U. S. Nuclear Regulatory Commission
November 20, 1998

DUKE ENERGY CORPORATION

OCONEE NUCLEAR STATION

ATTACHMENT 2

Calculation OSC-4467 Rev. 6

RB Pressure Needed for RBS Operation

(Recirculation Phase)

FORM 101.3 (R06/98)

CERTIFICATION OF ENGINEERING CALCULATION · REVISION LOG

Station And Unit Number: Oconee Units 1,2,&3

Title Of Calculation: RB Pressure Needed for RBS Operation

Calculation Number: OSC-4467

Rev. No.	Calculation Pages (Vol) Revised	Calculation Pages (Vol) Deleted	Calculation Pages (Vol) Added	Supporting Documentation (Vol) Revised	Supporting Documentation (Vol) Deleted	Supporting Documentation (Vol) Added	Volumes Deleted	Volumes Added	ORIG Date	CHKD Date	Verif. Meth. 1,2,3, "Other"	Appr' Date	Issue Date Rec'd Date
6		1-8	1-9	Att. 21, 22, & 23		Att. 25			R.L. Oakley 9-30-98	[signature] 10/1/98	1	[signature] 10/1/98	[illegible] 10/27/98 [illegible] 10/27/98
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NOTE 1: When approving a Calculation revision with multiple Originators or Checkers, the Approver need sign only one block.

Form 01077 (R7-89)

FORM 101.1	REVISION 13

CERTIFICATION OF ENGINEERING CALCULATION

STATION AND UNIT NUMBER Oconee Nuclear Station 1, 2, & 3

TITLE OF CALCULATION RB Pressure Needed for RBS Operation (Keywords: RBS* NPSH* RB Pressure*

CALCULATION NUMBER OSC-4467 Type II

ORIGINALLY CONSISTING OF:

PAGES 1 THROUGH 8

TOTAL ATTACHMENTS 1 ~~0~~ NEB TOTAL MICROFICHE ATTACHMENTS 0

TOTAL VOLUMES 0 TYPE I CALCULATION/ANALYSIS YES ☐ NO ☒

TYPE I REVIEW FREQUENCY NA

THESE ENGINEERING CALCULATIONS COVER QA CONDITION 1 ITEMS. IN ACCORDANCE WITH ESTABLISHED PROCEDURES, THE QUALITY HAS BEEN ASSURED AND I CERTIFY THAT THE ABOVE CALCULATION HAS BEEN ORIGINATED, CHECKED OR APPROVED AS NOTED BELOW:

ORIGINATED BY Norman E. Bartley DATE 2/26/92

CHECKED BY John B. Beckman DATE 3/9/92

APPROVED BY S L Nash DATE 3-9-92

ISSUED TO TECHNICAL SERVICES DIVISION ________ DATE ________

RECEIVED BY TECHNICAL SERVICES DIVISION ________ DATE ________

MICROFICHE ATTACHMENT LIST: ☐ Yes ☒ No SEE FORM 101.4

REV. NO.	CALCULATION PAGES (VOL)			ATTACHMENTS (VOL)			VOLUMES		ORIG / DATE	CHKD / DATE	APPR / DATE	ISSUE DATE / REC'D DATE
	REVISED	DELETED	ADDED	REVISED	DELETED	ADDED	DELETED	ADDED				
1		1-8	1-5		1	1-8			R.L. Oakley 4-2-96	[illegible] 4/16/96	R.J. Agriello 4/18/96	R.L. Oakley 4-25-96 / [illegible] 5/1/96
2		1-5	1-7		1-6	1-6 and 9-16			R.L. Oakley 12-4-97	R C Ginsberg 12-4-97	S L Nader 12-11-97	WAM 7/17/98
3	4, 1,3,5,6 and 7		8	10, 11, 16, 3, and 4		17 & 18			R.L. Oakley 5-11-98	R C Ginsberg 6/3/98	T.A. Saville 6/4/98	WAM 7/17/98 / WAM 7/17/98
4	1,2,3,4					19, 20			R.L. Oakley 6-24-98	R C Ginsberg 6/30/98	T A Saville 6/30/98	WAM 7/17/98 / WAM 7/17/98
5	1-8					21, 22, 23, 24			R.L. Oakley 8-20-98	R S [illegible] 8/27/98	T A Saville 8/31/98	[illegible] 9/2/98

Form 101.2 Revision 1
26164 (R9-89)

File/Calculation No: OSC-4467

REVISION DOCUMENTATION SHEET

Revision Number	Review Frequency Changed Yes/No	Revision Description
6	No	Revised assumption 7.6 to credit lower pump NPSH requirements per manufacturer's guidance. Added Reference 8.53 to reference manufacturer's correspondence providing updated NPSH requirements. (This correspondence supersedes NPSH requirements of reference 8.13 and 8.14.) Revised Attachment 21, pages 1 and 3, to reflect impact of new NPSH requirements. Revised Attachment 22 to reflect impact of new NPSH requirements. Added page 5A to Attachment 23 to show sump temperature versus time for Unit 3, which has lower RB temperatures than Units 1 & 2. Revised pages 1 and 2 of Attachment 23 to include reference to new figure on page 5A. Added Attachment 25 (manufacturer's letter providing updated NPSH requirements for IDP model 4X11A pumps). Page numbering revised on all pages.

Form 101.2 Revision 1.
26164 (R9-89)

File/Calculation No. OSC-4467

REVISION DOCUMENTATION SHEET

Revision Number	Review Frequency Changed Yes/No	Revision Description
5	No	Revised to evaluate operability at Tech. Spec. minimum building pressure of -2.45 psig, per PIP 0-098-3976. Added text (2 sentences) at the end of section 1.0. Added text referring to Attachments 23 and 21 in third paragraph of section 3.0. Added note to assumption 7.2. Added text to assumption 7.6. Added note to assumption 7.12. Added a reference in assumption 7.11. Added assumptions 7.14 and 7.15. Added parenthetical note to section 8.3. Added references 8.46 through 8.52. Added note in section 9.0 (see bottom of page 6). Added descriptive information in last paragraph on page 7. Added text to first paragraph on page 8. Added references to Attachments 21 and 22 in second paragraph on page 8. Added references to attachments 21, 22, and 23 in last paragraph of section 9. Added one additional paragraph of text at the end of section 10. Added Attachments 21 through 24.

Form 101.2 Revision 1
26164 (R9-89)

File/Calculation No. OSC-4467

REVISION DOCUMENTATION SHEET

Revision Number	Review Frequency Changed Yes/No	Revision Description
4	No	In first sentence of section 3.0, changed "Reference 8.4" to "OSC-1977". In section 7.3, replaced "Ref. 8.1, 8.4, 8.5, 8.6" with "See Attachment 19." Added new assumption 7.13. Deleted references 8.4, 8.5, and 8.6. Added Attachment 19 to incorporate applicable portions of deleted references. Added Attachment 20 as supporting documentation for Assumption 7.13.

File/Calculation No. OSC-4467

REVISION DOCUMENTATION SHEET

Revision Number	Review Frequency Changed Yes/No	Revision Description
3	No	Added one editorial sentence at the end of Section 1.0. Deleted last sentence in first paragraph of Section 3.0. Editorial changes made to Sections 7.6 and 7.7. Deleted assumptions 7.9 and 7.10. Added assumption 7.12. Added om number references for LPI pump curves in References 8.15 through 8.20. Added References 8.37 through 8.45. Section 9.0 was re-arranged for more logical flow and additional text was added for clarification. Added adjustment to RB static pressure in the NPSHa equation to account for periods of negative pressure during plant operation. Calculated new "mean" floor elevation, reactor building water level, and pump submergence in Section 9. Revised NPSHa and required building pressure results in Attachment 3. Added third page to Attachment 3 showing data used to calculate NPSHa. Plotted new curves for Attachment 4. Revised Attachment 10 to account for removal of flange/nipple assembly from the reactor vessel cavity drains. Revised Attachment 11 to account for removal of basket strainers from FTC deep end drains. Added new Attachments 16 and 17 to account for water lost to sumps and incore trench. Old Attachment 16 re-numbered to 18 and revised to show new volumes.

Form 101.2 Revision 1
26164 (R9-89)

File/Calculation No. OSC-4467

REVISION DOCUMENTATION SHEET

Revision Number	Review Frequency Changed Yes/No	Revision Description
1	No	Updated flow assumptions to reflect values determined from instrument uncertainty analyses, OSC-3566, Rev. 3, and OSC-4084, Rev. 2. Entire calculation reprinted. New flow model used for analysis. Expanded list of references to include supporting calculations and pump performance curves. Added excerpts from Safety Analysis Group's Hot Leg Break Analysis to demonstrate acceptability of results.
2	No	All pages revised. Entire calculation reprinted. Revised Woods model to increase minor loss at entrance reducer on sump recirculation pipe. Also deleted check valve 3BS-6 from model. Revised atmospheric pressure assumption to slightly less conservative value. Deleted ten percent penalty on suction pressure. Added calculation of reactor building water level (see new attachments 10-16) which accounts for volumes lost to vessel cavity, FTC, RCS shrinkage, PZR refill, BS piping fill, and flashing steam. Revised NPSHr to reflect more conservative performance curve N-281. Applied high temperature correction factor to NPSHr.

1.0 PROBLEM

The purpose of this calculation is to determine the Reactor Building pressures required for acceptable RBS operation in the sump recirculation mode at elevated sump fluid temperatures. Rev. 0 of this calculation did not take into account the effects of instrument uncertainty on the assumed flows in either RBS or LPI systems. Rev. 1 incorporated the most recent flow inaccuracies, which were updated in calculations OSC-3566, Rev.3, and OSC-4084, Rev. 2. An additional analysis was also included in Rev. 1 to evaluate the building pressure requirements for both the positive and negative instrument uncertainties. Minor changes were also made to the equation for determining building pressure. Rev. 2 removes some of the conservatisms applied in previous revisions, while adding adjustments for some non-conservatisms found in the model and others associated with our building level calculations. Attachment 4 shows a graphical representation of the operating NPSH margin as a function of sump temperature. Rev. 3 accounts for adjusted reactor building water level resulting from the removal of flanges from the reactor vessel cavity drains and the removal of basket strainers from the deep end of the FTC. Rev. 5 addresses the operability of the pumps with the reactor building pressure reduced to the Tech. Spec. minimum of -2.45 psig at time zero in the accident. A separate analysis is also provided to demonstrate acceptable operation at more limiting conditions of -1.0 psig in the building at time zero. Rev. 6 updates the analysis to incorporate new NPSHr information provided by the pump manufacturer.

2.0 RELATION TO NUCLEAR SAFETY

The RBS system is a safety related system that is needed for iodine removal following a LOCA. The LPI system is needed for emergency core cooling, and long term post-accident decay heat removal. The RBS and LPI systems are needed to mitigate the consequences of an accident. This calculation is QA Condition 1.

