs, and specifications required for fabrication: Assemble jumper parts identified on drawing 11-14-104132 as directed by CIG Engineering. Note that the three connector assemblies (parts #s 10 & 11) are already being assembled per 211-0004706/F. Steps should be taken to purchase the 2-inch 3-way valve (part #17) ASAP as it will take approximately 6 to 8 weeks before the item is received. Perform fabrication per SFS 03-101 Redline Procedure. 392

19. Check "Q" for inspection planning attributes desired below (Q = QUALITY CONTROL). Check "N/A" if not required (see NOTE below).

<table>
<thead>
<tr>
<th>Q</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>Welding inspection/examination</td>
</tr>
<tr>
<td>X</td>
<td>Dimensional inspection/verification</td>
</tr>
<tr>
<td>X</td>
<td>Component Identification</td>
</tr>
<tr>
<td>X</td>
<td>Functional tests / acceptance test / operational</td>
</tr>
<tr>
<td>X</td>
<td>QC acceptance tag (QL 1, 2, or 3)</td>
</tr>
<tr>
<td>X</td>
<td>Verification tag (QL 0)</td>
</tr>
</tbody>
</table>

NOTE: All items above marked N/A will default to General Shop Standard (SFS 05-161 — Copy available at SFS Planner/Scheduler Superintendent Office).

NEC INSPECTION REQUIRED ON ALL ELECTRICAL FABRICATION

MATERIAL PROCUREMENT REQUIREMENTS

20. For material (part/item) purchases, select from the following Safety Class/Quality Level designations for this fabrication request:

<table>
<thead>
<tr>
<th>Part/Item</th>
<th>F Card GS/NA — QL-0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passport GS/NA — QL-0</td>
<td></td>
</tr>
<tr>
<td>X</td>
<td>GS (Procurement/Receiving QC Inspection) — QL-3</td>
</tr>
<tr>
<td>SS (CGI Dedication) QL-2</td>
<td></td>
</tr>
<tr>
<td>SC (CGI Dedication) QL-1</td>
<td></td>
</tr>
<tr>
<td>SS (ESL Procurement) QL-2</td>
<td></td>
</tr>
<tr>
<td>SC (ESL Procurement) QL-1</td>
<td></td>
</tr>
</tbody>
</table>

All SFS supported procurement services for identified materials (part/items) required for this fabrication require pre-acquisition reviews, identification of safety classifications and quality levels, and approvals by all required customer Facility managers and core evaluators responsible for this fabrication. All pre-acquisition reviews and approvals shall meet requirements of HNF-ND-4635. The review approval signatures shall be documented below.

**NOTE**: All customer-supplied materials (part/items) must be identified with a minimum of Safety Classification, Quality Level, and material grade/type. All potential suspect/counterfeit items (i.e., fasteners, circuit breakers, flanges) supplied shall meet HNF-PRO-301 requirements.

Customer approval signatures according to MRP 5.43 — PLEASE PRINT OR TYPE NAME, SIGN AND DATE.

21. Cognizant Engineer: [Signature] Date: 5/15/00 Phone: 3-3850

22. Cognizant Engineer’s Manager: [Signature] Date: 5/15/00 Phone: 3-3929

23. Technical/Engineer Core Evaluator: [Signature] Date: 5/25/00 Phone: 3-3929

24. Health and Safety Assurance: [Signature] Date: 5/25/00 Phone: 3-3929

25. Environmental Assurance: [Signature] Date: 5/25/00 Phone: 3-3929

SFS FAB RiQ, Rev 0 11/9/99
SITE FABRICATION SERVICES (SFS) FABRICATION REQUEST

FOR SFS USE ONLY

1. Servicing Task No.: 2H-000 4769/E
2. Originator Tracking Number: ANN057-002
3. CAGN or Charge No. (Required): 111273
4. COA (Required): E110
5. Issuing Organization Code: 79800
6. Deliver to: Dan Reberger
7. Delivery Location: 272-AW
8. Requested Completion Date: 7/31/00
9. Quality Level of Component: Check one only
   - Nuclear: X
   - Non-Nuclear: 
10. Identify Facility Service Use for Fabrication: Check one only
    - Nuclear: X
    - Non-Nuclear: 
11. SCC Designation: Check one only
    - E: 
    - S: 
    - Q: 
    - N/A: X
12. Approval Designator: Check required approvals needed
   - 
13. Equipment Identification No.: P2 - AY/AZ
14. Application/Project: DST Annulus Pumping
15. Authorized Amount: $20,000
16. Originator: G.A. Leshikar
17. Mfg No.: GSMA-Ut..-0
18. Import:
19. GSM - Q1.-0
20. QC Inspection:
21. QC Specification:
22. Quality Assurance:

Note: All items above marked N/A will default to General Shop Standard (SFS 05-101 - Copies available at SFS Planner/Scheduler/Supintendent Office).

NEC INSPECTION REQUIRED ON ALL ELECTRICAL FABRICATION

MATERIAL PROCUREMENT REQUIREMENTS

For material (parts/itens) purchased, select from the following Safety Class/Quality Level designations for this fabrication request:

Check applicable Safety Class/Quality Levels:

- P-Card GSNA - QL-0
- Passport GSN - QL-0
- GS (Procurement/Receiving QC Inspection) - QL-3
- SS (CGI Dedication) QL-2
- SC (CGI Dedication) QL-1
- SS (ESL Procurement) QL-2
- SC (ESL Procurement) QL-1

All SFS supported procurement services for identified materials (parts/itens) required for this fabrication require pre-acquisition reviews, identification of safety classifications and quality levels, and approvals by all required customer Facility managers and core evaluators responsible for this fabrication. All pre-acquisition reviews and approvals shall meet requirements of the following HNF-PROS: 123, 259, 265, 301, 335, 1819, and 3144. The review approval signatures shall be documented below.

**NOTE**: All customer-supplied materials (parts/itens) must be identified with a minimum of Safety Classification, Quality Level, and material grade/type. All potential suspect/counterfeit items (i.e., fasteners, circuit breakers, flanges) supplied shall meet HNF-PRO-301 requirements.

Customer approval signatures according to MRF 5.43 - PLEASE PRINT OR TYPE NAME, SIGN AND DATE.

21. Cog/Responsible Engineer: Dan Reberger
   - Date: 7/31/00
   - Phone: 2-3926
22. Cog/Responsible Engineer's Manager: Bus Hardy
   - Date: 5/31/00
   - Phone: 2-3053
23. Quality Assurance: 
   - Date: 5/25/00
   - Phone: 512-4758
24. Design/Technical Engineer: All Leshikar
   - Date: 5/25/00
   - Phone: 373-4424
25. Health and Safety Assurance: 
   - Date: 
   - Phone: 
26. Environmental Assurance: 
   - Date: 
   - Phone: 

SFS FAB REQ, Rev 2 03/23/00

Page 1 of 2

2005 - 740
Procure all components on H-14-104138, sh. 1/2, for quantity of (2) assemblies except for items 12, 13, and 45-48.

Perform fabrication per SFS 03-101 Redline Procedure, Customer Design Authority designee - G.A. Leshikar

Fabrication is of "above the flange" components, the lower portion of the dilution line assembly, and the flange connection piece to the lower pump, with the following considerations:

- Cut 3" pipe for centrifugal pump discharge and 2" well casing pipe for Hydrostar sample pump approximately 1 foot below the mounting flange.
- Screw CGB fittings (item #19) into top of flange as shown (ready to accept electrical cables). Do not install top portion of dilution line (items 25, 30, 51, 53) to mounting flange at this time.
- Do not install (item #57) at end of trunion at this time. [For interchangeability with A/Y front configuration]
- Customer to supply items 46 and 47 required for fit-up of 3/4" discharge pipe to Hydrostar air motor/wellhead assembly. These items may be removed prior to shipment at customer's discretion.
- General Note #7 is not applicable at this time.
- Perform dimensional verification of nozzles A-B (x, y, z), trunions, and location of pump discharge pipe holes on mounting flange.
- Fabricate lower portion of dilution line assembly from item 31 (tee) downward, including spacer, to length specified by customer. Quantity (2)
- Fabricate quantity (14) of item 42 (spacer).
SITE FABRICATION SERVICES (SFS) FABRICATION REQUEST

