CRWMS/M&O

Design Analysis Cover Sheet

Complete only applicable items.

1.

QA: N/A

Page: 1 Of: 17

2. DESIGN ANALYSIS TITLE

FUEL SUPPLY SYSTEM ANALYSIS FOR ESF PACKAGE 1E

3. DOCUMENT IDENTIFIER (Including Rev. No.)

BABBD A000-01717-0200-00008 REV 01

4. REV. NO.

01

5. TOTAL PAGES

17

6. TOTAL ATTACHMENTS

6

7. ATTACHMENT NUMBERS - NO. OF PAGES IN EACH

I-3; II-1; III-3; IV-6; V-8; VI-5

8. SYSTEM ELEMENT

ESF

Print Name

Signature

Date

9. Originator

D. F. Vanica

D. F. Vanica

6-9-95

10. Checker

R. E. Flye

Russell E. Flye

6-9-95

11. Lead Design Engineer

R. E. Flye

Russell E. Flye

6-9-95

12. QA Manager

J. W. Willis

J. W. Willis

6-14-95

13. Department Manager

G. N. Kimura

G. N. Kimura

6-14-95

14. REMARKS

Design Analysis Revision Record

CRWMS/M&O

Complete only applicable items.

1.

QA: N/A

Page: 2 Of: 17

2. DESIGN ANALYSIS TITLE		
FUEL SUPPLY SYSTEM ANALYSIS FOR ESF PACKAGE 1E		
3. DOCUMENT IDENTIFIER (Including Rev. No.)		4. REVISION NO.
BABBDA000-01717-0200-00008 REV 01		01
5. Revision No.	6. Total Pages	7. Description of Revision
00	17	Issued for construction.
01	17	Deleted Paragraphs 4.2.3.2 and 4.2.3.3 and renumbered accordingly Revised Paragraphs 5.4 and 5.19 Added Reference 5.18 Revised pressure drops in Paragraphs 7.3.2 and 7.3.3 Revised Pages III-1, III-2, and III-3 for deletion of moisture separator Revised Pages V-7, V-8, VI-4 and VI-5 calculations for 60 mesh strainer screen. Editorial changes Paragraphs 1.1, 2, 4.3.1, 4.3.3, 7.2.4, and 7.3

1. PURPOSE

- 1.1 The primary objective of this analysis is to capture new inputs relative to the design of the Fuel Supply System (FSS) at the Yucca Mountain Site Characterization Project (YMP) Exploratory Studies Facility (ESF). The new inputs are analyzed and changes to the Fuel Supply System are made as necessary.
- 1.2 The FSS is essentially the same as the Standby Generator Fuel System. New project information makes certain modifications to the Standby Generator Fuel System necessary. The magnitude of the changes combined with possible revocation of new requirements led to the development of this analysis. The Standby Generator Fuel System Analysis (Reference 5.5) is used as the basis for this analysis.

2. QUALITY ASSURANCE

The FSS is a temporary utility not currently identified as a potential permanent facility. A Determination of Importance Evaluation (DIE) has determined that several "Q" controls are applicable to the operation and construction of the Standby Generator Fuel Supply System. However, these controls are not applicable to this analysis. (Reference 5.4 and 5.18)

The Quality Assurance (QA) classification of this analysis is: NONE. No QA Controls are applicable.

3. METHOD

This analysis captures new design information that supersedes the Standby Generator Fuel System Analysis (Reference 5.5). New information is analyzed, and where applicable, new design for the FSS is developed.

4. DESIGN INPUTS

4.1 DESIGN PARAMETERS

- 4.1.1 Standby electrical load: 3787 kVA total (Reference 5.6)
- 4.1.2 Number of diesel generators (Reference 5.6)
 - 4.1.2.1 Four at 500 kW each (diesel generators GN-401, 402, 403, and 404)
 - 4.1.2.2 Two at 1100 kW each (diesel generators GN-405 and 406)
- 4.1.3 Diesel fuel consumption requirements for electrical generators:
 - 4.1.3.1 500 kW, 35 gallons per hour (gph) each (Reference 5.7)

4.1.3.2 1100 kW, 64 gph each (Reference 5.7)

4.1.3.3 Total maximum fuel consumption: 233 gph, occurs when three 500 kW and two 1100 kW units are operating simultaneously. (Reference 5.7)

4.1.4 Diesel fuel daytanks: two 600 gallon tanks will support the first two 500 kW generators on a temporary basis. (Reference 5.8)

4.1.5 Main Fuel Supply Tank

4.1.5.1 Volume to be revised from 9,000 gallons to approximately 5,000 gallons. (Reference 5.8) Final sizing to be analyzed in Section 7 of this Design Analysis.

4.1.5.2 The main fuel storage tank shall be double walled. (Reference 5.5)

4.1.5.3 The main fuel storage tank shall be monitored for leak detection by programmable controllers. (Reference 5.5)

4.1.5.4 The main fuel supply tank shall be above grade, modular unit with lifting lugs. (Reference 5.5)

4.1.6 Fuel Transfer Pumps

4.1.6.1 Three pumps are required: two for maximum demand, one for standby. (Reference 5.5) This parameter is revisited in Section 7.

4.1.6.2 The actual size of the transfer pumps is to be revised from 10 gpm. (Reference 5.5) Final sizing is to be calculated in Section 7 of this analysis.

4.1.7 Piping and Accessories

4.1.7.1 Provide insulation and heat tracing to elements subject to freezing. (Reference 5.5)

4.1.7.2 Maintain a minimum fuel temperature of 40 degrees F. (Reference 5.5) This parameter is revisited in Section 7.

4.1.7.3 Pipe insulation thickness is .5 inch. (Reference 5.5) This parameter is revisited in Section 7.

4.1.7.4 Pipe insulation k-value is .027 BTU/hr-sqft-F. (Reference 5.5) This parameter is revisited in Section 7.

4.1.7.5 Maintain return line static pressure at 20 psig minimum. (Reference 5.11)

4.1.8 The Fuel Supply System (General)

4.1.8.1 Maintainable service life shall be for 25 years. (Reference 5.5)

4.1.8.2 The FSS shall support ESF standby operations for 24 hours. (Reference 5.5)

4.1.8.3 The FSS shall support the compressed air system and subsurface refuge chambers for a minimum of 48 hours. (Reference 5.5 and 5.12)

4.1.8.4 The FSS shall be capable of operation during ambient temperature extremes from -14 degrees F to + 108 degrees F. (Reference 5.5)

4.2 CRITERIA - (Sections 4.2.1 and 4.2.2 are copied directly from the Standby Generator Fuel System Analysis - Reference 5.5)

4.2.1 Criteria From The Design Summary Report (DSR) (Reference 5.1, Verbatim):

"The surface electrical power transmission and distribution system provides sufficient electrical power to meet construction and operational requirements for the surface and subsurface. **Standby and uninterruptible power supply (UPS) systems are available for equipment required during any utility power outage.** The main power source for the ESF site is a 69 kV transmission line fed from the existing Canyon Substation. (See Drawings No. YMP-025-1-ELECT-EL101 and YMP-025-1-ELEC-EL102.)"

"The design requires rerouting the existing 69 kV transmission line to the [Topopah Spring] TS north portal and TS south portal substations where the 69 kV transmission voltage is stepped down to 12,470 V, the primary distribution voltage. The 15 kV-rated power cables are routed in concrete-encased duct banks to various surface facilities, including site lighting, and supply subsurface power to the TS north portal, TS south portal, and optional shaft collar sites. Grounding provisions will be determined during Title II design."

"**Standby power is provided by diesel engine generators.** During utility power outages, power is supplied to the ventilation fans; the optional shaft hoist (if required); subsurface facilities; communications and security equipment; UPS; security lighting; life safety; and other required equipment."

"The UPS power is used for communications, security, life safety, ID equipment, and PI-supplied site characterization test equipment that must operate during any utility or **standby power outage.** Each UPS time duration requirement will be determined during Title II Design." (DSR Section 3.4.1, surface utilities, power distribution)

4.2.2 Criteria From The Exploratory Studies Facility Design Requirements (ESFDR) Document (Reference 5.2 Verbatim):

"Power system - systems, subsystems, components and structures that supply electrical power to the ESF site. These systems include, but are not limited to: ESF site substation(s); distribution systems; extension and upgrading of the existing 69-kV overhead power line to 138-kV; secondary power lines to the muck conveying system and booster pump station; surface lighting; a **standby power generation system**; power distribution to the facilities; and a UPS." (ESFDR 3.1.3.2 A.1. Requirements, Surface Utilities)

4.2.3 Criteria From The Basis For Design (BFD) (Reference 5.3 Verbatim):

4.2.3.1 "Standby generators shall be located immediately to the east of the switchgear building. Each standby generator unit shall be equipped with local and remote control capabilities." (BFD 7.2.4.1 IV.E.2.a)

4.2.3.2 "Standby Generator System is considered temporary and shall be removed to the extent practical by the most cost-effective method upon completion of the ESF operations." (BFD 7.2.4.1 IV.E.2.h)

4.2.3.3 "The component selection and workmanship shall be in compliance with ANSI, ASTM, IEEE, ISA, NEMA, NFPA, UBC, and UL codes and regulations." (BFD 7.2.4.1 IV.E.2.i)

4.2.3.4 "Initially the generators shall have local controls. Remote control shall be added in the future design packages." (BFD 7.2.4.1 IV.E.2.k)

4.2.4 Supplemental Criteria

Standby diesel generators are not required to supplement normal utility power at the ESF. (Reference 5.6)

4.3 ASSUMPTIONS

4.3.1 Ambient temperature increases should not cause the fuel to reach vapor pressure. Refer to Reference 5.5 for analysis of temperature vs. vapor pressure. Geometry of fuel tank is similar, therefore results are expected to be similar (no mitigating measures needed). No verification is required.

4.3.2 Inside surface film coefficient for finding heat transfer value in Section 7.2.4 is assumed to approach infinity, thereby negating the $\frac{1}{r_a h_i}$ term in the equation.

The effect of the term is judged to be insignificant. No verification is required.

4.3.3 Conductivity for steel pipe walls assumed as perfect. Heat transfer calculations in Section 7.2.4 will yield slightly higher values contributing to a small safety factor (overestimate of heat transfer). The effect is judged insignificant for the application. No verification is required.

4.3.4 Physical properties for diesel fuel are used for application at 40 degrees F fluid temperature (Attachment III-1) for pressure drop calculations. Section 7.2.4 discusses keeping the fuel temperature at a minimum of 60 degrees F. This discrepancy of 20 degrees F is provided as a safety factor. The net effect will produce higher pressure drops and a potentially larger motor size for the transfer pumps. No verification required.