3.0 DESIGN METHOD

The hydraulic model used in OSC-1977, as modified by Attachment 9, will be used to determine the friction losses for the RBS and LPI suction piping at various sump temperatures. A sketch of the flow paths for this model is included as Attachment 6 to this revision. The original calculation used the model from Reference 8.1. Although either model is acceptable, the model used here is more extensive in that it contains more of the LPI and BS piping. This would allow for analysis of additional system alignments if so desired. The two models have been compared and are in close agreement in all other respects.

NPSH available is determined by adding reactor building pressure (converted to feet of head), barometric pressure (converted to feet of head), and static head of submergence, then subtracting vapor pressure (expressed in feet of head) and friction losses. NPSH required is determined from certified manufacturer's pump performance curves and this value is adjusted for high temperature effects. Required building pressure is the amount by which required NPSH exceeds available NPSH, that quantity being converted to equivalent pressure at the sump temperature.

Attachments 7 and 23 are excerpts from Ref. 8.22 which shows the building pressure and sump temperature response for the hot leg break, which is bounding for NPSH analysis. Attachments 3 and 21 show NPSH available and required for the chosen range of fluid temperatures and RBS and LPI flowrates. They also show the extent to which reactor building pressure is credited to satisfy NPSH requirements.

4.0 APPLICABLE CODES AND STANDARDS

ANSI N45.2-11

5.0 DESIGN INPUTS

ANSI N45.2-11 has been reviewed and all applicable design inputs are addressed in the appropriate sections of this calculation.

6.0 FSAR CRITERIA

None.

7.0 ASSUMPTIONS

7.1 The reactor building water level used in the Woods model is known to be non-conservative. However, it is used only to calculate friction losses through piping and fittings. Therefore, this introduces no error into the analysis. The minimum RB water level is determined elsewhere in this calculation.

7.2 A barometric pressure of 14.2 psia is assumed. This value is shown by historical data to be exceeded 95 percent of the time, and is considered reasonably conservative for analytical purposes. (Ref. 8.3)

Note: This assumption is retained for purposes of demonstrating the bounding assumption of high flow errors for LPI and BS pumps as demonstrated in Attachment 4. See Assumption 7.15 for current design basis assumption for atmospheric pressure.

7.3 Flow path through "3B" sump line is conservative and bounds all other cases for NPSH analysis. (See Attachment 19.)

7.4 Instrument error results in a maximum flow of 3291 gpm and a minimum flow of 2883 gpm for LPI when indicated flow is 3000 gpm. (Ref. 8.8) Note that these values are approximated from the relationship A = I - E, where:

A = Actual flow, estimated
I = Indicated flow, taken as equal to actual flow in first column of tabulated data on page 35 of the reference, and
E = Error (+TLU or -TLU) from right-hand column of tabulated data on page 35 of the reference.

7.5 Instrument error results in a maximum flow of 1150 gpm and a minimum flow of 873 gpm for RBS when indicated flow is 1000 gpm. (Ref. 8.7) Note that these flow rates are not explicitly found in the reference, but are interpolated values determined from plotting the data in Table 7.3-4 on page 37 of the reference. A graph of the data is included here in Attachment 5.

7.6 The required NPSH for the 3B RBS pumps was taken from Ingersoll Rand curve N-281as 20 ft at 1150 gpm and 15 ft at 873 gpm. These NPSH requirements are bounding for all BS pumps, and are used to show relative sensitivity to flow uncertainty. (Ref. 8.9 through 8.14) Attachments 3 and 4 utilized these assumptions to illustrate that high flow errors are more limiting than low flow errors. A value of 17 ft at 1150 gpm is used for the evaluation at low RB pressures and high RB temperatures added per Rev. 6 of this calculation. (See Attachments 21 & 22.) This NPSH value is determined from References 8.9 and 8.53.

7.7 The required NPSH for the LPI pumps is taken as 13 ft. at 3291 and 11 ft. at 2883 gpm. These values are bounding for all LPI pumps. (Ref. 8.15 through 8.20)

7.8 A high temperature correction factor is applied to the NPSH requirement as permitted in Ref. 8.23.

7.9 This assumption was deleted by Rev. 3. Strainers have been removed from the deep end of the Fuel Transfer Canal. Strainers are installed at the beginning of each refueling outage and removed prior to unit startup. Therefore, water will not fill the deep end of the FTC.

7.10 This assumption was deleted by Rev. 3. Flanges and nipples have been removed from the vessel cavity drain pipes. Therefore, filling of the cavity area is not assumed.

7.11 Friction losses across the sump screen and grating are on the order of 0.01 ft. of head, even if the screen and grating surfaces are assumed to be 50% blocked (Ref. 8.46). This effect is negligible by engineering judgement and is not factored into the NPSH calculation.

7.12 Reactor building static pressure is taken from curves in OSC-6521. Figure B-6 was used for the low flow case (for maximum positive instrument error) and Figures B-5 and B-7 were used for the high flow case (for maximum negative instrument error). The lowest pressure value on each curve at each temperature was chosen in order to provide bounding conservative values. Each of these values was then reduced by 0.2 psi in order to account for operating variations in reactor building static pressure. This value was obtained from review of one year of static pressure data for the Unit 3 Reactor Building (retrieved from the PI server). The building static pressure varied in both the positive and negative directions. Since the probability of having barometric pressure and building static pressure both at their minimum values simultaneously was considered remote, this value was considered reasonably conservative for analytical purposes.

Note: Assumption 7.12 retained for historical purposes only. See assumption 7.14 for more current inputs associated with Rev. 5.

7.13 Vortexing is assumed to be effectively suppressed by the grating around and within the emergency sump. Therefore, air entrainment is not anticipated in the sump recirculation mode of operation and there is no adjustment to NPSHr applied as recommended by NUREG 0897 (Ref. 8.23.) This is well supported by industry testing and documented in the industry literature (see Attachment 20 for one example of supporting documentation).

7.14 For Rev. 5, new reactor building static pressure curves from OSC-6521 were evaluated (see Attachment 23). These new curves show the reactor building pressure and emergency sump temperature resulting from a hot leg break assuming initial reactor building pressure is -2.45 psig at 80F. This is to account for minimum allowable reactor building pressure per Technical Specification 3.6.4. A separate case is also provided for an initial reactor building pressure of -1.0 psig at 160 F to bound the current pressure and temperature limits for Units 1 and 2, which have their Aux Coolers valved out. Only the high flow cases will be revisited for these cases, since Rev. 4 showed the high flow cases to be limiting for NPSH.

7.15 A barometric pressure of 14.7 psia is assumed for consistency with OSC-6521. Although Ref. 8.3 (included as Attachment 24) shows that local barometric pressure may reach as low as 14.0 psia, OSC-6521 shows 14.7 psia with a -1.0 psig operating limit (yielding an actual initial pressure of 13.7 psia) to be bounding. It is not credible to assume that the reactor building can go from a pressure of 14.0 psia to 13.7 psia at the elevated temperature assumed for the containment response analysis due to the ideal gas law. Also, the ideal gas law shows that a temperature reduction from the assumed 160 F to 116 F would be required to produce an initial pressure of 13.0 psia in the building if it were vented to 14.0 psia. A confirmatory analysis was performed in OSC-6521 to show that the assumed initial conditions of 13.7 psia and 160 F are more limiting than conditions of 13.0 and 116 F.

8.0 REFERENCES

8.1 OSC-4361, Rev. 0, "RBS PUMP NPSH ANALYSIS".

8.2 Systems Water Data vs. Temperature Table dated 12-18-73, produced by Computer Program WATDAT0, QA certified and documented in file C-6.10-3.

8.3 Letter from S.T. Apple to R.A. Harris dated December 10, 1986 transmitting historical barometric pressure data. (Included in Attachment 24.)

8.4 This reference deleted by Rev. 4.

8.5 This reference deleted by Rev. 4.

8.6 This reference deleted by Rev. 4.

8.7 OSC-4084, Rev. 2, "BS FLOW LOOP INSTRUMENT INACCURACY"

8.8 OSC-3566, Rev. 3, "LPI FLOW LOOP INSTRUMENT INACCURACY"

8.9 Ingersoll-Rand Curve No. N-144, dated 6/27/69, Reactor Building Spray Pump 1A Performance Curve. (See OM-201-1704 for curve.)

8.10 Ingersoll-Rand Curve No. N-154, dated 8/11/69, Reactor Building Spray Pump 1B Performance Curve. (See OM-201-1704 for curve.)

8.11 Ingersoll-Rand Curve No. N-185, dated 2/20/70, Reactor Building Spray Pump 2A Performance Curve. (See OM-1201-1121 for curve.)

8.12 Ingersoll-Rand Curve No. N-186, dated 2/27/70, Reactor Building Spray Pump 2B Performance Curve. (See OM-1201-1121 for curve.)

8.13 Ingersoll-Rand Curve No. N-280, dated 4/26/71, Reactor Building Spray Pump 3A Performance Curve. (See OM-2201-0597 for curve.)

8.14 Ingersoll-Rand Curve No. N-281, dated 4/26/71, Reactor Building Spray Pump 3B Performance Curve. (See OM-2201-0597 for curve.)

8.15 Ingersoll-Rand Curve No. N-139, dated 6/16/69, Low Pressure Injection Pump 1A Performance Curve. (See OM-201-1704 for curve.)

8.16 Ingersoll-Rand Curve No. N-148, dated 7/16/69, Low Pressure Injection Pump 1B Performance Curve. (See OM-201-1704 for curve.)

8.17 Ingersoll-Rand Curve No. N-175, dated 1/16/70, Low Pressure Injection Pump 2A Performance Curve. (See OM-1201-1121 for curve.)

8.18 Ingersoll-Rand Curve No. N-180, dated 2/10/70, Low Pressure Injection Pump 2B Performance Curve. (See OM-1201-1121 for curve.)

8.19 Ingersoll-Rand Curve No. N-372, dated 10/13/71, Low Pressure Injection Pump 3A Performance Curve. (See OM-2201-0597 for curve.)

8.20 Ingersoll-Rand Curve No. N-373, dated 10/13/71, Low Pressure Injection Pump 3B Performance Curve. (See OM-2201-0597 for curve.)