FOR SFS USE ONLY

1. Servicing Task No.: 2H-0004711

2. Originator Tracking Number: ANN-003

3. CACN or Charge No. (Required): 111273

4. COA (Required): EL10

5. Issuing Organization Code: 79800

6. Deliver to: Dan Reberger @ 373-3926

7. Delivery Location: 272-AW

8. Requested Completion Date: July 5, 2000

9. Quality Level of Component: Check one only

   1 = Nuclear

   2 = Non-Nuclear

   3 = O

   0 = X

10. Identify Facility Service Use For Fabrication (Check only):

11. SSC Designation: Check one only

   GS = Non-Nuclear

   SS = Nuclear

   SC = Specialized

12. Approval Designate: Check required approvals needed


   P2 – ANAP/AW/SY

14. Originator:

   G. A. Leshikar

15. Authorized Amount:

   $20,000

16. Title/Description of Work – List all required drawings, ECNs, and specifications required for fabrication:

Fabricate (2) annulus pump mounting flange assemblies and associated piping per H-14-104134, Sh. 1 and 2. (Encompasses partial fabrication of entire pump assembly). See continuation sheet for special instructions.

Intended Use for Item Fabricated:

   DST Annulus Emergency Pumping

17. Funding Approval:

   

18. Material Procurement Requirements

   NEC Inspection Required on All Electrical Fabrication

   Material Procurement Requirements

   Check applicable Safety Class/Quality Levels:

   P-Card GS/NA – QL-0

   Passport GS/NA – QL-0

   GS (Procurement/Receiving QC Inspection) – QL-2

   SS (CGI Deduction) QL-2

   SC (CGI Dedication) QL-1

   SS (ESL Procurement) QL-2

   SC (ESL Procurement) QL-1

   All SFS supported procurement services for identified materials required for this fabrication require pre-acquisition reviews, identification of safety classifications and quality levels, and approvals by all required customer facility managers and core evaluators responsible for this fabrication. All pre-acquisition reviews and approvals shall meet requirements of the following HNF-PROs: 123, 259, 265, 301, 335, 1819, and 3144. The review approval signatures shall be documented below.

   **NOTE**: All customer-supplied materials (parts/items) must be identified with a minimum of Safety Classification, Quality Level, and material grade/type. All potential suspect/counterfeit items (i.e., fasteners, circuit breakers, flanges) supplied shall meet HNF-PRO-301 requirements.

   Customer approval signatures according to MRP 5.43 -- PLEASE PRINT OR TYPE NAME, SIGN, AND DATE.

   21. Cog/Responsible Engineer:

      

   22. Cog/Responsible Engineer’s Manager:

      

   23. Quality Assurance:

      

   24. Design/Technical Engineer:

      

   25. Health and Safety Assurance:

      

   26. Environmental Assurance:

      

   SFS FAB REQ, Rev 3 01/23/00

   Page 1 of 1
Procure all components on H-14-104134, sh. 1 & 2, for quantity of (2) of Assembly 2, except for Items 12, 13, and 45-48.


Fabrication is of "above the flange" components, the lower portion of the dilution line assembly, and the flange connection piece to the lower pump, with the following considerations:

- Cut 3" pipe for centrifugal pump discharge and 2" well casing pipe for Hydrostar sample pump approximately 1 foot below the mounting flange. Screw CGB fittings (item 19) into top of flange as shown (ready to accept electrical cables). Do not install top portion of dilution line (items 25, 30, 51 and 53) to mounting flange at this time.

- Customer to supply Hydrostar air motor/wellhead assembly (items 46 and 47), required for fit-up of ¾" discharge pipe. These items may be removed prior to shipment at customer's discretion.

- General Note #7 is not applicable at this time.

- Perform dimensional verification of nozzles A and B (X,Y,Z), dowel pin holes on mounting flange, and location of pump discharge pipe holes (2") on mounting flange.

- Fabricate lower portion of dilution line assembly from tee (item #31) downward, including spacer, to length specified by customer.