4.4 CODES AND STANDARDS

4.4.1 American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE):

ASHRAE 90.1	Standard for Energy Efficient Design of New Buildings Except New Low-Rise Residential Buildings - 1989
-------------	--

4.4.2 American Society for Testing and Materials (ASTM):

ASTM C335	Test Method for Steady-State Heat Transfer Properties of Horizontal Pipe Insulation - 1984
-----------	--

4.4.3 National Fire Protection Association (NFPA):

NFPA 30	Flammable and Combustible Liquids Code - August 20, 1993
---------	--

4.4.4 Underwriters Laboratories, Inc. (UL):

UL-142	Standard for Steel Aboveground Tanks for Flammable and Combustible Liquids - April 1, 1993
--------	--

5. REFERENCES

5.1 Title I DSR for the ESF, Rev. 1, May 6, 1992. Criteria for providing standby power generation.

5.2 ESFDR, YMP/CM-0019 Rev. 1, ICN 2, April 26, 1995. Criteria for providing standby power generation.

5.3 ESF BFD BAB000000-01717-6300-00002 Rev. 05, November 28, 1994. Criteria for providing standby power generation.

- 5.4 Determination of Importance Evaluation for ESF North Portal, BABB00000-01717-2200-00001, Rev. 05, December 5, 1994.
- 5.5 Analysis: Standby Generator Fuel System Analysis, BABBDA000-01717-0200-00002 Rev. 00, January 18, 1995. Conclusions provide inputs for this analysis.
- 5.6 Analysis: Standby Generators for North Portal Electrical Loads, BAB000000-01717-0200-00145 REV 00, March 31, 1995. Standby electrical loads and sizes of generators.
- 5.7 InterOffice Correspondence (IOC): LV.ESSD.YDS.1/95-019, Y. D. Shane to R. E. Flye, January 19, 1995. Subject: Diesel Generator Fuel Consumption and Operations.
- 5.8 Letter: LV.ESSD.REF.2/95-046, G. N. Kimura to D. L. Koss, February 10, 1995. Subject: Scope changes to Package 1D that will be shown on Package 1E, use of temporary daytanks.
- 5.9 Specification: BABBA0000-01717-6300-15060 REV 01, Mechanical Piping, February 17, 1995. Requirements for insulating and heat tracing mechanical piping, fittings, and valves.
- 5.10 Specification: BABBA0000-01717-6300-15260 REV 00, Piping Insulation, January 5, 1995. Piping insulation data.
- 5.11 IOC: LV.ESSD.REF.03/95-089, R. E. Flye to G. Kimura, dated March 31, 1995. Subject: Package 1D Technical Review of Mechanical Documents.
- 5.12 Analysis: TS North Ramp Alcove and Stubout Location Analysis, BABE00000-01717-0200-00003, REV 01, October 25, 1994. Requirements for 48 hour support.
- 5.13 1989 Fundamentals Handbook, ASHRAE Air Film Thermal Resistances.
- 5.14 IOC: LV.ESSD.REF.1/95-004, R. E. Flye to Distribution, dated January 11, 1995. Meeting minutes for the Standby Generator Fuel System.
- 5.15 Letter: LV.ESSD.RED.2/95-046, G. N. Kimura to D. L. Koss, dated February 10, 1995. Fuel Supply Systems Using Surplus Fuel Tanks.
- 5.16 Mechanical Engineering Reference Manual, 8th Edition. Michael R. Lindeburg, 1990. Insulated Pipe Heat Transfer Equation.
- 5.17 1992 ASHRAE HVAC Systems and Equipment Handbook. Piping physical data.
- 5.18 Determination of Importance Evaluation for ESF Auxiliary Generators and Associated Systems/Facilities BABB00000-01717-2200-00003, Rev. 00, dated April 25, 1995.
- 5.19 Cameron Hydraulic Data, 17th Edition. C. C. Heald, Editor, published by Ingersoll-Rand, 1992. Properties of diesel fuel, valve "k" factors.

6. USE OF COMPUTER SOFTWARE

This analysis uses computational support software as defined by QAP-SI-0 Rev. 0 and is not subject to the software controls of the SI series. The software used for this analysis is LOTUS 1-2-3 for Windows, Version 1.1.

7. DESIGN ANALYSIS

7.1 OPERATIONS

- 7.1.1 Attachment I shows two spreadsheets which simulate operational scenarios expected for the FSS. Both minimum and maximum operational scenarios are illustrated.
- 7.1.2 The maximum demand scenario in Attachment I, page I-1 illustrates all diesel generators operating except for one 500 kW unit (Reference 5.7). Using a single 5 gpm (300 gph) pump, the maximum transfer demand of 233 gph is satisfied; 67 gph is oversupplied and returned to the main fuel tank.
 - 7.1.2.1 From 4.1.6.1, an additional transfer pump is required for standby service.
- 7.1.3 The minimum demand scenario in Attachment I, page I-2 illustrates the operation of only one 500 kW generator. (Reference 5.7) One 5 gpm fuel pump is activated to supply the single generator's demand of 35 gph; 265 gph is oversupplied and returned to the main fuel tank.
- 7.1.4 From analysis of Attachment I, an additional operational scenario can be inferred. Occasionally, the fuel transfer system must be activated to "recirculate" the fuel. All the fuel from two pumps is recirculated through the piping system for a period of time. Therefore, the maximum fuel return flow is expected at 600 gph. This value is required for sizing the return piping loop.
 - 7.1.4.1 From 7.2.1 and 7.4 a minimum of two transfer pumps are required. One "in sequence" and one "in standby." Actual operational factors account for a third pump should one pump (of three) be unavailable due to maintenance or repair. By the installation of three pumps, the availability of the FSS to support the Standby Generator System approaches 100 percent.
- 7.1.5 Attachment I indicates that the minimum storage capacity of the fuel tank be 5600 gallons to fulfill operational requirements. From UL-142 (Reference 4.4.1), section 4.3, the actual capacity is to be 90 percent of nominal capacity, $5600/0.90 = 6222$ gallons. Therefore, the nominal fuel tank capacity should be at least 6250 gallons to satisfy requirements. This translates to inside tank dimensions of 94 inches in diameter by 210 inches in length.

7.1.6 Deviation of the FSS requirements as established in Design Package 1D Standby Generator Fuel System is supported by new requirements. Changes in the requirements for supplementary power combined with the high cost of instrumentation for the day tanks have scaled back the design of the FSS. The current design will focus on a recirculated type fuel delivery system, not utilizing day tanks at the standby generators. Maximum capacity of the FSS will reflect the simultaneous operation of three 500 kW and two 1100 kW generators. (Reference 5.14)

7.1.6.1 Pipe sizing for the FSS will be designed for two 5 gpm transfer pumps operating simultaneously. (Reference 5.7)

7.1.6.2 For temporary operations during construction of the standby power system, two generators will use surplus 600 gallon daytanks to support operations. (Reference 5.15)

7.2 PIPING INSULATION

Specification Sections 15060 and 15260 (Reference 5.9 and 5.10) specify piping, valves, and fittings shall have heat tracing and insulation (to elements subject to freezing [Reference 4.1.7.1]) as shown on drawings. The insulation thickness and k-value shall be as shown in ASHRAE 90.1 (Reference 4.4.1). Sections 4.1.7.2 through 4.1.7.4 contain values from the Standby Generator Fuel System Analysis (Reference 5.5) that differ from and must be addressed by this analysis.

7.2.1 Diesel fuel temperature requirements: The Standby Generator Fuel System Analysis (Reference 5.5) indicates that the minimum fuel temperature be no lower than 40 degrees F (Reference 4.1.7.2). However, external review feedback indicates that the temperature of the fuel be no lower than 60 degrees F (Reference 5.11). Therefore, the revised requirement for minimum fuel temperature shall be 60 degrees F.

7.2.2 Piping insulation thickness: Reference 4.1.7.3 suggests a minimum thickness of .5 inches. However, ASHRAE 90.1 Table 9-1 (Attachment II) does not agree with this value in all respects.

ASHRAE 90.1 is primarily intended for use with HVAC systems and does not have a direct approach to heat tracing diesel fuel lines. The most appropriate values are taken from the heating systems section, for fluids operating at 105 to 140 degrees F. From ASHRAE 90.1, the insulation thickness values applicable for the FSS design are:

- A. 1 inch thickness for pipe 2 inches and less diameter
- B. 1 ½ inch thickness for pipe over 2 inches diameter

Paragraph 2.02F of Specification Sections 15260 (Reference 5.10) indicates an increased thickness of ½ inch for pipe insulation exposed to the ambient. ASHRAE 90.1 makes no distinction between ambient conditions. Therefore, it

is recommended that the reference in the specification for increased insulation thickness be revised to show no additional thickness required.

- 7.2.3** Piping insulation conductivity: Reference 4.1.7.4 suggests a K-value of .27 BTU-in/(H-ft³-°F). Referring to the discussion in Section 7.6.2, ASHRAE 90.1 specifies a value of 0.24 through 0.28 BTU-in/(H-ft³-°F). While not incorrect, the .27 figure is within the allowable range but should be revised as a parameter to show the full range allowed. Also, ASTM C335 (Reference 4.4.2) should be referenced for determination of pipe insulation properties for calculations, use worst case values for conservative results.

7.2.4 Low Temperature Considerations:

Potential problems for low-temperature operation include the freezing of water vapor within the diesel fuel and excessive pump head. Freezing water can clog lines and damage equipment. At low temperatures, diesel fuel becomes highly viscous and requires more pump energy to circulate.

To mitigate these concerns, the operation of the Standby Generator Fuel System will employ recirculation through heat-traced (and insulated) piping when the ambient temperature reaches 60 degrees F or below. The fuel will pick up enough heat from the heat-traced piping loop to offset losses through the tank and piping insulation. At fluid temperature (measured in header and fuel tank) over 60 degrees F, the heat-tracing will turn off.

To determine the heat flux required to be added to the piping loop, heat losses from the tank and piping need to be approximated. A static heat transfer balance technique is used to solve for the heat input needed to maintain fuel temperature equilibrium at 60 degrees F. The analysis will investigate the heat transfer from the fuel tank at half full so as to average the effect of wetted surfaces within the tank.

The extreme low temperature minimum ambient of -14 degrees F (Reference 4.1.8.4) is used as the low ambient temperature for calculations. Inside piping and tank convective film coefficients for wet surfaces are ignored as conservative estimates. Air film coefficients are used for both inside and outside surfaces.