8.21 OSC-1969, Rev. 2, "POST ACCIDENT REACTOR BUILDING WATER LEVEL FOLLOWING A LARGE BREAK LOCA"

8.22 OSC-6521, Rev. 3, "Containment Response With 30 Minute Delay in LPSW Flow"

8.23 NUREG 0897, Rev. 1 Containment Emergency Sump Performance

8.24 O-68A, Rev. 18 Reactor Building Unit 1, Reactor Foundation Concrete

8.25 O-69D, Rev. 16 Reactor Building Primary and Secondary Shield Walls Sections and Elevations Concrete

8.26 O-2435C, Rev. 36 Oconee Nuclear Station Unit 3 Piping Layout Sections - Elevation 758'-0" Auxiliary Building

8.27 O-67A, Rev. 31, Oconee Nuclear Station Units 1, 2, & 3 Reactor Building Plan at Elevation 777'- 6" Basement Floor Slab - Concrete

8.28 OM-201-3153, Rev. D15 Arrgt. Reactor Vessel Long. Sec.

8.29 O-58A, Rev. 16 Reactor Building Refueling Canal Liner Plate Elevations

8.30 OSC-2729, Rev. 1 RETRAN Transient Analysis Model

8.31 O-477, Rev. 12 Piping Layout Spray System Reactor Building - Unit 1

8.32 O-439A, Rev. 55 Piping Layout East Penetration Room Elevation 809'-6" - 821'-6" Auxiliary Building

8.33 Crane Technical Paper 410, Sixteenth Printing, 1976

8.34 OSS-0254.00-00-1033, Rev. 2 Design Basis Specification for the Reactor Coolant System

8.35 O-59M, Rev. 6 Reactor Building Base Slab Embedded Piping

8.36 Pump Handbook, by Igor J. Karassik, Second Edition, McGraw-Hill Book Co., copyright 1986.

8.37 O-68C, Rev. 14 Reactor Building, Reactor Foundation Misc. Steel

8.38 American Institute of Chemical Engineering Journal, Vol. 23, No. 1, dated January 1977.

8.39 Handbook of Hydraulic Resistance, 3rd Edition, by I. E. Idelchik, copyright 1994 by CRC Press, Inc.

8.40 O-58C, Rev. 8, Refueling Canal Liner Plate Details and Bill of Materials

8.41 O-478E, Rev. 9, Piping Layout Basement Floor Partial Plan and Sections - SSF System Reactor Building

8.42 O-1067A, Rev. 29, Reactor Building 2 & 3 Plan at Elevation 777'+6 Basement Floor Slab Concrete

8.43 O-1067L, Rev. 4, Reactor Building 2&3 Floor Slabs Misc. Steel

8.44 Chemical Engineering Magazine, Reprinted from June 17, 1968.

8.45 O-69J, Rev. 4, Reactor Annulus Assembly Concrete & Miscellaneous Steel

8.46 OSC-6827, Rev. 2, Emergency Sump Operability Evaluation

8.47 PIP 0-O98-3976, Tech. Spec. Minimum RB Pressure Not Bounded by NPSH Calculations

8.48 OSC-6901, Rev. 0, Determination of Average Reactor Building Temperature

8.49 MEMO TO FILE dated July 23, 1987 from S. L. Nader. (Included in Attachment 24.)

8.50 OSC-6854, Rev 0, CCW Inlet Temperature Instrumentation Loop Accuracy

8.51 OSC-6807, Rev. 0, Borated Water Storage Tank Temperature Instrumentation Loop Accuracy

8.52 OSC-2495, Rev. 2, Reactor Building Narrow Range Pressure Instrument Loop Accuracy Calculation PT-4P, 5P, 6P

8.53 Letter from Paul Kasztenja of Ingersoll-Dresser Pump Company to Russ Oakley of Duke Power Company Dated 9/24/98. (Included as Attachment 25.)

9.0 CALCULATION

NPSHa is determined by the following relationship:

NPSHa = (Pb-Pov) x C + Pa x C + Hs - hf - Psat x C

Where: NPSHa = Available Pump NPSH at assumed flow
Pb = reactor building static pressure (from Ref. 8.22)
Pov = Operating variance in RB static pressure (from OAC data)
C = conversion factor to convert psig to ft. of water (from Ref. 8.2)
Pa = Barometric pressure (14.2 psia) (see Assumption 7.2)
Hs = submergence of pump below water level (see below)
hf = friction losses in piping system (see Attachments 1 & 2)
Psat = Saturation pressure at sump temperature (from tables of water properties)

NOTE: No adjustment to reactor building static pressure (for operating variance) is required for NPSH determinations provided in Rev. 5, since negative pressure is assumed in the accident analysis at time zero. Also, revised results in Attachments 21 and 22 are based upon atmospheric pressure of 14.7 psia and an initial reactor building static pressure of -1.0 psig. This has been shown (in reference 8.22) to be more limiting than the previous analysis due to the elevated reactor building atmospheric temperatures.

Pump submergence is determined from the known elevation of the pump suction and the calculated level of water in the reactor building. This quantity is given by the following expression:

Hs = Zwl - Zps

where: Zwl = elevation of water level in reactor building
Zps = elevation of pump suction

Zwl will be determined from the volume drawn out of the BWST and CFT's, reduced by the quantities lost to the vessel annulus and cavity areas, the FTC, RCS shrinkage, filling the spray headers, refill of the pressurizer vapor space, water lost to vaporization, water lost to the incore instrumentation tunnel, and water lost to the normal and emergency sumps. These quantities are determined in Attachments 10 through 17. The resulting depth above mean floor level is given in Attachment 18 as Lrb = 4.27 ft. Elevation of water surface is then given by:

Zwl = Lrb + Zfl

where Zfl = Reactor Building Floor Mean Elevation
= (777.5 +777.25 + 777.17 + 777.0 + 776.42 + 776.0 + 776.67 + 777.08 + 776.92 + 776.75 + 776.75 + 777.08)/12
= 776.88 ft. (Ref. 8.27 and 8.42)

Therefore: Zwl = 4.27 + 776.88 = 781.15 ft.

The following information is found in the references noted:

BS: Zps = 760.1 ft. (Ref. 8.26)
LPI: Zps = 761.1 ft. (Ref. 8.26)

Submergence is then determined from known pump elevations for the BS and LPI pumps, respectively:

BS: Hs = 781.15 - 760.1 = 21.05 ft.
LPI: Hs = 781.15 - 761.1 = 20.05 ft.

The Woods hydraulic modelling program calculates friction losses for various combinations of flows and sump temperature. Sump temperatures ranging from 195F to 240F are analyzed in increments of 5 degrees . Maximum sump temperature of 237.5F is also analyzed by interpolation. Specific gravity and viscosity at each temperature are inputs to the hydraulic model. Two flow cases are considered. The first case looks at maximum flows determined from instrument uncertainties. LPI flow is assumed to be 3291 gpm and RBS flow is assumed to be 1150 gpm. This allows for maximum negative instrument error at indicated flows of 3000 gpm and 1000 gpm, respectively. The second case looks at minimum flows determined from instrument uncertainties. LPI flow is assumed to be 2883 gpm and RBS flow is assumed to be 873 gpm. This allows for maximum positive instrument error at indicated flows of 3000 gpm and 1000 gpm, respectively. Both cases model RBS and LPI aligned through a separated "B" train (no cross-connecting of headers). Note that a minor correction for minor loss coefficient at the sump inlet has been made as noted in Attachment 9. Results of these model runs are included as Attachments 1 and 2.

Data used for calculation of NPSHa is presented in Attachment 3 showing the values of each of the above parameters versus temperature. Attachment 21 shows the same information for a more bounding analysis assuming lower initial reactor building pressure and higher initial reactor building temperature. In this analysis, a temperature range of 195F to 229.6F is evaluated.

NPSHr is determined from manufacturer's certified performance curve and adjusted for high temperature effect as permitted by NUREG 0897. Performance curve for BS pump 3B (Ref. 8.14) is used for conservatism. The NPSH requirements for this pump are bounding for all BS pumps. LPI pump NPSH data was taken from Ref. 8.15 for the 1A LPI pump, and verified as bounding for all LPI pumps. For Rev. 5, which was initiated to respond to PIP 0-O98-3976, the curve for BS pump 2A (Ref. 8.11) was used. This is acceptable because the high temperature effect from having Aux Coolers out of service is applicable only to Units 1&2. This effect more than offsets the difference in required NPSH for Unit 3. See curves in Attachment 23 for confirmation.

Attachments 3 and 21 show NPSHa and NPSHr in tabular form for each system over the stated temperature range and flow assumptions. NPSHa in these attachments includes credit for available reactor building overpressure. Attachments 4 and 22 show the same information in graphical form.

Reactor building pressure requirements are determined from the following equation:

Pr = (NPSHr - NPSHavp) / C (Where NPSHavp is the NPSH available without overpressure credit.)

The reactor building pressure requirement at each temperature is shown in Attachments 3 and 21, along with the available pressure. Available pressure is taken from Attachments 7 and 23 as the lowest pressure calculated for all cases at any given temperature. An adjustment of -0.2 psi is applied to these values in Attachments 3 & 4 in order to account for operating variation in reactor building static pressure (see NOTE above for exception in Attachments 21 & 22). Attachments 4 & 22 show building pressure required and available versus temperature in graphical form.

10.0 CONCLUSION

Attachment 4 illustrates that NPSHr is satisfied for both systems for all combinations of reactor building pressure and sump temperatures based upon assumed system operating flows. In both flow cases the NPSH requirements of the BS pumps govern the building pressure requirements. Attachment 7 shows the graphical results of the containment response analyses (Ref. 8.22), which have been determined to be worst case for purposes of BS pump NPSH analysis. Comparison of the graphical data shows that the building response (expressed in combinations of building pressure and sump temperature) is adequate to meet the NPSH requirements of the Reactor Building Spray Pumps and LPI pumps for all operating conditions. Attachment 4 illustrates the available margin between building pressure required and building pressure available.

Attachments 21 & 22 illustrate the adequacy of NPSHa for both LPI and BS systems with elevated initial temperatures for Units 1 &2 (due to having the Aux Coolers out of service for those units) and with bounding initial reactor building pressure of -1.0 psig. Attachment 23 demonstrates that the lower reactor building pressures allowed by Technical Specification 3.6.4 are bounded by the high temperature analysis. Attachment 23 also shows that Unit 3 is bounded by the high temperature analysis presented for Units 1 & 2.