- Fabricate quantity (14) of spacers (item #42).
SITE FABRICATION SERVICES (SFS) FABRICATION REQUEST

FOR SFS USE ONLY

2. Originator Tracking Number:
DWR-004

3. CACN or Change No. (Required):
111273

4. CDA (Required):
EL10

5. Issuing Organization Code:
74100

6. Deliver To:
Contact Dan Reberger @ 373-3926 for location

7. Delivery Location:
Contact Dan Reberger @ 373-3926 for location

8. Requested Completion Date:
July 19, 2000

9. Quality Level of Component
Check only
1 2 3 0
X

10. Identify Facility Service Use for
Fabrication (Check one only):
X
Nuclear
Non-Nuclear

11. ESC Designation
Check one only
GS SS SC
E S Q N/A
X

12. Approval Designator
Check required approvals needed


14. Application/Project:
Annulus Pumping

15. Authorized Amount:
$4,999

16. Originator:
Dan Reberger

17. Funding Approval:
C E Shipley

NOTE: All items above marked N/A will default to General Shop Standard (SFS 95-101 – Copy available at SFS Planner/Scheduler Superintendent Office).

NEC INSPECTION REQUIRED ON ALL ELECTRICAL FABRICATION

MATERIAL PROCUREMENT REQUIREMENTS

20. For material (part/item) purchases, select from the following Safety Class/Quality Level designations for this fabrication request:

Check applicable Safety Class/Quality Levels:

P-Card GS/NA – QL-0
Passport GS/NA – QL-0
X GS (Procurement/Receiving QC Inspection) – QL-3
SS (CGI Dedication) QL-2
SC (CGI Dedication) QL-1
SS (ESL Procurement) QL-2
SC (ESL Procurement) QL-1

NOTE: All SFS supported procurement services for identified materials (parts/items) required for this fabrication require pre-acquisition reviews, identification of safety classifications and quality levels, and approval by all required customer facility managers and core evaluators responsible for this fabrication. All pre-acquisition reviews and approvals shall meet requirements of HNF-MD-4635. The review/approval signatures shall be documented below:

Customer approval signatures according to MRP 543 – PLEASE PRINT OR TYPE NAME, SIGN AND DATE.

Date: 6/26/00 Phone: 3-3235
21. CEC/Responsible Engineer:

Date: Phone: 6/26/00 3-3235
22. CEC/Responsible Engineer’s Manager:

Date: Phone: 6/26/00 3-3235
23. Quality Assurance – CEC Evaluator:

Date: Phone: 6/26/00 3-3053
24. Technical/Engineer – Core Evaluator:

Date: Phone: 6/26/00 3-3235
25. Health and Safety Assurance:

Date: Phone: 6/26/00 3-3235
26. Environmental Assurance:

Date: Phone: 6/26/00 3-3235
<table>
<thead>
<tr>
<th>Description</th>
<th>Drawings/ECN</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>2&quot; Gasket, Type III</td>
<td>H-2-3997, Part # 6</td>
<td>1</td>
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<tr>
<td>3&quot; Gasket, Type III</td>
<td>H-2-3997, Part # 7</td>
<td>1</td>
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<tr>
<td>Lifting Bail</td>
<td>H-2-90161</td>
<td>1</td>
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<tr>
<td>2&quot; Horizontal Lifting Bail</td>
<td>H-2-90162-2</td>
<td>1</td>
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<tr>
<td>3&quot; Horizontal Lifting Bail</td>
<td>H-2-90162-3</td>
<td>1</td>
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<td>2&quot; Sched 40 SR 90 Degree Elbow (ASTM A403 304-L SST)</td>
<td>H-2-64457, Part # 8</td>
<td>2</td>
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<tr>
<td>2&quot; Sched 40 LR 90 Degree Elbow (ASTM A403 304-L SST)</td>
<td>H-2-64457, Part # 7</td>
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<tr>
<td>2&quot; Sched 40 LR 90 Degree Elbow (ASTM A234 GR WPB CS)</td>
<td>H-2-37800, Part # 7</td>
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<td>2&quot; Sched 40 Pipe (ASTM A312 304-L SST)</td>
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<tr>
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<td>2&quot; Flex Hose</td>
<td>H-2-57901, Part # 5</td>
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NOTE: Jumper parts listed above are essential parts for assembling jumper in the following central pump pits: AN Farm (H-2-72025), AP Farm (H-2-90726), AW Farm (H-2-70444), AY/AZ Farm (H-2-64457) and SY Farm (H-2-37800). The jumper head connector assemblies have already been assembled per 211-0004706/F.