Tank Heat Losses:

$$Q_{\text{Tank}} = Q_{\text{Level 1}} + Q_{\text{Level 2}} = Q_{\text{Tk 1}} + Q_{\text{Tk 2}} \text{ (Tank Half Filled)}$$

$$Q_{\text{Tk 1}} \Rightarrow \text{Fuel in contact with tank}$$

$$Q_{\text{Tk 2}} \Rightarrow \text{Air in contact with tank interior}$$

- Solve for Wetted Area Transmission

$$Q_{Tk1} = U_{Tk1} (A_{Tk1}) (\Delta t)$$

$$A_{Tk1} = \frac{1}{2}(A_{Tk}), \quad \text{Wetted Area Inside Tank}$$

$$U_{Tk1} = .4649 \text{ BTU/H} \cdot \text{ft}^2 \cdot \text{F} \quad (\text{Reference 5.5) Tank Conductance}$$

$$A_{Tk} = A_{SIDES} + A_{ENDS}$$

$$= \pi D L + 2(\pi D^2/4), D=94" (7.83'), L=210" (17.5')$$

$$= \pi(7.83)(17.5) + 2[(\pi(7.83)^2/4)] = 527.0 \text{ ft}^2 \quad \text{Total Tank Area}$$

- Find Total Tank Conductance - Wetted Areas

$$U_{Tk1} = 1/R_{Tk1} ; R_{Tk1} = R_{Tk} + R_o + R_i; R_i \Rightarrow 0, \therefore \text{Ignore Inside Air Film}$$

- Outside Air Film

$$R_o = 1/h_o ;$$

$$[h_o = 6.00 \text{ BTU/H} \cdot \text{ft}^2 \cdot \text{F} (\text{Reference 5.13, Table 22-1})]$$

Air Film Conductance

$$R_o = .1667$$

Air Film Resistance

$$R_{TK1} = 1/.4649 + .1667$$

$$R_{Tk1} = 2.318 \text{ (H} \cdot \text{ft}^2 \cdot \text{F)/BTU}$$

Total Tank Resistance - Wet

$$U_{Tk1} = .4315 \text{ BTU/H} \cdot \text{ft}^2 \cdot \text{F}$$

Total Tank Conductance - Wet

$$Q_{TK1} = \left(.4315 \frac{\text{BTU}}{\text{H} \cdot \text{ft}^2 \cdot \text{F}} \right) \left[\left(\frac{1}{2} \right) (527 \text{ ft}^2) \right] (60 + 14)^\circ \text{F}$$

$$= 8,414 \text{ BTU/H}$$

Total Heat Loss for Wetted Areas of Tank

- Solve For Dry Surface Transmission

$$Q_{Tk2} = U_{Tk2} (A_{Tk2})(\Delta t) \quad \text{where} \quad \frac{1}{2}A_{Tk} = A_{Tk2} = 263.5 \text{ ft}^2$$

$$U_{Tk2} = 1/R_{Tk2} ; R_{Tk2} = R_o + R_{Tk} + R_i$$

$$R_i = .625 \quad (\text{Reference 5.13, Table 22-1) Inside Air Film}$$

$$R_{Tk2} = .1667 + 1/.4649 + .625 = 2.94 \text{ (H} \cdot \text{ft}^2 \cdot \text{F)/BTU}$$

$$U_{TK2} = .3398 \text{ BTU}/(\text{H} \cdot \text{ft}^2 \cdot \text{F}) \text{ (I/R}_{TK2}\text{)}$$

$$Q_{TK2} = (.3398 \text{ BTU}/[\text{H} \cdot \text{ft}^2 \cdot \text{F}]) (263.5 \text{ ft}^2) (60 + 14^\circ\text{F})$$

$$= 6625 \text{ BTU/H}$$

Total Heat Loss - Dry Areas

$$Q_{TANK} = 8,413 + 6,625 = 15,039 \text{ BTU/Hr (4,410 watts) Total Tank Loses}$$

Pipe Losses

$$q = \frac{2 \pi L \Delta t}{\frac{1}{r_a h_i} + \frac{\ln}{k_{ins}} + \frac{1}{r_b h_o}} \quad (\text{Reference 5.16, Eq. 10.11})$$

where

- h_i = inside pipe surface film coefficient (BTU/hr·ft²·°R)
- h_o = outside pipe surface film coefficient (BTU/hr·ft²·°R)
- L = length of pipe (ft)
- q = heat transfer rate (BTU/hr)
- ΔT = $T_o - T_\infty$ (°R) (same as °F)
- T_o = fuel temperature (°R)
- T_∞ = ambient temperature (°R)
- k = thermal conductivity (BTU·ft/hr·ft²·°R)
- r_a = inside radius (ft)
- r_b = outside radius (ft)

For the analysis, it is reasonable to assume fully turbulent flow with piping.

Therefore, heat transfer through h_i approaches a perfect state. The term $\frac{1}{r_a h_i}$ approaches zero as h_i approaches infinity, thereby giving the term insignificant influence over the equation above. The term $\frac{1}{r_a h_i}$ will be ignored, yielding a final result of heat transfer slightly higher than what might otherwise be solved for. This effect is judged to be insignificant for the application.

Pipe losses will be calculated for various sizes of piping. Let:

- L_1 = length of 1" diameter pipe
- L_2 = length of 2" diameter pipe
- L_3 = length of 6" diameter pipe (header)

For all lengths:

$$\begin{aligned}
 h_i &\Rightarrow \text{ignored} \\
 h_o &\Rightarrow 6.00 \text{ BTU/h}\cdot\text{ft}\cdot^\circ\text{F} \text{ (Reference 5.13, Table 22-1, 15 mph wind)} \\
 T_o &\Rightarrow 60^\circ\text{F} \text{ (fuel temperature)} \\
 T_\infty &\Rightarrow -14^\circ\text{F} \text{ (Reference 4.1.8.4)} \\
 \Delta T &\Rightarrow 60 - (-14) = 74^\circ\text{F} \text{ (74}^\circ\text{R)} \\
 k_{\text{ins}} &\Rightarrow .28 \text{ BTU}\cdot\text{in/h}\cdot\text{ft}^3\cdot^\circ\text{F} \text{ or } .0233 \text{ BTU/h}\cdot\text{ft}^2\cdot^\circ\text{F} \\
 &\text{(Attachment II and Reference 5.10, pipe insulation per ASHRAE Standard} \\
 &\text{90.1, Electric Heating Systems, 105-140}^\circ\text{F)}
 \end{aligned}$$

The conductivity of steel pipe is assumed perfect for this analysis and is not included as an element within the equation. Effect is judged to be insignificant, perhaps yielding a small safety factor contribution to a slightly conservative estimate.

- Solve for 1 inch, schedule 40, steel pipe: (Reference 5.9)

$$\begin{aligned}
 \text{Inside diameter} &\Rightarrow 1.049 \text{ inches (Reference 5.17, Table 42-2)} \\
 \text{Outside diameter} &\Rightarrow 1.315 \text{ inches (Reference 5.17, Table 42-2)} \\
 \text{Insulation thickness} &\Rightarrow 1.0 \text{ inches (Attachment II-1)} \\
 \text{Estimated Length (L}_1\text{)} &\Rightarrow 10 \text{ feet (Attachment III-3)}
 \end{aligned}$$

$$\begin{aligned}
 r_a &= 1.049/12 = 0.08742 \text{ feet} \\
 r_b &= 1.315/12 + 1.0/12 = 0.19292 \text{ feet}
 \end{aligned}$$

$$q = \frac{2 \pi (10) (74)}{\frac{\ln \left(\frac{1929}{.08742} \right)}{.0233} + \frac{1}{(.1929) (6.00)}}$$

$$q = 133.5 \text{ BTU/h}$$

- Solve for 2 inch, schedule 40, steel pipe: (Reference 5.9)

$$\begin{aligned}
 \text{Inside diameter} &\Rightarrow 2.067 \text{ inches (Reference 5.17, Table 42-2)} \\
 \text{Outside diameter} &\Rightarrow 2.375 \text{ inches (Reference 5.17, Tables 42-2)} \\
 \text{Insulation thickness} &\Rightarrow 1.0 \text{ inches (Attachment II)} \\
 \text{Estimated length (L}_2\text{)} &\Rightarrow 10 + 7 + 60 + 40 + 100 + 40 + 20 + 20 = 297 \text{ feet (Attachment III-3)}
 \end{aligned}$$

$$r_a = 2.067/12 = 0.17225 \text{ feet}$$

$$r_b = 2.375/12 + 1/12 = 0.28125 \text{ feet}$$

$$q_2 = \frac{2 \pi (297) (74)}{\frac{\ln \left(\frac{2813}{.1723} \right)}{.0233} + \frac{1}{(.2813) (6.00)}}$$

$$q_2 = 6,384 \text{ BTU/h}$$

- Solve for 6 inch, schedule 40, steel pipe: (Reference 5.9)

Inside diameter	$\Rightarrow$	6.065 inches (Reference 5.17, Table 42-2)
Outside diameter	$\Rightarrow$	6.625 inches (Reference 5.17, Table 42-2)
Insulation thickness	$\Rightarrow$	1.5 inches (Attachment II)
Estimated length (L_1)	$\Rightarrow$	100 feet (Attachment III-3)

$$r_a = 6.065/12 = 0.50542 \text{ feet}$$

$$r_b = 6.625/12 + 1.5/12 = 0.677008 \text{ feet}$$

$$q_3 = \frac{2 \pi (100) (74)}{\frac{\ln \left(\frac{6771}{.5054} \right)}{.0233} + \frac{1}{(.6771) (6.00)}}$$

$$q_3 = 3,633 \text{ BTU/h}$$

- Total Piping Heat Losses

$$q_{\text{pipe}} = q_1 + q_2 + q_3$$

$$q_{\text{pipe}} = 133.5 + 6,384 + 3,633 = 10,150 \text{ BTU/h}$$

Total Losses

$$Q_{\text{TOTAL}} = Q_{\text{Tk}} + Q_{\text{PIPE}} = 15,039 + 10,151 = 25,190 \text{ BTU/h} \quad (7,387 \text{ watts})$$

Heat Input

$$Q_{in} = 25,190 \text{ BTU/h or } 7,387 \text{ watts}$$

Heat Flux $\phi = Q_{in}/L_T$, where L_T = Total Length

$$L_T = L_1 + L_2 + L_3 = 10 + 297 + 100 = 407 \text{ feet}$$

$$\phi = 7,387/407 = 18.15 \text{ watts/feet}$$

The analysis indicates that the heat-tracing flux should be 18.15 watts/linear feet of piping to ensure the fuel temperature stays at or above 60 degrees F.