FLOWRATE IS EXPRESSED IN GPM AND PRESSURE IN PSIG

A SUMMARY OF THE ORIGINAL DATA FOLLOWS

THE DARCY WEISBACH HEAD LOSS EQUATION IS USED, THE KINEMATIC VIS. = .0000035

THE SPECIFIC GRAVITY OF THIS LIQUID = .97

PIPE NO.	NODE NOS.		LENGTH (FEET)	DIAMETER (INCHES)	ROUGHNESS	MINOR LOSS K	FIXED GRADE
1	0	1	27.1	17.4	.2	1.92	782.50
LINE 1 IS CLOSED							
2	0	12	53.3	17.4	.2	1.91	782.50
3	1	2	24.0	13.5	.2	.89	
4	2	3	2.2	13.5	.2	.38	
5	3	4	7.1	10.3	.2	3.44	
6	4	5	6.0	8.1	.2	.20	
7	2	6	2.3	13.5	.2	.26	
8	6	7	19.0	13.5	.2	1.84	
9	7	8	6.5	12.3	.2	.19	
10	6	9	.4	13.5	.2	.63	
11	9	10	32.2	13.5	.2	1.73	
12	10	11	6.5	12.3	.2	.19	
13	9	13	.1	13.5	.2	.37	
14	12	13	24.8	13.5	.2	.89	
15	13	14	31.8	13.5	.2	1.24	
16	14	15	14.7	10.3	.2	1.94	
17	15	16	6.0	8.1	.2	.20	
18	14	17	23.5	13.5	.2	.75	
19	17	18	6.0	12.3	.2	.19	

JUNCTION NUMBER	DEMAND	ELEVATION	CONNECTING PIPES		
1	.00	.00	1	3	
2	.00	.00	3	4	7
3	.00	.00	4	5	
4	.00	.00	5	6	
5	1.00	760.10	6		
6	.00	.00	7	8	10
7	.00	.00	8	9	
8	1.00	761.10	9		
9	.00	.00	10	11	13
10	.00	.00	11	12	
11	1.00	761.10	12		
12	.00	.00	2	14	
13	.00	.00	13	14	15
14	.00	.00	15	16	18
15	.00	.00	16	17	
16	1150.00	760.10	17		
17	.00	.00	18	19	
18	3291.00	761.10	19		

OUTPUT SELECTION: ALL RESULTS ARE OUTPUT EACH PERIOD

THIS SYSTEM HAS 19 PIPES WITH 18 JUNCTIONS , 0 LOOPS AND 2 FGNS

THE RESULTS ARE OBTAINED AFTER 2 TRIALS WITH AN ACCURACY = .00000

RBS NPSH analysis for OSC-4467, Rev. 2. Model taken from OSC-1977, modified by removal of minor loss from 3BS-6 and addition of minor loss from sump inlet reducer. Sump temperature is 195F. No RB pressure.

PIPE NO.	NODE NOS.		FLOWRATE	HEAD LOSS	PUMP HEAD	MINOR LOSS	VELOCITY	HL/1000
LINE	1 IS CLOSED							
2	0	12	4444.00	.26	.00	1.07	6.01	4.96
3	1	2	.00	.00	.00	.00	.00	.00
4	2	3	1.00	.00	.00	.00	.00	.00
5	3	4	1.00	.00	.00	.00	.00	.00
6	4	5	1.00	.00	.00	.00	.01	.00
7	2	6	-1.00	.00	.00	.00	.00	.00
8	6	7	1.00	.00	.00	.00	.00	.00
9	7	8	1.00	.00	.00	.00	.00	.00
10	6	9	-2.00	.00	.00	.00	.00	.00
11	9	10	1.00	.00	.00	.00	.00	.00
12	10	11	1.00	.00	.00	.00	.00	.00
13	9	13	-3.00	.00	.00	.00	-.01	.00
14	12	13	4444.00	.45	.00	1.37	9.96	18.04
15	13	14	4441.00	.57	.00	1.91	9.95	18.01
16	14	15	1150.00	.08	.00	.60	4.47	5.24
17	15	16	1150.00	.10	.00	.16	7.12	17.15
18	14	17	3291.00	.24	.00	.63	7.38	10.00
19	17	18	3291.00	.10	.00	.24	8.96	16.45

JUNCTION NUMBER	DEMAND	GRADE LINE	ELEVATION	PRESSURE
1	.00	779.35		
2	.00	779.35		
3	.00	779.35		
4	.00	779.35		
5	1.00	779.35	760.10	8.05
6	.00	779.35		
7	.00	779.35		
8	1.00	779.35	761.10	7.63
9	.00	779.35		
10	.00	779.35		
11	1.00	779.35	761.10	7.63
12	.00	781.16		
13	.00	779.35		
14	.00	776.87		
15	.00	776.19		
16	1150.00	775.93	760.10	6.62
17	.00	776.00		
18	3291.00	775.66	761.10	6.09

THE NET SYSTEM DEMAND = 4444.00

SUMMARY OF INFLOWS(+) AND OUTFLOWS(-) FROM FIXED GRADE NODES

PIPE NUMBER	FLOWRATE
2	4444.00

THE NET FLOW INTO THE SYSTEM FROM FIXED GRADE NODES = 4444.00
THE NET FLOW OUT OF THE SYSTEM INTO FIXED GRADE NODES = .00

A SUMMARY OF CONDITIONS SPECIFIED FOR THE NEXT SIMULATION FOLLOWS

THE RESULTS ARE OBTAINED AFTER 1 TRIALS WITH AN ACCURACY = .00000

PIPE NO.	NODE NOS.		FLOWRATE	HEAD LOSS	PUMP HEAD	MINOR LOSS	VELOCITY	HL/1000
LINE	1 IS CLOSED							
2	0	12	4444.00	.26	.00	1.07	6.01	4.96
3	1	2	.00	.00	.00	.00	.00	.00
4	2	3	1.00	.00	.00	.00	.00	.00
5	3	4	1.00	.00	.00	.00	.00	.00
6	4	5	1.00	.00	.00	.00	.01	.00
7	2	6	-1.00	.00	.00	.00	.00	.00
8	6	7	1.00	.00	.00	.00	.00	.00
9	7	8	1.00	.00	.00	.00	.00	.00
10	6	9	-2.00	.00	.00	.00	.00	.00
11	9	10	1.00	.00	.00	.00	.00	.00
12	10	11	1.00	.00	.00	.00	.00	.00
13	9	13	-3.00	.00	.00	.00	-.01	.00
14	12	13	4444.00	.45	.00	1.37	9.96	18.04
15	13	14	4441.00	.57	.00	1.91	9.95	18.01
16	14	15	1150.00	.08	.00	.60	4.47	5.24
17	15	16	1150.00	.10	.00	.16	7.12	17.15
18	14	17	3291.00	.24	.00	.63	7.38	10.00
19	17	18	3291.00	.10	.00	.24	8.96	16.45

JUNCTION NUMBER	DEMAND	GRADE LINE	ELEVATION	PRESSURE
1	.00	779.35		
2	.00	779.35		
3	.00	779.35		
4	.00	779.35		
5	1.00	779.35	760.10	8.05
6	.00	779.35		
7	.00	779.35		
8	1.00	779.35	761.10	7.63
9	.00	779.35		
10	.00	779.35		
11	1.00	779.35	761.10	7.63
12	.00	781.16		
13	.00	779.35		
14	.00	776.87		
15	.00	776.19		
16	1150.00	775.93	760.10	6.62
17	.00	776.00		
18	3291.00	775.66	761.10	6.09

THE NET SYSTEM DEMAND = 4444.00

SUMMARY OF INFLOWS(+) AND OUTFLOWS(-) FROM FIXED GRADE NODES

PIPE NUMBER	FLOWRATE
2	4444.00

THE NET FLOW INTO THE SYSTEM FROM FIXED GRADE NODES = 4444.00
THE NET FLOW OUT OF THE SYSTEM INTO FIXED GRADE NODES = .00

FLOWRATE IS EXPRESSED IN GPM AND PRESSURE IN PSIG

A SUMMARY OF THE ORIGINAL DATA FOLLOWS

THE DARCY WEISBACH HEAD LOSS EQUATION IS USED, THE KINEMATIC VIS. = .0000034

THE SPECIFIC GRAVITY OF THIS LIQUID = .96

PIPE NO.	NODE NOS.		LENGTH (FEET)	DIAMETER (INCHES)	ROUGHNESS	MINOR LOSS K	FIXED GRADE
1	0	1	27.1	17.4	.2	1.91	782.50
LINE 1 IS CLOSED							
2	0	12	53.3	17.4	.2	1.91	782.50
3	1	2	24.0	13.5	.2	.89	
4	2	3	2.2	13.5	.2	.38	
5	3	4	7.1	10.3	.2	3.44	
6	4	5	6.0	8.1	.2	.20	
7	2	6	2.3	13.5	.2	.26	
8	6	7	19.0	13.5	.2	1.84	
9	7	8	6.5	12.3	.2	.19	
10	6	9	.4	13.5	.2	.63	
11	9	10	32.2	13.5	.2	1.73	
12	10	11	6.5	12.3	.2	.19	
13	9	13	.1	13.5	.2	.37	
14	12	13	24.8	13.5	.2	.89	
15	13	14	31.8	13.5	.2	1.24	
16	14	15	14.7	10.3	.2	1.94	
17	15	16	6.0	8.1	.2	.20	
18	14	17	23.5	13.5	.2	.75	
19	17	18	6.0	12.3	.2	.19	

JUNCTION NUMBER	DEMAND	ELEVATION	CONNECTING PIPES		
1	.00	.00	1	3	
2	.00	.00	3	4	7
3	.00	.00	4	5	
4	.00	.00	5	6	
5	1.00	760.10	6		
6	.00	.00	7	8	10
7	.00	.00	8	9	
8	1.00	761.10	9		
9	.00	.00	10	11	13
10	.00	.00	11	12	
11	1.00	761.10	12		
12	.00	.00	2	14	
13	.00	.00	13	14	15
14	.00	.00	15	16	18
15	.00	.00	16	17	
16	1150.00	760.10	17		
17	.00	.00	18	19	
18	3291.00	761.10	19		

OUTPUT SELECTION: ALL RESULTS ARE OUTPUT EACH PERIOD

THIS SYSTEM HAS 19 PIPES WITH 18 JUNCTIONS , 0 LOOPS AND 2 FGNS

THE RESULTS ARE OBTAINED AFTER 2 TRIALS WITH AN ACCURACY = .00000

RBS NPSH analysis for OSC-4467, Rev. 2. Model taken from OSC-1977, modified by removal of minor loss from 3BS-6, and addition of minor loss from sump inlet reducer. Sump temperature is 200F. No RB pressure.

PIPE NO.	NODE NOS.		FLOWRATE	HEAD LOSS	PUMP HEAD	MINOR LOSS	VELOCITY	HL/1000
LINE 1 IS CLOSED								
2	0	12	4444.00	.26	.00	1.07	6.01	4.95
3	1	2	.00	.00	.00	.00	.00	.00
4	2	3	1.00	.00	.00	.00	.00	.00
5	3	4	1.00	.00	.00	.00	.00	.00
6	4	5	1.00	.00	.00	.00	.01	.00
7	2	6	-1.00	.00	.00	.00	.00	.00
8	6	7	1.00	.00	.00	.00	.00	.00
9	7	8	1.00	.00	.00	.00	.00	.00
10	6	9	-2.00	.00	.00	.00	.00	.00
11	9	10	1.00	.00	.00	.00	.00	.00
12	10	11	1.00	.00	.00	.00	.00	.00
13	9	13	-3.00	.00	.00	.00	-.01	.00
14	12	13	4444.00	.45	.00	1.37	9.96	18.02
15	13	14	4441.00	.57	.00	1.91	9.95	18.00
16	14	15	1150.00	.08	.00	.60	4.47	5.23
17	15	16	1150.00	.10	.00	.16	7.12	17.13
18	14	17	3291.00	.23	.00	.63	7.38	9.99
19	17	18	3291.00	.10	.00	.24	8.96	16.43

JUNCTION NUMBER	DEMAND	GRADE LINE	ELEVATION	PRESSURE
1	.00	779.35		
2	.00	779.35		
3	.00	779.35		
4	.00	779.35		
5	1.00	779.35	760.10	8.04
6	.00	779.35		
7	.00	779.35		
8	1.00	779.35	761.10	7.62
9	.00	779.35		
10	.00	779.35		
11	1.00	779.35	761.10	7.62
12	.00	781.16		
13	.00	779.35		
14	.00	776.87		
15	.00	776.19		
16	1150.00	775.93	760.10	6.61
17	.00	776.00		
18	3291.00	775.66	761.10	6.08

THE NET SYSTEM DEMAND = 4444.00

SUMMARY OF INFLOWS(+) AND OUTFLOWS(-) FROM FIXED GRADE NODES

PIPE NUMBER	FLOWRATE
2	4444.00

THE NET FLOW INTO THE SYSTEM FROM FIXED GRADE NODES = 4444.00
THE NET FLOW OUT OF THE SYSTEM INTO FIXED GRADE NODES = .00

A SUMMARY OF CONDITIONS SPECIFIED FOR THE NEXT SIMULATION FOLLOWS

THE RESULTS ARE OBTAINED AFTER 1 TRIALS WITH AN ACCURACY = .00000

PIPE NO.	NODE NOS.		FLOWRATE	HEAD LOSS	PUMP HEAD	MINOR LOSS	VELOCITY	HL/1000
LINE	1 IS CLOSED							
2	0	12	4444.00	.26	.00	1.07	6.01	4.95
3	1	2	.00	.00	.00	.00	.00	.00
4	2	3	1.00	.00	.00	.00	.00	.00
5	3	4	1.00	.00	.00	.00	.00	.00
6	4	5	1.00	.00	.00	.00	.01	.00
7	2	6	-1.00	.00	.00	.00	.00	.00
8	6	7	1.00	.00	.00	.00	.00	.00
9	7	8	1.00	.00	.00	.00	.00	.00
10	6	9	-2.00	.00	.00	.00	.00	.00
11	9	10	1.00	.00	.00	.00	.00	.00
12	10	11	1.00	.00	.00	.00	.00	.00
13	9	13	-3.00	.00	.00	.00	-.01	.00
14	12	13	4444.00	.45	.00	1.37	9.96	18.02
15	13	14	4441.00	.57	.00	1.91	9.95	18.00
16	14	15	1150.00	.08	.00	.60	4.47	5.23
17	15	16	1150.00	.10	.00	.16	7.12	17.13
18	14	17	3291.00	.23	.00	.63	7.38	9.99
19	17	18	3291.00	.10	.00	.24	8.96	16.43

JUNCTION NUMBER	DEMAND	GRADE LINE	ELEVATION	PRESSURE
1	.00	779.35		
2	.00	779.35		
3	.00	779.35		
4	.00	779.35		
5	1.00	779.35	760.10	8.04
6	.00	779.35		
7	.00	779.35		
8	1.00	779.35	761.10	7.62
9	.00	779.35		
10	.00	779.35		
11	1.00	779.35	761.10	7.62
12	.00	781.16		
13	.00	779.35		
14	.00	776.87		
15	.00	776.19		
16	1150.00	775.93	760.10	6.61
17	.00	776.00		
18	3291.00	775.66	761.10	6.08

THE NET SYSTEM DEMAND = 4444.00

SUMMARY OF INFLOWS(+) AND OUTFLOWS(-) FROM FIXED GRADE NODES

PIPE NUMBER	FLOWRATE
2	4444.00

THE NET FLOW INTO THE SYSTEM FROM FIXED GRADE NODES = 4444.00
THE NET FLOW OUT OF THE SYSTEM INTO FIXED GRADE NODES = .00

FLOWRATE IS EXPRESSED IN GPM AND PRESSURE IN PSIG

A SUMMARY OF THE ORIGINAL DATA FOLLOWS

THE DARCY WEISBACH HEAD LOSS EQUATION IS USED, THE KINEMATIC VIS. = .0000033

THE SPECIFIC GRAVITY OF THIS LIQUID = .96

PIPE NO.	NODE NOS.		LENGTH (FEET)	DIAMETER (INCHES)	ROUGHNESS	MINOR LOSS K	FIXED GRADE
1	0	1	27.1	17.4	.2	1.91	782.50
LINE 1 IS CLOSED							
2	0	12	53.3	17.4	.2	1.91	782.50
3	1	2	24.0	13.5	.2	.89	
4	2	3	2.2	13.5	.2	.38	
5	3	4	7.1	10.3	.2	3.44	
6	4	5	6.0	8.1	.2	.20	
7	2	6	2.3	13.5	.2	.26	
8	6	7	19.0	13.5	.2	1.84	
9	7	8	6.5	12.3	.2	.19	
10	6	9	.4	13.5	.2	.63	
11	9	10	32.2	13.5	.2	1.73	
12	10	11	6.5	12.3	.2	.19	
13	9	13	.1	13.5	.2	.37	
14	12	13	24.8	13.5	.2	.89	
15	13	14	31.8	13.5	.2	1.24	
16	14	15	14.7	10.3	.2	1.94	
17	15	16	6.0	8.1	.2	.20	
18	14	17	23.5	13.5	.2	.75	
19	17	18	6.0	12.3	.2	.19	

JUNCTION NUMBER	DEMAND	ELEVATION	CONNECTING PIPES		
1	.00	.00	1	3	
2	.00	.00	3	4	7
3	.00	.00	4	5	
4	.00	.00	5	6	
5	1.00	760.10	6		
6	.00	.00	7	8	10
7	.00	.00	8	9	
8	1.00	761.10	9		
9	.00	.00	10	11	13
10	.00	.00	11	12	
11	1.00	761.10	12		
12	.00	.00	2	14	
13	.00	.00	13	14	15
14	.00	.00	15	16	18
15	.00	.00	16	17	
16	1150.00	760.10	17		
17	.00	.00	18	19	
18	3291.00	761.10	19		

OUTPUT SELECTION: ALL RESULTS ARE OUTPUT EACH PERIOD

THIS SYSTEM HAS 19 PIPES WITH 18 JUNCTIONS , 0 LOOPS AND 2 FGNS

THE RESULTS ARE OBTAINED AFTER 2 TRIALS WITH AN ACCURACY = .00000

RBS NPSH analysis for OSC-4467, Rev. 2. Model taken from OSC-1977, modified by removal of minor loss from 3BS-6, and addition of minor loss from sump inlet reducer. Sump temperature is 205F. No RB pressure.

PIPE NO.	NODE NOS.		FLOWRATE	HEAD LOSS	PUMP HEAD	MINOR LOSS	VELOCITY	HL/1000
LINE 1 IS CLOSED								
2	0	12	4444.00	.26	.00	1.07	6.01	4.95
3	1	2	.00	.00	.00	.00	.00	.00
4	2	3	1.00	.00	.00	.00	.00	.00
5	3	4	1.00	.00	.00	.00	.00	.00
6	4	5	1.00	.00	.00	.00	.01	.00
7	2	6	-1.00	.00	.00	.00	.00	.00
8	6	7	1.00	.00	.00	.00	.00	.00
9	7	8	1.00	.00	.00	.00	.00	.00
10	6	9	-2.00	.00	.00	.00	.00	.00
11	9	10	1.00	.00	.00	.00	.00	.00
12	10	11	1.00	.00	.00	.00	.00	.00
13	9	13	-3.00	.00	.00	.00	-.01	.00
14	12	13	4444.00	.45	.00	1.37	9.96	18.00
15	13	14	4441.00	.57	.00	1.91	9.95	17.98
16	14	15	1150.00	.08	.00	.60	4.47	5.22
17	15	16	1150.00	.10	.00	.16	7.12	17.11
18	14	17	3291.00	.23	.00	.63	7.38	9.98
19	17	18	3291.00	.10	.00	.24	8.96	16.42

JUNCTION NUMBER	DEMAND	GRADE LINE	ELEVATION	PRESSURE
1	.00	779.35		
2	.00	779.35		
3	.00	779.35		
4	.00	779.35		
5	1.00	779.35	760.10	8.02
6	.00	779.35		
7	.00	779.35		
8	1.00	779.35	761.10	7.60
9	.00	779.35		
10	.00	779.35		
11	1.00	779.35	761.10	7.60
12	.00	781.16		
13	.00	779.35		
14	.00	776.87		
15	.00	776.19		
16	1150.00	775.93	760.10	6.60
17	.00	776.00		
18	3291.00	775.66	761.10	6.07

THE NET SYSTEM DEMAND = 4444.00

SUMMARY OF INFLOWS(+) AND OUTFLOWS(-) FROM FIXED GRADE NODES

PIPE NUMBER	FLOWRATE
2	4444.00

THE NET FLOW INTO THE SYSTEM FROM FIXED GRADE NODES = 4444.00
THE NET FLOW OUT OF THE SYSTEM INTO FIXED GRADE NODES = .00

A SUMMARY OF CONDITIONS SPECIFIED FOR THE NEXT SIMULATION FOLLOWS

THE RESULTS ARE OBTAINED AFTER 1 TRIALS WITH AN ACCURACY = .00000

PIPE NO.	NODE NOS.		FLOWRATE	HEAD LOSS	PUMP HEAD	MINOR LOSS	VELOCITY	HL/1000
LINE 1 IS CLOSED								
2	0	12	4444.00	.26	.00	1.07	6.01	4.95
3	1	2	.00	.00	.00	.00	.00	.00
4	2	3	1.00	.00	.00	.00	.00	.00
5	3	4	1.00	.00	.00	.00	.00	.00
6	4	5	1.00	.00	.00	.00	.01	.00
7	2	6	-1.00	.00	.00	.00	.00	.00
8	6	7	1.00	.00	.00	.00	.00	.00
9	7	8	1.00	.00	.00	.00	.00	.00
10	6	9	-2.00	.00	.00	.00	.00	.00
11	9	10	1.00	.00	.00	.00	.00	.00
12	10	11	1.00	.00	.00	.00	.00	.00
13	9	13	-3.00	.00	.00	.00	-.01	.00
14	12	13	4444.00	.45	.00	1.37	9.96	18.00
15	13	14	4441.00	.57	.00	1.91	9.95	17.98
16	14	15	1150.00	.08	.00	.60	4.47	5.22
17	15	16	1150.00	.10	.00	.16	7.12	17.11
18	14	17	3291.00	.23	.00	.63	7.38	9.98
19	17	18	3291.00	.10	.00	.24	8.96	16.42