7.3 EQUIPMENT ANALYSIS

7.3.1 Transfer Pump Selection and Details (Attachment VI)

- Provide three "Viking" model G-432D-F transfer pumps.
- 50 psig @ 1200 rpm, 5 gpm.
- 1 inch port size, internal safety relief valve.
- ½ HP, 208 V/3 ϕ /60 HZ

7.3.2 Basket Strainer Selection and Details (Attachment V)

- Provide one "Hayward" Model 50 Duplex Basket Strainer with #60 mesh screen.
- Pressure drop of 0.469 psig (1.083 feet H₂O).

7.3.3 Y-Strainer Selection and Details (Attachment VI)

- Provide one "Hayward" Model 80 Y-Strainer with #60 mesh screen.
- Pressure drop of 0.938 psig (2.166 feet H₂O).

7.3.4 Fuel Tank Sizing (Section 7.1.5)

- 6250 gallon nominal capacity.
- Inside dimensions are 94 inch diameter x 210 inch length.
- Estimated dry weight 17,500 lbs.
- Estimated wet weight 64,500 lbs.

8. CONCLUSIONS

8.1 MAIN TANK VOLUME

- 8.1.1 As shown in Attachment I, the minimum actual main fuel tank volume required to operate the generators for 24 hours (Reference 5.7 and Section 7.3.4) is 5600 gallons.

- 8.1.2 The minimum nominal main fuel tank capacity shall be 6250 gallons (Section 7.1.5) with dimensions of 94 inch diameter by 210 inch length.

8.2 TRANSFER PUMP CAPACITY

- 8.2.1 As shown in Attachment I, the optimum fuel transfer pump size is 5 gallons per minute (300 gph).
- 8.2.2 As shown in Attachment I, one transfer pump is required to operate to satisfy maximum load requirements.
- 8.2.3 A total of three, identical transfer pumps are needed to satisfy all operational requirements. (Reference Section 7.2.1)

8.3 REVISED DESIGN PARAMETERS FOR DESIGN PACKAGE 1E

- 8.3.1 Main fuel supply tank: 5600 gallons actual capacity minimum with a minimum nominal capacity of 6250 gallons. (Reference 7.3.4)
- 8.3.2 Fuel transfer pumps: Three pumps sized at 5 gpm (300 gph). (Reference 7.1, 7.2, 7.2.1, 7.3)
- 8.3.3 Minimum allowable fuel temperature: 60 degrees F (Reference 7.2.1)
- 8.3.4 Piping insulation thickness: 1 inch for pipe 2 inch diameter and less, 1 ½ inch for pipe over 5 inch diameter. (Specification Section 15260, Reference 5.10, Attachment II)
- 8.3.5 Piping insulation value: 0.24 through 0.28 BTU-in/(H-ft³-°F).
- 8.4 Provide heat tracing to prevent line freezing. The required heat input is 18.15 watts/linear foot for a minimum of 407 feet yielding a total of 7387 watts.

9. ATTACHMENTS

ATTACHMENT

TITLE

I	Fuel Storage Operation Simulation (3 pages)
II	ASHRAE 90.1 Table 9-1. Minimum Pipe Insulation (1 page)
III	Piping Calculations (3 pages)
IV	"Viking" G-432D-F Pump Cut Sheets (6 pages)
V	"Hayward" Model 50 Duplex Strainer Cut Sheets (8 pages)
VI	"Hayward" Model 80 Y-Strainer Cut Sheets (5 pages)

FUEL STORAGE OPERATION SIMULATION

Maximum Capacity Demand Senario

BY: C. MELLEN
 DATE: 04/11 1995
 FN: FUELSTR6.WK3

Pump - 5 gpm (main)
 Pump - 5 gpm (secondary)
 Pump - 5 gpm (standby)

Mn Tnk	Pump	Pump	Pump	Gross	Net	Trnsfr	DG-001	DG-002	DG-003	DG-004	DG-005	DG-00		
HR volume	1	2	3	Supply	Return	demand	demand	demand	demand	demand	demand	demand		
0	5600	100%	0	0	0	0	0	0	0	0	0	0		
1	5367	96%	300	0	0	300	67	233	35	35	35	0	64	64
2	5134	92%	300	0	0	300	67	233	35	35	35	0	64	64
3	4901	88%	300	0	0	300	67	233	35	35	35	0	64	64
4	4668	83%	300	0	0	300	67	233	35	35	35	0	64	64
5	4435	79%	300	0	0	300	67	233	35	35	35	0	64	64
6	4202	75%	300	0	0	300	67	233	35	35	35	0	64	64
7	3969	71%	300	0	0	300	67	233	35	35	35	0	64	64
8	3736	67%	300	0	0	300	67	233	35	35	35	0	64	64
9	3503	63%	300	0	0	300	67	233	35	35	35	0	64	64
10	3270	58%	300	0	0	300	67	233	35	35	35	0	64	64
11	3037	54%	300	0	0	300	67	233	35	35	35	0	64	64
12	2804	50%	300	0	0	300	67	233	35	35	35	0	64	64
13	2571	46%	300	0	0	300	67	233	35	35	35	0	64	64
14	2338	42%	300	0	0	300	67	233	35	35	35	0	64	64
15	2105	38%	300	0	0	300	67	233	35	35	35	0	64	64
16	1872	33%	300	0	0	300	67	233	35	35	35	0	64	64
17	1639	29%	300	0	0	300	67	233	35	35	35	0	64	64
18	1406	25%	300	0	0	300	67	233	35	35	35	0	64	64
19	1173	21%	300	0	0	300	67	233	35	35	35	0	64	64
20	940	17%	300	0	0	300	67	233	35	35	35	0	64	64
21	707	13%	300	0	0	300	67	233	35	35	35	0	64	64
22	474	8%	300	0	0	300	67	233	35	35	35	0	64	64
23	241	4%	300	0	0	300	67	233	35	35	35	0	64	64
24	8	0%	300	300	300	600	367	233	35	35	35	0	64	64
Totals							5592	840	840	840	0	1536	1536	

FUEL STORAGE OPERATION SIMULATION (CONTINUED)

Minimum Capacity Demand Senario

BY: C. MELLEN
 DATE: 04/11 1995
 FN: FUELSTR6.WK3

Pump - 5 gpm (main)
 Pump - 5 gpm (secondary)
 Pump - 5 gpm (standby)

Mn Tnk	Pump	Pump	Pump	Gross	Net	Trnsfr	DG-001	DG-002	DG-003	DG-004	DG-005	DG-00
HR volume	1	2	3	Supply	Return	demand	demand	demand	demand	demand	demand	demand
%												
0 5600 100%	0	0	0	0	0	0	0	0	0	0	0	0
1 5565 99%	300	0	0	300	265	35	35	0	0	0	0	0
2 5530 99%	300	0	0	300	265	35	35	0	0	0	0	0
3 5495 98%	300	0	0	300	265	35	35	0	0	0	0	0
4 5460 98%	300	0	0	300	265	35	35	0	0	0	0	0
5 5425 97%	300	0	0	300	265	35	35	0	0	0	0	0
6 5390 96%	300	0	0	300	265	35	35	0	0	0	0	0
7 5355 96%	300	0	0	300	265	35	35	0	0	0	0	0
8 5320 95%	300	0	0	300	265	35	35	0	0	0	0	0
9 5285 94%	300	0	0	300	265	35	35	0	0	0	0	0
10 5250 94%	300	0	0	300	265	35	35	0	0	0	0	0
11 5215 93%	300	0	0	300	265	35	35	0	0	0	0	0
12 5180 93%	300	0	0	300	265	35	35	0	0	0	0	0
13 5145 92%	300	0	0	300	265	35	35	0	0	0	0	0
14 5110 91%	300	0	0	300	265	35	35	0	0	0	0	0
15 5075 91%	300	0	0	300	265	35	35	0	0	0	0	0
16 5040 90%	300	0	0	300	265	35	35	0	0	0	0	0
17 5005 89%	300	0	0	300	265	35	35	0	0	0	0	0
18 4970 89%	300	0	0	300	265	35	35	0	0	0	0	0
19 4935 88%	300	0	0	300	265	35	35	0	0	0	0	0
20 4900 88%	300	0	0	300	265	35	35	0	0	0	0	0
21 4865 87%	300	0	0	300	265	35	35	0	0	0	0	0
22 4830 86%	300	0	0	300	265	35	35	0	0	0	0	0
23 4795 86%	300	0	0	300	265	35	35	0	0	0	0	0
24 4760 85%	300	0	300	300	265	35	35	0	0	0	0	0
Totals						840	840	0	0	0	0	0

FUEL STORAGE OPERATION SIMULATION (CONTINUED)

Recirculation Senario

BY: C. MELLEN
 DATE: 04/11 1995
 FN: FUELSTR6.WK3

Pump - 5 gpm (main)
 Pump - 5 gpm (secondary)
 Pump - 5 gpm (standby)

Mn Tnk	Pump	Pump	Pump	Gross	Net	Trnsfr	DG-001	DG-002	DG-003	DG-004	DG-005	DG-00
HR volume	1	2	3	Supply	Return	demand	demand	demand	demand	demand	demand	demand
%												
0	5600	100%	0	0	0	0	0	0	0	0	0	0
1	5600	100%	300	300	0	600	600	0	0	0	0	0
2	5600	100%	300	300	0	600	600	0	0	0	0	0
3	5600	100%	300	300	0	600	600	0	0	0	0	0
4	5600	100%	300	300	0	600	600	0	0	0	0	0
5	5600	100%	300	300	0	600	600	0	0	0	0	0
6	5600	100%	300	300	0	600	600	0	0	0	0	0
7	5600	100%	300	300	0	600	600	0	0	0	0	0
8	5600	100%	300	300	0	600	600	0	0	0	0	0
9	5600	100%	300	300	0	600	600	0	0	0	0	0
10	5600	100%	300	300	0	600	600	0	0	0	0	0
11	5600	100%	300	300	0	600	600	0	0	0	0	0
12	5600	100%	300	300	0	600	600	0	0	0	0	0
13	5600	100%	300	300	0	600	600	0	0	0	0	0
14	5600	100%	300	300	0	600	600	0	0	0	0	0
15	5600	100%	300	300	0	600	600	0	0	0	0	0
16	5600	100%	300	300	0	600	600	0	0	0	0	0
17	5600	100%	300	300	0	600	600	0	0	0	0	0
18	5600	100%	300	300	0	600	600	0	0	0	0	0
19	5600	100%	300	300	0	600	600	0	0	0	0	0
20	5600	100%	300	300	0	600	600	0	0	0	0	0
21	5600	100%	300	300	0	600	600	0	0	0	0	0
22	5600	100%	300	300	0	600	600	0	0	0	0	0
23	5600	100%	300	300	0	600	600	0	0	0	0	0
24	5600	100%	300	300	0	600	600	0	0	0	0	0
Totals								0	0	0	0	0