JUNCTION NUMBER	DEMAND	GRADE LINE	ELEVATION	PRESSURE
1	.00	779.35		
2	.00	779.35		
3	.00	779.35		
4	.00	779.35		
5	1.00	779.35	760.10	8.02
6	.00	779.35		
7	.00	779.35		
8	1.00	779.35	761.10	7.60
9	.00	779.35		
10	.00	779.35		
11	1.00	779.35	761.10	7.60
12	.00	781.16		
13	.00	779.35		
14	.00	776.87		
15	.00	776.19		
16	1150.00	775.93	760.10	6.60
17	.00	776.00		
18	3291.00	775.66	761.10	6.07

THE NET SYSTEM DEMAND = 4444.00

SUMMARY OF INFLOWS(+) AND OUTFLOWS(-) FROM FIXED GRADE NODES

PIPE NUMBER	FLOWRATE
2	4444.00

THE NET FLOW INTO THE SYSTEM FROM FIXED GRADE NODES = 4444.00
THE NET FLOW OUT OF THE SYSTEM INTO FIXED GRADE NODES = .00

FLOWRATE IS EXPRESSED IN GPM AND PRESSURE IN PSIG

A SUMMARY OF THE ORIGINAL DATA FOLLOWS

THE DARCY WEISBACH HEAD LOSS EQUATION IS USED, THE KINEMATIC VIS. = .0000032

THE SPECIFIC GRAVITY OF THIS LIQUID = .96

PIPE NO.	NODE NOS.		LENGTH (FEET)	DIAMETER (INCHES)	ROUGHNESS	MINOR LOSS K	FIXED GRADE
1	0	1	27.1	17.4	.2	1.91	782.50
LINE 1 IS CLOSED							
2	0	12	53.3	17.4	.2	1.91	782.50
3	1	2	24.0	13.5	.2	.89	
4	2	3	2.2	13.5	.2	.38	
5	3	4	7.1	10.3	.2	3.44	
6	4	5	6.0	8.1	.2	.20	
7	2	6	2.3	13.5	.2	.26	
8	6	7	19.0	13.5	.2	1.84	
9	7	8	6.5	12.3	.2	.19	
10	6	9	.4	13.5	.2	.63	
11	9	10	32.2	13.5	.2	1.73	
12	10	11	6.5	12.3	.2	.19	
13	9	13	.1	13.5	.2	.37	
14	12	13	24.8	13.5	.2	.89	
15	13	14	31.8	13.5	.2	1.24	
16	14	15	14.7	10.3	.2	1.94	
17	15	16	6.0	8.1	.2	.20	
18	14	17	23.5	13.5	.2	.75	
19	17	18	6.0	12.3	.2	.19	

JUNCTION NUMBER	DEMAND	ELEVATION	CONNECTING PIPES		
1	.00	.00	1	3	
2	.00	.00	3	4	7
3	.00	.00	4	5	
4	.00	.00	5	6	
5	1.00	760.10	6		
6	.00	.00	7	8	10
7	.00	.00	8	9	
8	1.00	761.10	9		
9	.00	.00	10	11	13
10	.00	.00	11	12	
11	1.00	761.10	12		
12	.00	.00	2	14	
13	.00	.00	13	14	15
14	.00	.00	15	16	18
15	.00	.00	16	17	
16	1150.00	760.10	17		
17	.00	.00	18	19	
18	3291.00	761.10	19		

OUTPUT SELECTION: ALL RESULTS ARE OUTPUT EACH PERIOD

THIS SYSTEM HAS 19 PIPES WITH 18 JUNCTIONS , 0 LOOPS AND 2 FGNS

THE RESULTS ARE OBTAINED AFTER 2 TRIALS WITH AN ACCURACY = .00000

RBS NPSH analysis for OSC-4467, Rev. 2. Model taken from OSC-1977, modified by removal of minor loss from 3BS-6, and addition of minor loss from sump inlet reducer. Sump temperature is 210F. No RB pressure.

PIPE NO.	NODE NOS.		FLOWRATE	HEAD LOSS	PUMP HEAD	MINOR LOSS	VELOCITY	HL/1000
LINE 1 IS CLOSED								
2	0	12	4444.00	.26	.00	1.07	6.01	4.94
3	1	2	.00	.00	.00	.00	.00	.00
4	2	3	1.00	.00	.00	.00	.00	.00
5	3	4	1.00	.00	.00	.00	.00	.00
6	4	5	1.00	.00	.00	.00	.01	.00
7	2	6	-1.00	.00	.00	.00	.00	.00
8	6	7	1.00	.00	.00	.00	.00	.00
9	7	8	1.00	.00	.00	.00	.00	.00
10	6	9	-2.00	.00	.00	.00	.00	.00
11	9	10	1.00	.00	.00	.00	.00	.00
12	10	11	1.00	.00	.00	.00	.00	.00
13	9	13	-3.00	.00	.00	.00	-.01	.00
14	12	13	4444.00	.45	.00	1.37	9.96	17.99
15	13	14	4441.00	.57	.00	1.91	9.95	17.96
16	14	15	1150.00	.08	.00	.60	4.47	5.21
17	15	16	1150.00	.10	.00	.16	7.12	17.09
18	14	17	3291.00	.23	.00	.63	7.38	9.97
19	17	18	3291.00	.10	.00	.24	8.96	16.40

JUNCTION NUMBER	DEMAND	GRADE LINE	ELEVATION	PRESSURE
1	.00	779.35		
2	.00	779.35		
3	.00	779.35		
4	.00	779.35		
5	1.00	779.35	760.10	8.01
6	.00	779.35		
7	.00	779.35		
8	1.00	779.35	761.10	7.59
9	.00	779.35		
10	.00	779.35		
11	1.00	779.35	761.10	7.59
12	.00	781.16		
13	.00	779.35		
14	.00	776.87		
15	.00	776.19		
16	1150.00	775.93	760.10	6.58
17	.00	776.00		
18	3291.00	775.67	761.10	6.06

THE NET SYSTEM DEMAND = 4444.00

SUMMARY OF INFLOWS(+) AND OUTFLOWS(-) FROM FIXED GRADE NODES

PIPE NUMBER	FLOWRATE
2	4444.00

THE NET FLOW INTO THE SYSTEM FROM FIXED GRADE NODES = 4444.00
THE NET FLOW OUT OF THE SYSTEM INTO FIXED GRADE NODES = .00

A SUMMARY OF CONDITIONS SPECIFIED FOR THE NEXT SIMULATION FOLLOWS

THE RESULTS ARE OBTAINED AFTER 1 TRIALS WITH AN ACCURACY = .00000

LINE 1 IS CLOSED

PIPE NO.	NODE NOS.		FLOWRATE	HEAD LOSS	PUMP HEAD	MINOR LOSS	VELOCITY	HL/1000
2	0	12	4444.00	.26	.00	1.07	6.01	4.94
3	1	2	.00	.00	.00	.00	.00	.00
4	2	3	1.00	.00	.00	.00	.00	.00
5	3	4	1.00	.00	.00	.00	.00	.00
6	4	5	1.00	.00	.00	.00	.01	.00
7	2	6	-1.00	.00	.00	.00	.00	.00
8	6	7	1.00	.00	.00	.00	.00	.00
9	7	8	1.00	.00	.00	.00	.00	.00
10	6	9	-2.00	.00	.00	.00	.00	.00
11	9	10	1.00	.00	.00	.00	.00	.00
12	10	11	1.00	.00	.00	.00	.00	.00
13	9	13	-3.00	.00	.00	.00	-.01	.00
14	12	13	4444.00	.45	.00	1.37	9.96	17.99
15	13	14	4441.00	.57	.00	1.91	9.95	17.96
16	14	15	1150.00	.08	.00	.60	4.47	5.21
17	15	16	1150.00	.10	.00	.16	7.12	17.09
18	14	17	3291.00	.23	.00	.63	7.38	9.97
19	17	18	3291.00	.10	.00	.24	8.96	16.40

JUNCTION NUMBER	DEMAND	GRADE LINE	ELEVATION	PRESSURE
1	.00	779.35		
2	.00	779.35		
3	.00	779.35		
4	.00	779.35		
5	1.00	779.35	760.10	8.01
6	.00	779.35		
7	.00	779.35		
8	1.00	779.35	761.10	7.59
9	.00	779.35		
10	.00	779.35		
11	1.00	779.35	761.10	7.59
12	.00	781.16		
13	.00	779.35		
14	.00	776.87		
15	.00	776.19		
16	1150.00	775.93	760.10	6.58
17	.00	776.00		
18	3291.00	775.67	761.10	6.06

THE NET SYSTEM DEMAND = 4444.00

SUMMARY OF INFLOWS(+) AND OUTFLOWS(-) FROM FIXED GRADE NODES

PIPE NUMBER	FLOWRATE
2	4444.00

THE NET FLOW INTO THE SYSTEM FROM FIXED GRADE NODES = 4444.00
THE NET FLOW OUT OF THE SYSTEM INTO FIXED GRADE NODES = .00

FLOWRATE IS EXPRESSED IN GPM AND PRESSURE IN PSIG

A SUMMARY OF THE ORIGINAL DATA FOLLOWS

THE DARCY WEISBACH HEAD LOSS EQUATION IS USED, THE KINEMATIC VIS. = .0000032

THE SPECIFIC GRAVITY OF THIS LIQUID = .96

PIPE NO.	NODE NOS.		LENGTH (FEET)	DIAMETER (INCHES)	ROUGHNESS	MINOR LOSS K	FIXED GRADE
1	0	1	27.1	17.4	.2	1.91	782.50
THERE IS A PUMP IN LINE 1 WITH USEFUL POWER = 782.50							
LINE 1 IS CLOSED							
2	0	12	53.3	17.4	.2	1.91	782.50
3	1	2	24.0	13.5	.2	.89	
4	2	3	2.2	13.5	.2	.38	
5	3	4	7.1	10.3	.2	3.44	
6	4	5	6.0	8.1	.2	.20	
7	2	6	2.3	13.5	.2	.26	
8	6	7	19.0	13.5	.2	1.84	
9	7	8	6.5	12.3	.2	.19	
10	6	9	.4	13.5	.2	.63	
11	9	10	32.2	13.5	.2	1.73	
12	10	11	6.5	12.3	.2	.19	
13	9	13	.1	13.5	.2	.37	
14	12	13	24.8	13.5	.2	.89	
15	13	14	31.8	13.5	.2	1.24	
16	14	15	14.7	10.3	.2	1.94	
17	15	16	6.0	8.1	.2	.20	
18	14	17	23.5	13.5	.2	.75	
19	17	18	6.0	12.3	.2	.19	

JUNCTION NUMBER	DEMAND	ELEVATION	CONNECTING PIPES		
1	.00	.00	1	3	
2	.00	.00	3	4	7
3	.00	.00	4	5	
4	.00	.00	5	6	
5	1.00	760.10	6		
6	.00	.00	7	8	10
7	.00	.00	8	9	
8	1.00	761.10	9		
9	.00	.00	10	11	13
10	.00	.00	11	12	
11	1.00	761.10	12		
12	.00	.00	2	14	
13	.00	.00	13	14	15
14	.00	.00	15	16	18
15	.00	.00	16	17	
16	1150.00	760.10	17		
17	.00	.00	18	19	
18	3291.00	761.10	19		

OUTPUT SELECTION: ALL RESULTS ARE OUTPUT EACH PERIOD

THIS SYSTEM HAS 19 PIPES WITH 18 JUNCTIONS , 0 LOOPS AND 2 FGNS

THE RESULTS ARE OBTAINED AFTER 2 TRIALS WITH AN ACCURACY = .00000

RBS NPSH analysis for OSC-4467, Rev. 2. Model taken from OSC-1977, modified by removal of minor loss from 3BS-6, and addition of minor loss from sump inlet reducer. Sump temperature is 215. No RB pressure.