**ASHRAE 90.1 TABLE 9-1
MINIMUM PIPE INSULATION**

Fluid Design Operating Temperature Range, °F	Insulation Conductivity		Nominal Pipe Diameter (in.)					
	Conductivity Range Btu·in./(h·ft²·°F)	Mean Rating Temperature °F	Runouts* up to 2	1 and less	1-1 1/4 to 2	2-2 1/2 to 4	5 & 6	8 & up
Heating Systems (Steam, Steam Condensate, and Hot Water)								
Above 350	0.32-0.34	250	1.5	2.5	2.5	3.0	3.5	3.5
251-350	0.29-0.31	200	1.5	2.0	2.5	2.5	3.5	3.5
201-250	0.27-0.30	150	1.0	1.5	1.5	2.0	2.0	3.5
141-200	0.25-0.29	125	0.5	1.5	1.5	1.5	1.5	1.5
105-140	0.24-0.28	100	0.5	1.0	1.0	1.0	1.5	1.5
Domestic and Service Hot Water Systems**								
105 & Greater	0.24-0.28	100	0.5	1.0	1.0	1.5	1.5	1.5
Cooling Systems (Chilled Water, Brine, and Refrigerant)								
40-55	0.23-0.27	75	0.5	0.5	0.75	1.0	1.0	1.0
Below 40	0.23-0.27	75	1.0	1.0	1.5	1.5	1.5	1.5

FUEL SYSTEM PRESSURE DROP CALCULATION

Calc #: BABBDA000-01717-0200-00002 Operation: FULL LOAD TRANSFER
 Project: MDGS - YUCCA MOUNTAIN Site: ESF-NORTH PORTAL PAD
 Job #: DE-AC01-91RW00134 Service: DIESEL FUEL TRANSFER
 Author: C. Mellen Client: DOE-YMPO
 Fluid: DIESEL NO.2
 S.G.: 0.9 Viscosity: 10.2 (centpse.)
 Density (56.07 (lbm/ft3) Viscosity: 0.000213 (lb/ft-s)
 Roughne 0.00015 (ft) Kinematic viscosity (v)= 1.22E-04 (ft2/s) 60 (SSU @ 40F)

05/17/95

NODE	GPM	DIA. (FT)	VEL. (FPS)	LENGTH (FT)	Re	FRICTION (f)	FITTINGS #	FRICTION (k)	VALVE TYPE	FRICTION (Cv)	PIPE dH (ft)	FITTING dH (ft)	VALVE dH (ft)	SUBTOT dH (ft)	SUM dH (ft)
a-b	10	0.17225	0.95	10	4.32E+04	0.0219	90-ell	6	0.63	1000000	0.02	0.048	0.000	0.066	0.066
	10	0.17225	0.95	0	4.32E+04	0.0219		0	0	1000000	0.00	0.000	0.000	0.000	0.066
b-c	10	0.17225	0.95	0	4.32E+04	0.0219		0	0 duplx strainer	14.13	0.00	0.000	1.041	1.041	1.107
c-d	10	0.17225	0.95	7	4.32E+04	0.0219	90-ell	1	0.63	1000000	0.01	0.008	0.000	0.021	1.128
d-e	5	0.087417	1.85	10	4.26E+04	0.0220	t-brnch	1	1.5	1000000	0.13	0.072	0.000	0.206	1.334
	5	0.087417	1.85	0	4.26E+04	0.0220	gate	1	0.15	1000000	0.00	0.007	0.000	0.007	1.341
	5	0.087417	1.85	0	4.26E+04	0.0220	check	1	13.8	1000000	0.00	0.661	0.000	0.661	2.002
e-f	10	0.17225	0.95	100	4.32E+04	0.0219	90-ell	6	0.63	33	0.18	0.048	0.191	0.419	2.421
f-g	9.416667	0.505417	0.10	16	1.39E+04	0.0292	t-thru	1	0.3	1000000	0.00	0.000	0.000	0.000	0.000
g-h	8.833333	0.505417	0.10	16	1.30E+04	0.0296	t-thru	1	0.3	1000000	0.00	0.000	0.000	0.000	0.000
h-i	8.25	0.505417	0.09	16	1.22E+04	0.0301	t-thru	1	0.3	1000000	0.00	0.000	0.000	0.000	0.001
i-j	7.666667	0.505417	0.08	16	1.13E+04	0.0307	t-thru	1	0.3	1000000	0.00	0.000	0.000	0.000	0.001
j-k	7.083333	0.505417	0.08	16	1.04E+04	0.0313	t-thru	1	0.3	1000000	0.00	0.000	0.000	0.000	0.001
k-l	6.5	0.505417	0.07	16	9.58E+03	0.0320	t-thru	1	0.3	1000000	0.00	0.000	0.000	0.000	0.001
l-m	5.916667	0.505417	0.07	16	8.72E+03	0.0327	t-thru	1	0.3	1000000	0.00	0.000	0.000	0.000	0.001
m-n	5.916667	0.17225	0.56	160	2.56E+04	0.0250	90-ell	4	0.63	1000000	0.11	0.011	0.000	0.126	0.127
n-o	5.916667	0.17225	0.56	0	2.56E+04	0.0250	gate	1	0.15	1000000	0.00	0.001	0.000	0.001	0.128
o-p	5.916667	0.17225	0.56	0	2.56E+04	0.0250			BP reg	9.2	0.00	0.000	0.860	0.860	0.988
	5.916667	0.17225	0.56	0	2.56E+04	0.0250	gate	1	0.15 y-strainer	10.44	0.00	0.001	0.668	0.668	1.656
p-q	5.916667	0.17225	0.56	20	2.56E+04	0.0250	90-ell	3	0.63	1000000	0.01	0.008	0.000	0.023	1.679

k from cameron 3-111 Cv derived from catalog values

TOTAL: 0.47 0.865 2.760 4.100 feet
 1.77474 psig

PIPING CALCULATIONS

Title: Fuel Supply System Analysis for ESF Package 1E

DI: BABBDA000-01717-0200-00008 REV 01
 Page: III-1

ATTACHMENT III

FUEL SYSTEM PRESSURE DROP CALCULATION

Calc #: BABBDAA000-01717-0200-00002 Operation: FULL LOAD RECIRCULATION 05/17/95
 Project: MDGS - YUCCA MOUNTAIN Site: ESF-NORTH PORTAL PAD
 Job #: DE-AC01-91RW00134 Service: DIESEL FUEL TRANSFER
 Author: C. Mellen Client: DOE-YMPO
 Fluid: DIESEL NO.2
 S.G.: 0.9 Viscosity: 10.2 (centpse.)
 Density (56.07 (lbm/ft3) Viscosity: 0.000213 (lb/ft-s)
 Roughne 0.00015 (ft) Kinematic viscosity (v)= 1.22E-04 (ft2/s) 60 (SSU)

NODE	GPM	DIA. (FT)	VEL. (FPS)	LENGTH (FT)	Re	FRICTION (f)	FITTINGS #	FRICTION (k)	VALVE TYPE	FRICTION (Cv)	PIPE dH (ft)	FITTING dH (ft)	VALVE dH (ft)	SUBTOT dH (ft)	SUM dH (ft)
a-b	10	0.17225	0.95	10	4.32E+04	0.0219	90-ell	6	0.63	1000000	0.02	0.048	0.000	0.066	0.066
	10	0.17225	0.95	0	4.32E+04	0.0219		0	0	1000000	0.00	0.000	0.000	0.000	0.066
b-c	10	0.17225	0.95	0	4.32E+04	0.0219		0	0 duplex strainer	14.13	0.00	0.000	1.041	1.041	1.107
c-d	10	0.17225	0.95	7	4.32E+04	0.0219	90-ell	1	0.63	1000000	0.01	0.008	0.000	0.021	1.128
d-e	5	0.087417	1.85	10	4.26E+04	0.0220	t-brnch	1	1.5	1000000	0.13	0.072	0.000	0.206	1.334
	5	0.087417	1.85	0	4.26E+04	0.0220	gate	1	0.15	1000000	0.00	0.007	0.000	0.007	1.341
	5	0.087417	1.85	0	4.26E+04	0.0220	check	1	13.8	1000000	0.00	0.661	0.000	0.661	2.002
e-f	10	0.17225	0.95	100	4.32E+04	0.0219	90-ell	6	0.63	33	0.18	0.048	0.191	0.419	2.421
f-g	10	0.505417	0.11	16	1.47E+04	0.0287	t-thru	1	0.3	1000000	0.00	0.000	0.000	0.000	0.000
g-h	10	0.505417	0.11	16	1.47E+04	0.0287	t-thru	1	0.3	1000000	0.00	0.000	0.000	0.000	0.000
h-i	10	0.505417	0.11	16	1.47E+04	0.0287	t-thru	1	0.3	1000000	0.00	0.000	0.000	0.000	0.001
i-j	10	0.505417	0.11	16	1.47E+04	0.0287	t-thru	1	0.3	1000000	0.00	0.000	0.000	0.000	0.001
j-k	10	0.505417	0.11	16	1.47E+04	0.0287	t-thru	1	0.3	1000000	0.00	0.000	0.000	0.000	0.001
k-l	10	0.505417	0.11	16	1.47E+04	0.0287	t-thru	1	0.3	1000000	0.00	0.000	0.000	0.000	0.001
l-m	10	0.505417	0.11	16	1.47E+04	0.0287	t-thru	1	0.3	1000000	0.00	0.000	0.000	0.000	0.002
m-n	10	0.17225	0.95	160	4.32E+04	0.0219	90-ell	4	0.63	1000000	0.29	0.032	0.000	0.320	0.321
n-o	10	0.17225	0.95	0	4.32E+04	0.0219	gate	1	0.15	1000000	0.00	0.002	0.000	0.002	0.323
o-p	10	0.17225	0.95	0	4.32E+04	0.0219			BP reg	9.2	0.00	0.000	2.456	2.456	2.780
	10	0.17225	0.95	0	4.32E+04	0.0219	gate	1	0.15 y-strainer	9.99	0.00	0.002	2.083	2.085	4.865
p-q	10	0.17225	0.95	20	4.32E+04	0.0219	90-ell	3	0.63	1000000	0.04	0.024	0.000	0.060	4.925

k from cameron 3-111 Cv derived from catalog values

TOTAL: 0.67 0.904 5.772 7.346 feet
 3.17988 psig

PIPING CALCULATIONS (CONTINUED)

Title: Fuel Supply System Analysis for ESF Package 1E

ATTACHMENT III
 DI: BABBDAA000-01717-0200-00008 REV 01
 Page: III-2

PIPING CALCULATIONS (CONTINUED)

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

Civilian Radioactive Waste Management System

Management & Operating Contractor

CONTRACT NO. DE-AC01-91RW00134

SUBJECT: FUEL SUPPLY SYSTEM

WBS NO: 1.2.6.

DATE: _____ REV NO: _____

CALC NO: BABBDA000-01717-0200-00008

ORIGINATOR: D. F. VANICA

CHECKED BY: _____

CHECKED DATE: _____

"VIKING" G-432D-F PUMP CUT SHEETS

SERIES 32 and 432 Pump
3 GPM Size Shown. Packed
or Mechanical seal type.
Valve on casing.

SERIES 432 Pump,
6 GPM Mechanical seal type.
Shown with valve on head.

**SAFETY RELIEF VALVE ON
CASING OR HEAD**
(Standard Equipment, All Sizes)

The integral safety relief valve on casing or head permits bypassing of liquid from discharge back to suction side of pump. Reverse valve when reversing pump rotation on large pumps. Small pumps with relief valve built with right hand suction as standard, left hand special.

**STEAM JACKETED HEAD
(On Request)**

Jacketed head or plate permits temperature control of the liquid being pumped. Jacketed plate available on "Q" through "LL" size pumps. Jacketed head available on "Q" through "HR" size. Relief valve not available with jacketed head or plate. For complete jacketed pumps, see Section 450.

**UPRIGHT, OPPOSITE AND
RIGHT ANGLE PORTS**
(Standard Equipment)

"Q", "HR" and "FH" size pumps furnished with upright port casings. "Q" size pump with opposite port casing and "HR" through "N" size pumps with right angle port casings. Right hand port determined by location of side port when facing pump from shaft end. Left hand casing furnished only on special order.

MECHANICAL SEAL
"G", "H" and "HL" sizes
illustrated.

All General Purpose pumps are available with packed stuffing boxes. Mechanical seals are available on "Q" through "HL" size pumps as standard. The seal is a rotary type packaged unit that is simple and self-adjusting. It works WITH rather than against pressure.

⊙ **Pressure
Range**

250 PSI for 100 SSU and above

("C" through "FH" Size)

⊙ 100 PSI or less than 100 SSU

100 PSI for 100 SSU and above

("G" through "LL" Size)

50 PSI for less than 100 SSU

75 PSI for 100 SSU and above

("Q" through "N" Size)

50 PSI for less than 100 SSU

⊙ **Temperature
Range**

-60° F. to +450° F.

⊙ **Viscosity
Range**

1.0 cps. to 250,000 SSU

⊙ **GPM ½ - 1½ - 3 - 5 - 10 - 20 - 35 -
50 - 90 - 140 - 200 - 280 - 450**
(Nominal Rating)

Viking General Purpose Series 32 pumps are extremely well suited for light, medium and intermittent service handling a variety of liquids. The smaller sizes "C", "F" and "FH" are constructed for heavier duty service. Mechanical seal equipped General Purpose pump models in sizes from "C" thru "HL" shown in this section are available with Underwriters label for handling fuel oil. Model numbers for these pumps must be designated by a suffix -X. "UL" listed models can be equipped with integral relief valve. The additional sizes of unmounted General Purpose pumps are illustrated on the following page. Also for continuous service and for handling viscous liquids, see Viking's line of heavy-duty pumps, Section 100.

- ⊙ See following pages or consult factory for specific recommendations on individual models or sizes.
⊙ Nominal capacities based on handling 50% liquids.
⊙ 150 PSI handling fuel oil less than 100 SSU.

"VIKING" G-432D-F PUMP CUT SHEETS (CONTINUED)**CONSTRUCTION — 32 and 432 SERIES ("C", "F" and "FH" SIZES)**

Pump Construction	Casing	Head	Rotor and Shaft	Idler	Idler Pin	Casing Bushing		Internal Relief Valve
						Packed	Mech. Seal	
Standard Construction	Iron	Iron	Steel	Steel	Steel	Carbon Graphite	Carbon Graphite	Iron
Bronze Fitted	Iron	Iron	Bronze	Bronze	Steel	Carbon Graphite	Carbon Graphite	Iron
All Bronze	Bronze	Bronze	Bronze	Bronze	Stainless Steel	Carbon Graphite	Carbon Graphite	Bronze

CONSTRUCTION — 32 and 432 SERIES ("G", "H" and "HL" SIZES)

Pump Construction	Casing	Head	Rotor	Idler	Rotor Shaft	Idler Pin	Bushings		Internal Relief Valve
							Packed	Mechanical Seal	
Standard Construction	Iron	Iron	Iron	⊕ Iron	Steel	Steel	Bronze	Carbon Graphite	Iron
Steel Fitted	Iron	Iron	Steel	⊕ Iron	Steel	Steel	Bronze	Carbon Graphite	Iron
Bronze Fitted	Iron	Iron	⊕ Bronze	Bronze	Stainless Steel	Steel	Bronze	Carbon Graphite	Iron
All Bronze	Bronze	Bronze	⊕ Bronze	Bronze	Stainless Steel	Stainless Steel	Bronze	Carbon Graphite	Bronze

CONSTRUCTION — 32 SERIES ("J" THROUGH "N" SIZES)

Pump Construction	Casing	Head	Rotor	Idler	Rotor Shaft	Idler Pin	Bushings	Internal Relief Valve
Standard Construction	Iron	Iron	Iron	Iron	Steel	Steel	Bronze	Iron
Steel Fitted	Iron	Iron	Steel	⊕ Iron	Steel	Steel	Bronze	Iron
Bronze Fitted	Iron	Iron	⊕ Bronze	Bronze	Stainless Steel	Steel	Bronze	Iron

SPECIFICATIONS — UNMOUNTED PUMPS

Model Number	Port Size	Nominal Pump Rating	Motor HP Required at Rated Speed Pumping 100 SSU Liquid			Maximum Recommended Discharge Pressure PSIG			Minimum Recommended Temperature for Catalogued Pump or		Steel Fitted Construction Recommended Above This Viscosity SSU	Maximum Hydrostatic Pressure PSIG	Approximate Shipping Weight With Valve Pounds	
			GPM	RPM	25 PSI	50 PSI	100 PSI	Less than 100 SSU	Feed Oil Less than 100 SSU	100 SSU and Up				Packed
Parted	① Mech. Seal	Inches												
C32	C432	1/4	1/2	1800	1/4	1/4	1/4	⊕ 100	⊕ 150	⊕ 250	⊕ 300	⊕ 225	750	5
F32	F432	1/2	1 1/2	1800	1/4	1/4	1/4	⊕ 100	⊕ 150	⊕ 250	⊕ 300	⊕ 225	750	6
FH32	FH432	1/2	3	1800	1/4	1/4	1/4	⊕ 100	⊕ 150	⊕ 250	⊕ 300	⊕ 225	750	6
G32	G432	1	8	1200	1/4	1/4	1/4	60	100	300	225	⊕ 25,000	400	18
H32	H432	1	10	1200	1/4	1/4	1 1/2	60	100	300	225	⊕ 25,000	400	20
HL32	HL432	1 1/4	20	1200	1/4	1 1/2	2	60	100	300	225	⊕ 7,500	400	26
J32		1 1/4	20	420	1/4	1 1/2	3	60	100	300		⊕ 7,500	400	55
K32		1 1/2	35	420	1	2	6	60	100	300		25,000	400	65
KK32		2	50	420	1 1/4	3	5	50	100	300		7,500	400	70
L32		2	90	420	3	5	10	50	100	300		25,000	400	120
LQ32		⊕ 2 1/4	90	420	3	5	10	50	100	300		25,000	400	125
LL32		⊕ 3	140	620	5	7 1/2	15	50	100	300		7,500	400	135
Q32		⊕ 3	200	350	7 1/2	10		50	75	300		7,500	400	335
M32		⊕ 4	280	280	10	15		50	75	300		25,000	400	500
N32		⊕ 5	450	280	15	25		50	75	300		2,500	400	670

⊕ Buna N elastomer used in Mechanical Seal of 432 Series pumps.

⊕ Valve integral with pump casing. Right hand port standard.

⊕ "E" Size pump has steel idler.

⊕ "Q" Size pump has steel idler.

⊕ Mechanical Seal pumps not recommended on applications with viscosities above 15,000 SSU.

⊕ Ports are suitable for use with 125# ANSI (ASA) cast iron or 150# ANSI (ASA) steel companion flanges or flanged fittings. All others tapped for standard pipe.

⊕ 50 PSI maximum for bronze fitted pumps.

⊕ 100 PSI maximum for bronze fitted pumps.

⊕ With extra clearance, pumps can be used to 500 PSI on intermittent duty.

⊕ With special construction, temperatures to 500° F. can be handled with seal pumps and to 650° F. with packed pumps.

⊕ Not available in steel fitted construction.

⊕ Mechanical seal seal has bronze bushing.

⊕ Check factory before using bronze rotors at viscosities normally requiring steel fitted construction.

"VIKING" G-432D-F PUMP CUT SHEETS (CONTINUED)

SERIES 32 and 432 Pumps
with "D" Drive,
"C", "F" and "FH" size pumps.

SERIES 32 and 432 Pumps
with "D" Drive,
"G", "H" and "HL" size pumps.

The direct drive unit incorporating a "C", "F" or "FH" size pump is direct driven from an 1800 RPM motor. All pumps and motors are connected through flexible couplings with guards and mount on formed steel bases.

The direct drive unit in "G", "H" or "HL" size include a pump mounted on a short bracket base with a sealed, radial type ball bearing supported shaft. The bracket

mounted pump in turn mounts on a formed steel base and is connected to a 1200 RPM motor through a flexible coupling with guard. This drive arrangement makes a compact, quiet operating unit for all six sizes.

Dimensions for "D" Drive Units—See Pages 310.13 and 310.14.

Performance Data for "D" Drive Units—See Pages 310.19 thru 310.30.