PIPE NO.	NODE NOS.		FLOWRATE	HEAD LOSS	PUMP HEAD	MINOR LOSS	VELOCITY	HL/1000
LINE 1 IS CLOSED								
2	0	12	4444.00	.26	.00	1.07	6.01	4.94
3	1	2	.00	.00	.00	.00	.00	.00
4	2	3	1.00	.00	.00	.00	.00	.00
5	3	4	1.00	.00	.00	.00	.00	.00
6	4	5	1.00	.00	.00	.00	.01	.00
7	2	6	-1.00	.00	.00	.00	.00	.00
8	6	7	1.00	.00	.00	.00	.00	.00
9	7	8	1.00	.00	.00	.00	.00	.00
10	6	9	-2.00	.00	.00	.00	.00	.00
11	9	10	1.00	.00	.00	.00	.00	.00
12	10	11	1.00	.00	.00	.00	.00	.00
13	9	13	-3.00	.00	.00	.00	-.01	.00
14	12	13	4444.00	.45	.00	1.37	9.96	17.99
15	13	14	4441.00	.57	.00	1.91	9.95	17.96
16	14	15	1150.00	.08	.00	.60	4.47	5.21
17	15	16	1150.00	.10	.00	.16	7.12	17.09
18	14	17	3291.00	.23	.00	.63	7.38	9.97
19	17	18	3291.00	.10	.00	.24	8.96	16.40

JUNCTION NUMBER	DEMAND	GRADE LINE	ELEVATION	PRESSURE
1	.00	779.35		
2	.00	779.35		
3	.00	779.35		
4	.00	779.35		
5	1.00	779.35	760.10	7.99
6	.00	779.35		
7	.00	779.35		
8	1.00	779.35	761.10	7.57
9	.00	779.35		
10	.00	779.35		
11	1.00	779.35	761.10	7.57
12	.00	781.16		
13	.00	779.35		
14	.00	776.87		
15	.00	776.19		
16	1150.00	775.93	760.10	6.57
17	.00	776.00		
18	3291.00	775.67	761.10	6.05

THE NET SYSTEM DEMAND = 4444.00

SUMMARY OF INFLOWS(+) AND OUTFLOWS(-) FROM FIXED GRADE NODES

PIPE NUMBER	FLOWRATE
2	4444.00

THE NET FLOW INTO THE SYSTEM FROM FIXED GRADE NODES = 4444.00
THE NET FLOW OUT OF THE SYSTEM INTO FIXED GRADE NODES = .00

A SUMMARY OF CONDITIONS SPECIFIED FOR THE NEXT SIMULATION FOLLOWS

THE RESULTS ARE OBTAINED AFTER 1 TRIALS WITH AN ACCURACY = .00000

PIPE NO.	NODE NOS.		FLOWRATE	HEAD LOSS	PUMP HEAD	MINOR LOSS	VELOCITY	HL/1000
LINE	1 IS CLOSED							
2	0	12	4444.00	.26	.00	1.07	6.01	4.94
3	1	2	.00	.00	.00	.00	.00	.00
4	2	3	1.00	.00	.00	.00	.00	.00
5	3	4	1.00	.00	.00	.00	.00	.00
6	4	5	1.00	.00	.00	.00	.01	.00
7	2	6	-1.00	.00	.00	.00	.00	.00
8	6	7	1.00	.00	.00	.00	.00	.00
9	7	8	1.00	.00	.00	.00	.00	.00
10	6	9	-2.00	.00	.00	.00	.00	.00
11	9	10	1.00	.00	.00	.00	.00	.00
12	10	11	1.00	.00	.00	.00	.00	.00
13	9	13	-3.00	.00	.00	.00	-.01	.00
14	12	13	4444.00	.45	.00	1.37	9.96	17.99
15	13	14	4441.00	.57	.00	1.91	9.95	17.96
16	14	15	1150.00	.08	.00	.60	4.47	5.21
17	15	16	1150.00	.10	.00	.16	7.12	17.09
18	14	17	3291.00	.23	.00	.63	7.38	9.97
19	17	18	3291.00	.10	.00	.24	8.96	16.40

JUNCTION NUMBER	DEMAND	GRADE LINE	ELEVATION	PRESSURE
1	.00	779.35		
2	.00	779.35		
3	.00	779.35		
4	.00	779.35		
5	1.00	779.35	760.10	7.99
6	.00	779.35		
7	.00	779.35		
8	1.00	779.35	761.10	7.57
9	.00	779.35		
10	.00	779.35		
11	1.00	779.35	761.10	7.57
12	.00	781.16		
13	.00	779.35		
14	.00	776.87		
15	.00	776.19		
16	1150.00	775.93	760.10	6.57
17	.00	776.00		
18	3291.00	775.67	761.10	6.05

THE NET SYSTEM DEMAND = 4444.00

SUMMARY OF INFLOWS(+) AND OUTFLOWS(-) FROM FIXED GRADE NODES

PIPE NUMBER	FLOWRATE
2	4444.00

THE NET FLOW INTO THE SYSTEM FROM FIXED GRADE NODES = 4444.00
THE NET FLOW OUT OF THE SYSTEM INTO FIXED GRADE NODES = .00

FLOWRATE IS EXPRESSED IN GPM AND PRESSURE IN PSIG

A SUMMARY OF THE ORIGINAL DATA FOLLOWS

THE DARCY WEISBACH HEAD LOSS EQUATION IS USED, THE KINEMATIC VIS. = .0000031

THE SPECIFIC GRAVITY OF THIS LIQUID = .96

PIPE NO.	NODE NOS.		LENGTH (FEET)	DIAMETER (INCHES)	ROUGHNESS	MINOR LOSS K	FIXED GRADE
1	0	1	27.1	17.4	.2	1.91	782.50
LINE 1 IS CLOSED							
2	0	12	53.3	17.4	.2	1.91	782.50
3	1	2	24.0	13.5	.2	.89	
4	2	3	2.2	13.5	.2	.38	
5	3	4	7.1	10.3	.2	3.44	
6	4	5	6.0	8.1	.2	.20	
7	2	6	2.3	13.5	.2	.26	
8	6	7	19.0	13.5	.2	1.84	
9	7	8	6.5	12.3	.2	.19	
10	6	9	.4	13.5	.2	.63	
11	9	10	32.2	13.5	.2	1.73	
12	10	11	6.5	12.3	.2	.19	
13	9	13	.1	13.5	.2	.37	
14	12	13	24.8	13.5	.2	.89	
15	13	14	31.8	13.5	.2	1.24	
16	14	15	14.7	10.3	.2	1.94	
17	15	16	6.0	8.1	.2	.20	
18	14	17	23.5	13.5	.2	.75	
19	17	18	6.0	12.3	.2	.19	

JUNCTION NUMBER	DEMAND	ELEVATION	CONNECTING PIPES		
1	.00	.00	1	3	
2	.00	.00	3	4	7
3	.00	.00	4	5	
4	.00	.00	5	6	
5	1.00	760.10	6		
6	.00	.00	7	8	10
7	.00	.00	8	9	
8	1.00	761.10	9		
9	.00	.00	10	11	13
10	.00	.00	11	12	
11	1.00	761.10	12		
12	.00	.00	2	14	
13	.00	.00	13	14	15
14	.00	.00	15	16	18
15	.00	.00	16	17	
16	1150.00	760.10	17		
17	.00	.00	18	19	
18	3291.00	761.10	19		

OUTPUT SELECTION: ALL RESULTS ARE OUTPUT EACH PERIOD

THIS SYSTEM HAS 19 PIPES WITH 18 JUNCTIONS , 0 LOOPS AND 2 FGNS

THE RESULTS ARE OBTAINED AFTER 2 TRIALS WITH AN ACCURACY = .00000

RBS NPSH analysis for OSC-4467, Rev. 2. Model taken from OSC-1977, modified by removal of minor loss from 3BS-6, and addition of minor loss from sump inlet reducer. Sump temperature is 220F. No RB pressure.

PIPE NO.	NODE NOS.		FLOWRATE	HEAD LOSS	PUMP HEAD	MINOR LOSS	VELOCITY	HL/1000
LINE	1 IS CLOSED							
2	0	12	4444.00	.26	.00	1.07	6.01	4.93
3	1	2	.00	.00	.00	.00	.00	.00
4	2	3	1.00	.00	.00	.00	.00	.00
5	3	4	1.00	.00	.00	.00	.00	.00
6	4	5	1.00	.00	.00	.00	.01	.00
7	2	6	-1.00	.00	.00	.00	.00	.00
8	6	7	1.00	.00	.00	.00	.00	.00
9	7	8	1.00	.00	.00	.00	.00	.00
10	6	9	-2.00	.00	.00	.00	.00	.00
11	9	10	1.00	.00	.00	.00	.00	.00
12	10	11	1.00	.00	.00	.00	.00	.00
13	9	13	-3.00	.00	.00	.00	-.01	.00
14	12	13	4444.00	.45	.00	1.37	9.96	17.97
15	13	14	4441.00	.57	.00	1.91	9.95	17.95
16	14	15	1150.00	.08	.00	.60	4.47	5.20
17	15	16	1150.00	.10	.00	.16	7.12	17.07
18	14	17	3291.00	.23	.00	.63	7.38	9.95
19	17	18	3291.00	.10	.00	.24	8.96	16.38

JUNCTION NUMBER	DEMAND	GRADE LINE	ELEVATION	PRESSURE
1	.00	779.35		
2	.00	779.35		
3	.00	779.35		
4	.00	779.35		
5	1.00	779.35	760.10	7.97
6	.00	779.35		
7	.00	779.35		
8	1.00	779.35	761.10	7.56
9	.00	779.35		
10	.00	779.35		
11	1.00	779.35	761.10	7.56
12	.00	781.17		
13	.00	779.35		
14	.00	776.87		
15	.00	776.19		
16	1150.00	775.93	760.10	6.56
17	.00	776.00		
18	3291.00	775.67	761.10	6.03