SPECIFICATIONS — "D" DRIVE UNITS

Model Number	Packing Seal	Port Size	Nominal Pump Rating	Motor Horsepower Required at Rated Speed Pumping 100 SSU Liquid			Maximum Recommended Discharge Pressure PSIG			Maximum Recommended Temperature for Catalog Pump or		Steel Fitted Construction Recommended Above This Viscosity SSU	Maximum Hydrostatic Pressure PSIG	Approximate Shipping Weight With Valve and Power Pounds
				GPM	RPM	25 PSI	50 PSI	100 PSI	Low Head 100 SSU	Full On 100 SSU	110 SSU and Up			
Packed	ONCH Seal	inches								Packed	Mechanical Seal			
G32D	C432D	1/4	1/4	1800	1/4	1/4	1/4	100	150	250	300	225	760	26
F32D	F432D	1/4	1/4	1800	1/4	1/4	1/4	100	150	250	300	225	750	27
FH32D	FH432D	1/4	3/8	1800	1/4	1/4	1/4	100	150	250	300	225	750	29
G32D	G432D	1	5	1200	1/2	1/2	1/2	50	100	300	225	25,000	400	46
H32D	H432D	1	10	1200	1/2	1/2	1/2	50	100	300	225	25,000	400	70
HL32D	HL432D	1 1/4	20	1200	1/2	1 1/4	2	50	100	300	225	7,500	400	76

① Mechanical Seal pumps not recommended on applications with viscosities above 15,000 SSU.
② 50 PSI maximum for bronze fitted pumps.
③ 100 PSI maximum for bronze fitted pumps.

④ With extra clearance, pumps can be used to 500 PSI on intermittent duty.
⑤ With special construction, temperatures to 500° F. can be handled with seal pumps and to 650° F. with packed pumps.

"VIKING" G-432D-F PUMP CUT SHEETS (CONTINUED)

For specifications, see pages 310.4
and 310.5

DIMENSIONS —
32 AND 432 SERIES
UNMOUNTED PUMPS
"C"—"F"—"FH" SIZE

MODEL NO.		A	B	C	G	H	L	M	N	W
PACKED	SEAL									
C32	C432	$\frac{1}{4}$	$1\frac{11}{16}$	$\frac{3}{4}$	$4\frac{25}{32}$	$\frac{17}{32}$	$2\frac{1}{4}$	$6\frac{11}{16}$	$\frac{7}{8}$	$2\frac{9}{16}$
F32	F432	$\frac{1}{2}$	2	$\frac{15}{16}$	5	$\frac{19}{32}$	2	7	1	$2\frac{7}{8}$
FH32	FH432	$\frac{1}{2}$	2	$\frac{15}{16}$	$5\frac{3}{8}$	$\frac{19}{32}$	$2\frac{3}{8}$	$7\frac{3}{8}$	1	$2\frac{7}{8}$

For specifications, see pages 310.4
and 310.5

DIMENSIONS —
32 AND 432 SERIES
UNMOUNTED PUMPS
"G" SIZE

MODEL NO.	
PACKED	SEAL
G32	G432

① Minimum dimension for reworking. Assembled dimension on seal pumps $2\frac{1}{16}$ ".

"VIKING" G-432D-F PUMP CUT SHEETS (CONTINUED)

For specifications, see page 310.8

DIMENSIONS —
32 AND 432 SERIES
("D" DRIVE)
"G" "H" "HL" SIZE

- ① All "T" ports are equipped with opposite ports with approx. 3/4" above shaft center line. See drawing page 310.11.
 ② For motor frames 58, 143T and 145T.
 ③ For motor frames 182, 182T, 184 and 184T.
 Frame 48 (3" center line), scabbler base required.
 Frame 213 or up, larger base required.
 These dimensions are average and not for construction purposes. Certified prints on request.

For specifications, see pages 310.4 and 310.5

DIMENSIONS —
32 AND 432 SERIES
("B" DRIVE)
"G" SIZE

- ① Minimum dimension for repacking. Assembled dimension for seal pump 3 1/16.

"VIKING" G-432D-F PUMP CUT SHEETS (CONTINUED)

PERFORMANCE DATA

"HAYWARD" MODEL 50 DUPLEX STRAINER CUT SHEETS

Hayward® Duplex Basket Strainers

Sizes from $\frac{3}{4}$ " to 36"

Available in Iron, Bronze,
Stainless Steel, Carbon Steel

A Duplex, or double, basket strainer can operate continuously and never has to be shut down for cleaning. When one basket becomes full, flow is switched to the other. The first basket is removed, cleaned and replaced, ready for use again.

For 60 years, hundreds of thousands of Hayward Duplex Strainers have been installed all over the world to remove unwanted material from every conceivable kind of industrial fluid. The majority of these strainers are still in service.

Examples of where Duplex Strainers are used are in continuously running lubrication systems where the flow of oil cannot be stopped, cooling lines in places like power plants where the cooling water must always run, industrial heating and power systems where the fuel lines must never be stopped. On board a ship, for instance, the vessel cannot stop in the middle of the ocean if the oil burner nozzles become clogged and must be cleaned. A Duplex Strainer is used here to clean dirt out of the oil. Many chemical operations must run continuously and a Duplex Strainer in the line provides assurance that auxiliary equipment will not plug and stop functioning.

We make Duplex Strainers in several styles. In the smaller sizes (up to 8") a tapered plug is used to divert flow from one side to the other.

In larger sizes (10"-16") a newly developed design uses synchronized butterfly valves to switch the flow. For still larger sizes (up to 36"), we use synchronized gate valves. This strainer has many years of successful service behind it, especially in the power and water industries where large volumes of water must be handled.

"HAYWARD" MODEL 50 DUPLEX STRAINER CUT SHEETS (CONTINUED)

Hayward® Duplex Basket Strainers

Model 50

Tapered Plug Type

Available in Iron, Bronze, Stainless Steel, Carbon Steel

For sizes up to 8", we use the time tested tapered plug principle. It is the simplest, most economical and trouble-free design for a Duplex Strainer in smaller sizes.

This type of strainer is actually a high quality, pressure rated plug valve with integral straining baskets. Switching flow from one basket to another is accomplished by moving the handle through a 90° arc. It is impossible for this operation to stop the flow because of the unique port design in the diverter plug. The entire switching operation takes less than 30 seconds. No tools are needed. The plug is automatically positioned each time in exactly the right spot by integral stops.

The top handle is rotated. A lifting jack raises the diverter plug off its seat. The plug handle is moved 90°. The top handle is rotated again and the plug is resealed. Because of the mechanical lifting jack, the plug lifts and seats easily, even under high pressure. A built-in stop limits the distance the diverter plug can be raised.

This minimizes the possibility of material bypassing the plug while it is rotated. It also prevents debris from building up under the plug and making it difficult to reseat.

The strainer covers feature our quick opening, swing away yoke design. Again, no tools are needed, just a pair of hands to open the strainer well and remove the basket in seconds. Each basket compartment has a side drain outlet. All strainers are provided with legs for bolting to the floor.

The diverter valves in Hayward Duplex Strainers are used only for diversion of flow. While they are built to stand the full rated pressure of the strainer, they cannot be depended upon for dead tight shut-off. A general criterion of tightness is that it should take at least 20 minutes to fill the basket well.

Illustration of flow direction through a typical Plug Type Duplex Basket Strainer.

"HAYWARD" MODEL 50 DUPLEX STRAINER CUT SHEETS (CONTINUED)**Hayward®
Duplex Basket
Strainers****Model 50****Tapered Plug Type**

Type	All Wetted Parts	Exterior Trim	Baskets	Cover O-Rings	Stem O-Rings
Iron	ASTM A-126 bodies, bonnets and covers Bronze Diverter Plug	Ductile Iron	Brass, SS or Monel	Buna-N	Buna-N
Bronze	ASTM B-62 Valve bronze	Ductile Iron	Brass, SS or Monel	Buna-N	Buna-N
Stainless Steel	ASTM 351 Grade CF-8M Type 316	Ductile Iron	SS or Monel	Viton-A	Viton-A
Carbon Steel	ASTM A-216 Grade WCB carbon steel Bronze Diverter Plug	Ductile Iron	SS or Monel	Buna-N	Buna-N

Material	Pressure Rating at 100°F	End Connections	
		Screwed	Flanged
Iron	200 psi WOG	NPT Threads	125 lbs. ANSI Dimensions
Bronze	200 psi WOG	NPT Threads	150 lbs. ANSI Dimensions
Stainless Steel	200 psi WOG	NPT Threads	150 lbs. ANSI Dimensions
Carbon Steel	200 psi WOG	NPT Threads	150 lbs. ANSI Dimensions

Materials shown are standard.

"HAYWARD" MODEL 50 DUPLEX STRAINER CUT SHEETS (CONTINUED)**Hayward®
Duplex Basket
Strainers****Model 50****Tapered Plug Type - Sizes 3/4" - 8"**

Available in Iron, Bronze, Stainless Steel, Carbon Steel

Clear instructions provided on each strainer minimize the chance of operator error. The mechanical lifting jack, to raise the plug off its seat and then lower it, prevents galling of the plug against the body.

An O-ring seal between the plug stem and the jack bonnet gives tight sealing, especially when the plug is being rotated to divert flow.

Basket seats are precision machined to give a tight seal against the top flange of the basket. This eliminates the possibility of any material bypassing the basket.

*Threaded End
Connection in
sizes from 3/4"
to 2 1/2".*

*Flanged End Connection in
sizes from 1" to 8".*

"HAYWARD" MODEL 50 DUPLEX STRAINER CUT SHEETS (CONTINUED)**Hayward®
Duplex Basket
Strainers****Model 50****Tapered Plug Type - Sizes 3/4" - 8"** **Threaded - 3/4" - 2 1/2"****Flanged - 1" - 4"****Flanged - 5" - 8"**

Dimensions are in inches.

	Pipe Size	Net Weight (lbs.)				A	B	C	D	E	F	G	H	I	J	K	DIA
		Iron	Bronze	Stain- less	Carbon Steel												
THREADED	3/4, 1	26	33	31	31	11	10 1/8	5	5 1/2	1/4	14 3/4	8	4 1/2	12 1/2	8	1 1/8	1 1/32
	1 1/4, 1 1/2	57	64	62	62	15	13 1/8	6 1/8	7 1/2	1/4	18 3/4	8	5 1/2	15	8	1 1/8	7/16
	2	110	120	109	109	18 5/8	17 3/8	8 3/8	10	3/8	24	8 1/2	7 1/8	20	16	1 1/8	9/16
	2 1/2	124	123	—	—	18 5/8	17 3/8	8 3/8	10	3/8	24	8 1/2	7 1/8	20	16	1 1/8	9/16
FLANGED	1	31	38	36	36	11	10 1/8	5	6 1/8	1/4	14 3/4	8	4 1/2	12 1/2	8	1 1/8	1 1/32
	1 1/2	66	74	72	72	15	13 1/8	6 1/8	9 3/8	1/4	18 3/4	8	5 1/2	15 3/8	8	1 1/8	7/16
	2	122	133	122	122	18 5/8	17 3/8	8 3/8	10 3/8	3/8	24	8 1/2	7 1/8	20 1/8	16	1 1/8	9/16
	2 1/2	142	143	145	145	18 5/8	17 3/8	8 3/8	10 3/4	3/8	24	8 1/2	7 1/8	20 1/8	16	1 1/8	9/16
	3	193	231	204	204	22	20 3/4	8 7/8	13 1/2	1/2	25 1/4	8 1/2	8 1/8	21 3/8	16	2 1/2	9/16
	4	285	283	300	315	23	21 1/2	13 1/4	16	1/2	35	9 1/2	8 1/8	27 1/8	18	3	9/16
	5	403	412	—	—	26	17 1/4	14 3/4	18 3/8	3/8	41	19 3/4	10 1/4	33 1/4	—	9 3/4	9/16
	6	500	—	—	—	32	20 3/4	19 1/2	22	3/8	42	19 3/4	11 3/4	34 1/4	—	12 1/2	5/8
	6	—	583	—	—	32	21 1/4	15 1/8	21 1/2	3/8	42	19 3/4	11 3/4	34 1/4	—	12 1/2	5/8
	6	—	—	615	—	31 1/4	20 3/4	18 1/2	22	3/8	42	19 3/4	11 3/4	35	—	12 1/2	5/8
	6	—	—	—	580	31 1/4	20 3/4	18 1/2	22	3/8	42	19 3/4	11 3/4	35	—	12 1/2	5/8
	8	1500	1800	1670	1610	45 1/2	30 3/4	23	25	1/2	56	28 1/2	—	50 3/8	—	17	1 1/32

These dimensions are for reference only. For installation purposes, request certified drawings.

"HAYWARD" MODEL 50 DUPLEX STRAINER CUT SHEETS (CONTINUED) **Technical Data**

These curves are for clean baskets, without mesh liners, and with WATER flowing through the strainer.

For mesh lined baskets and/or for other fluids, use the correction factor.

Model 50 Duplex (1" through 8") **Model 50 Duplex (10" through 16")**

"HAYWARD" MODEL 50 DUPLEX STRAINER CUT SHEETS (CONTINUED) **Technical Data****PRESSURE DROP CURVES**

This bulletin shows the pressure drop for Hayward Strainers models 30, 50, 510, 570, 72, 80, 90 and 91. The curves are based on clean, perforated baskets or screens handling water. For mesh lined baskets or screens and/or other fluids use the correction factors listed below.

Correction Factors**MESH LINED BASKETS — WATER ONLY**

Multiply the pressure drop shown in charts for perforated baskets by the following:

40 mesh — 1.2	80 mesh — 1.6
60 mesh — 1.4	100 mesh — 1.7

FLUIDS OTHER THAN WATER

First — Multiply the pressure drop for water shown in charts by the specific gravity of the liquid.

Second — Multiply the corrected pressure drop figure by the following correction factors for more viscous liquids. (Water has a viscosity of 30 SSU.)

Viscosity (SSU)	Unlined Perforated Basket	40 Mesh Lined Basket	60 Mesh Lined Basket	80 Mesh Lined Basket	100 Mesh Lined Basket
500	1.6	1.9	2.1	2.4	2.6
1000	1.7	2.2	2.4	2.6	2.8
2000	1.9	2.4	2.7	2.9	3.2
3000	2.0	2.6	2.9	3.2	3.5
5000	2.2	3.0	3.5	4.0	4.5
10000	2.5	3.5	4.2	5.0	6.0

"HAYWARD" MODEL 50 DUPLEX STRAINER CUT SHEETS (CONTINUED)**Y-STRAINER PRESSURE DROP**

Hayward Model 50

Screen: 60 Mesh

Fuel Viscosity: 60 SSU

Specific Gravity, SG = 0.9

Max Flow (Full Recirculation) = 10 GPM

Size = 1½ inch NPT

Pressure Drop for Water = 0.2 psi (PG V-6)

Correction for Diesel Fuel = $0.2 \times 0.9 = 0.18$ psi

By Interpolation:

SSU	ΔP , PSI
30	1.4
60	X
500	2.1

$$\frac{X-1.4}{2.1-1.4} = \frac{60-30}{500-30}$$

$$X = 1.4 + \frac{0.7 \times 30}{470} = 1.4447$$

Correction = $0.2 \times 1.4447 = 0.288$ psiTotal Pressure Drop = $0.18 + 0.288 = 0.469$ psig = 1.083 ft

"HAYWARD" MODEL 80 Y-STRAINER CUT SHEETS

Hayward® Y-Strainers

Model 80

Y-Strainer Screens

Recommended Standard Screen Sizes

STEEL			STAINLESS STEEL		
SIZE	THD *	FLG *	SIZE	THD *	FLG *
1/4"-2"	20 Mesh 0.033	—	1/4"-2"	20 Mesh 0.033	—
1/2"-2"	—	0.033 0.045 Perf	1/2"-2"	—	0.033 0.045 Perf
2 1/2"-10"	—	0.062 0.125 Perf	2 1/2"-10"	—	0.062 0.125 Perf

* Other Stock Stainless Steel Screens Available:
Perf - 0.033, 0.045, 0.057, 0.125 & 0.156
Mesh - 20, 40, 60, 80, & 100
Special Screens Available on Request.

Sizes and End Connections Pressure and Temperature Limits

Carbon Steel

Size Range (Inches)	End Connection	ANSI Class	Non-Shock Rating (PSI at 100°F)
1/4" to 2"	Threaded	600*	1480
1/4" to 2"	Socket Weld	600*	1480
1/2" to 3"	Socket Weld	1500	3705
1" to 2"	Socket Weld	2500	6170
1/2" to 10"	Flanged	150	285
1/2" to 10"	Flanged	300	740
1/2" to 10"	Flanged	600	1480
1/2" to 4"	Flanged	900	2220
1 1/2" to 2 1/2"	Flanged	1500	3705

Stainless Steel

1/4" to 2"	Threaded	600	1440
1/4" to 2"	Socket Weld	600	1440
1/2" to 3"	Socket Weld	1500	3600
1" to 2"	Socket Weld	2500	6000
1/2" to 10"	Flanged	150	275
1/2" to 10"	Flanged	300	720
1 1/2" to 10"	Flanged	600	1440
1 1/2" to 4"	Flanged	900	2160
1 1/2" to 2 1/2"	Flanged	1500	3600

"HAYWARD" MODEL 80 Y-STRAINER CUT SHEETS (CONTINUED)**Hayward®
Y-Strainers****Model 80**

FLANGED - BRONZE - SIZES: 1/2" - 12"

BRONZE - Flanged - Class 150 lb.

Pipe Size	A	B	C	D	Weight (lbs.) approx.
1/2	5 1/2	2 3/4	3 1/2	3/8	5 1/2
3/4	5 5/8	3 1/4	4	3/8	8
1	6 1/8	3 3/4	5	1/2	10
1 1/4	6 3/8	4 3/8	5 3/4	3/4	16
1 1/2	8 3/4	5 3/4	6 1/2	3/4	20 1/2
2	10	6 3/4	7 1/2	1	28 1/2
2 1/2	11 3/8	7 1/8	8 1/2	1 1/4	42
3	13	8 3/8	9 1/4	1 1/4	54
4	15 1/8	11 1/4	13 1/2	1 1/2	94 1/2
6	19 3/4	16 1/2	20 1/2	2	200 1/2
8	24 3/8	20 1/4	27	2	570

These dimensions are for reference only.

For installation purposes, request certified drawings. Dimensions are in inches.

"HAYWARD" MODEL 80 Y-STRAINER CUT SHEETS (CONTINUED) **Technical Data**

These curves are for clean baskets, without mesh liners, and with WATER flowing through the strainer.

For mesh lined baskets and/or for other fluids, use the correction factors.

Y-Strainers-Liquids

"HAYWARD" MODEL 80 Y-STRAINER CUT SHEETS (CONTINUED) **Technical Data****PRESSURE DROP CURVES**

This bulletin shows the pressure drop for Hayward Strainers models 30, 50, 510, 570, 72, 80, 90 and 91. The curves are based on clean, perforated baskets or screens handling water. For mesh lined baskets or screens and/or other fluids use the correction factors listed below.

Correction Factors**MESH LINED BASKETS — WATER ONLY**

Multiply the pressure drop shown in charts for perforated baskets by the following:

40 mesh — 1.2	80 mesh — 1.6
60 mesh — 1.4	100 mesh — 1.7

FLUIDS OTHER THAN WATER

First — Multiply the pressure drop for water shown in charts by the specific gravity of the liquid.

Second — Multiply the corrected pressure drop figure by the following correction factors for more viscous liquids. (Water has a viscosity of 30 SSU.)

Viscosity (SSU)	Unlined Perforated Basket	40 Mesh Lined Basket	60 Mesh Lined Basket	80 Mesh Lined Basket	100 Mesh Lined Basket
500	1.6	1.9	2.1	2.4	2.6
1000	1.7	2.2	2.4	2.6	2.8
2000	1.9	2.4	2.7	2.9	3.2
3000	2.0	2.6	2.9	3.2	3.5
5000	2.2	3.0	3.5	4.0	4.5
10000	2.5	3.5	4.2	5.0	6.0

"HAYWARD" MODEL 80 Y-STRAINER CUT SHEETS (CONTINUED)

Y-Strainer Pressure Drop

Hayward Model 80

Screen: 60 Mesh

Fuel Viscosity: 60 SSU

Specific Gravity, SG = 0.9

Max Flow (Full Recirculation) = 10 GPM

Size: 1 inch NPT

Pressure Drop for Water = 0.4 psig (Page VI-3)

Correction for Diesel Fuel, 60 SSU = $0.4 \times 0.9 = .36$ psig (Page VI-4)

By Interpolation:

SSU	ΔP_1 PSI
30	1.4
60	X
500	2.1

$$\frac{X - 1.4}{21 - 1.4} + \frac{60 - 30}{500 - 30}$$

$$X - 1.4 + \frac{(2.1 - 1.4)(60 - 30)}{500 - 30} = 1.4 + \frac{0.7 \times 30}{470} = 1.4 + .0447$$

$$X + 1.4447$$

$$\text{Correction} = 0.4 \times 1.444 = 0.578 \text{ psig}$$

$$\text{Total Pressure Drop} = 0.36 + 0.578 = .938 \text{ psig} = 2.166 \text{ feet}$$