THE NET SYSTEM DEMAND = 4444.00

SUMMARY OF INFLOWS(+) AND OUTFLOWS(-) FROM FIXED GRADE NODES

PIPE NUMBER	FLOWRATE
2	4444.00

THE NET FLOW INTO THE SYSTEM FROM FIXED GRADE NODES = 4444.00
THE NET FLOW OUT OF THE SYSTEM INTO FIXED GRADE NODES = .00

A SUMMARY OF CONDITIONS SPECIFIED FOR THE NEXT SIMULATION FOLLOWS

THE RESULTS ARE OBTAINED AFTER 1 TRIALS WITH AN ACCURACY = .00000

LINE 1 IS CLOSED

PIPE NO.	NODE NOS.		FLOWRATE	HEAD LOSS	PUMP HEAD	MINOR LOSS	VELOCITY	HL/1000
2	0	12	4444.00	.26	.00	1.07	6.01	4.93
3	1	2	.00	.00	.00	.00	.00	.00
4	2	3	1.00	.00	.00	.00	.00	.00
5	3	4	1.00	.00	.00	.00	.00	.00
6	4	5	1.00	.00	.00	.00	.01	.00
7	2	6	-1.00	.00	.00	.00	.00	.00
8	6	7	1.00	.00	.00	.00	.00	.00
9	7	8	1.00	.00	.00	.00	.00	.00
10	6	9	-2.00	.00	.00	.00	.00	.00
11	9	10	1.00	.00	.00	.00	.00	.00
12	10	11	1.00	.00	.00	.00	.00	.00
13	9	13	-3.00	.00	.00	.00	-.01	.00
14	12	13	4444.00	.45	.00	1.37	9.96	17.97
15	13	14	4441.00	.57	.00	1.91	9.95	17.95
16	14	15	1150.00	.08	.00	.60	4.47	5.20
17	15	16	1150.00	.10	.00	.16	7.12	17.07
18	14	17	3291.00	.23	.00	.63	7.38	9.95
19	17	18	3291.00	.10	.00	.24	8.96	16.38

JUNCTION NUMBER	DEMAND	GRADE LINE	ELEVATION	PRESSURE
1	.00	779.35		
2	.00	779.35		
3	.00	779.35		
4	.00	779.35		
5	1.00	779.35	760.10	7.97
6	.00	779.35		
7	.00	779.35		
8	1.00	779.35	761.10	7.56
9	.00	779.35		
10	.00	779.35		
11	1.00	779.35	761.10	7.56
12	.00	781.17		
13	.00	779.35		
14	.00	776.87		
15	.00	776.19		
16	1150.00	775.93	760.10	6.56
17	.00	776.00		
18	3291.00	775.67	761.10	6.03

THE NET SYSTEM DEMAND = 4444.00

SUMMARY OF INFLOWS(+) AND OUTFLOWS(-) FROM FIXED GRADE NODES

PIPE NUMBER	FLOWRATE
2	4444.00

THE NET FLOW INTO THE SYSTEM FROM FIXED GRADE NODES = 4444.00
THE NET FLOW OUT OF THE SYSTEM INTO FIXED GRADE NODES = .00

FLOWRATE IS EXPRESSED IN GPM AND PRESSURE IN PSIG

A SUMMARY OF THE ORIGINAL DATA FOLLOWS

THE DARCY WEISBACH HEAD LOSS EQUATION IS USED, THE KINEMATIC VIS. = .0000030

THE SPECIFIC GRAVITY OF THIS LIQUID = .95

PIPE NO.	NODE NOS.		LENGTH (FEET)	DIAMETER (INCHES)	ROUGHNESS	MINOR LOSS K	FIXED GRADE
1	0	1	27.1	17.4	.2	1.91	782.50
LINE 1 IS CLOSED							
2	0	12	53.3	17.4	.2	1.91	782.50
3	1	2	24.0	13.5	.2	.89	
4	2	3	2.2	13.5	.2	.38	
5	3	4	7.1	10.3	.2	3.44	
6	4	5	6.0	8.1	.2	.20	
7	2	6	2.3	13.5	.2	.26	
8	6	7	19.0	13.5	.2	1.84	
9	7	8	6.5	12.3	.2	.19	
10	6	9	.4	13.5	.2	.63	
11	9	10	32.2	13.5	.2	1.73	
12	10	11	6.5	12.3	.2	.19	
13	9	13	.1	13.5	.2	.37	
14	12	13	24.8	13.5	.2	.89	
15	13	14	31.8	13.5	.2	1.24	
16	14	15	14.7	10.3	.2	1.94	
17	15	16	6.0	8.1	.2	.20	
18	14	17	23.5	13.5	.2	.75	
19	17	18	6.0	12.3	.2	.19	

JUNCTION NUMBER	DEMAND	ELEVATION	CONNECTING PIPES		
1	.00	.00	1	3	
2	.00	.00	3	4	7
3	.00	.00	4	5	
4	.00	.00	5	6	
5	1.00	760.10	6		
6	.00	.00	7	8	10
7	.00	.00	8	9	
8	1.00	761.10	9		
9	.00	.00	10	11	13
10	.00	.00	11	12	
11	1.00	761.10	12		
12	.00	.00	2	14	
13	.00	.00	13	14	15
14	.00	.00	15	16	18
15	.00	.00	16	17	
16	1150.00	760.10	17		
17	.00	.00	18	19	
18	3291.00	761.10	19		

OUTPUT SELECTION: ALL RESULTS ARE OUTPUT EACH PERIOD

THIS SYSTEM HAS 19 PIPES WITH 18 JUNCTIONS , 0 LOOPS AND 2 FGNS

THE RESULTS ARE OBTAINED AFTER 2 TRIALS WITH AN ACCURACY = .00000

RBS NPSH analysis for OSC-4467, Rev. 2. Model taken from OSC-1977, modified by removal of minor loss from 3BS-6, and addition of minor loss from sump inlet reducer. Sump temperature is 225F. No RB pressure.

PIPE NO.	NODE NOS.		FLOWRATE	HEAD LOSS	PUMP HEAD	MINOR LOSS	VELOCITY	HL/1000
LINE 1 IS CLOSED								
2	0	12	4444.00	.26	.00	1.07	6.01	4.93
3	1	2	.00	.00	.00	.00	.00	.00
4	2	3	1.00	.00	.00	.00	.00	.00
5	3	4	1.00	.00	.00	.00	.00	.00
6	4	5	1.00	.00	.00	.00	.01	.00
7	2	6	-1.00	.00	.00	.00	.00	.00
8	6	7	1.00	.00	.00	.00	.00	.00
9	7	8	1.00	.00	.00	.00	.00	.00
10	6	9	-2.00	.00	.00	.00	.00	.00
11	9	10	1.00	.00	.00	.00	.00	.00
12	10	11	1.00	.00	.00	.00	.00	.00
13	9	13	-3.00	.00	.00	.00	-.01	.00
14	12	13	4444.00	.45	.00	1.37	9.96	17.95
15	13	14	4441.00	.57	.00	1.91	9.95	17.93
16	14	15	1150.00	.08	.00	.60	4.47	5.20
17	15	16	1150.00	.10	.00	.16	7.12	17.05
18	14	17	3291.00	.23	.00	.63	7.38	9.94
19	17	18	3291.00	.10	.00	.24	8.96	16.37

JUNCTION NUMBER	DEMAND	GRADE LINE	ELEVATION	PRESSURE
1	.00	779.35		
2	.00	779.35		
3	.00	779.35		
4	.00	779.35		
5	1.00	779.35	760.10	7.96
6	.00	779.35		
7	.00	779.35		
8	1.00	779.35	761.10	7.54
9	.00	779.35		
10	.00	779.35		
11	1.00	779.35	761.10	7.54
12	.00	781.17		
13	.00	779.35		
14	.00	776.87		
15	.00	776.19		
16	1150.00	775.93	760.10	6.54
17	.00	776.00		
18	3291.00	775.67	761.10	6.02

THE NET SYSTEM DEMAND = 4444.00

SUMMARY OF INFLOWS(+) AND OUTFLOWS(-) FROM FIXED GRADE NODES

PIPE NUMBER	FLOWRATE
2	4444.00

THE NET FLOW INTO THE SYSTEM FROM FIXED GRADE NODES = 4444.00
THE NET FLOW OUT OF THE SYSTEM INTO FIXED GRADE NODES = .00

A SUMMARY OF CONDITIONS SPECIFIED FOR THE NEXT SIMULATION FOLLOWS

THE RESULTS ARE OBTAINED AFTER 1 TRIALS WITH AN ACCURACY = .00000

PIPE NO.	NODE NOS.		FLOWRATE	HEAD LOSS	PUMP HEAD	MINOR LOSS	VELOCITY	HL/1000
LINE 1 IS CLOSED								
2	0	12	4444.00	.26	.00	1.07	6.01	4.93
3	1	2	.00	.00	.00	.00	.00	.00
4	2	3	1.00	.00	.00	.00	.00	.00
5	3	4	1.00	.00	.00	.00	.00	.00
6	4	5	1.00	.00	.00	.00	.01	.00
7	2	6	-1.00	.00	.00	.00	.00	.00
8	6	7	1.00	.00	.00	.00	.00	.00
9	7	8	1.00	.00	.00	.00	.00	.00
10	6	9	-2.00	.00	.00	.00	.00	.00
11	9	10	1.00	.00	.00	.00	.00	.00
12	10	11	1.00	.00	.00	.00	.00	.00
13	9	13	-3.00	.00	.00	.00	-.01	.00
14	12	13	4444.00	.45	.00	1.37	9.96	17.95
15	13	14	4441.00	.57	.00	1.91	9.95	17.93
16	14	15	1150.00	.08	.00	.60	4.47	5.20
17	15	16	1150.00	.10	.00	.16	7.12	17.05
18	14	17	3291.00	.23	.00	.63	7.38	9.94
19	17	18	3291.00	.10	.00	.24	8.96	16.37

JUNCTION NUMBER	DEMAND	GRADE LINE	ELEVATION	PRESSURE
1	.00	779.35		
2	.00	779.35		
3	.00	779.35		
4	.00	779.35		
5	1.00	779.35	760.10	7.96
6	.00	779.35		
7	.00	779.35		
8	1.00	779.35	761.10	7.54
9	.00	779.35		
10	.00	779.35		
11	1.00	779.35	761.10	7.54
12	.00	781.17		
13	.00	779.35		
14	.00	776.87		
15	.00	776.19		
16	1150.00	775.93	760.10	6.54
17	.00	776.00		
18	3291.00	775.67	761.10	6.02

THE NET SYSTEM DEMAND = 4444.00

SUMMARY OF INFLOWS(+) AND OUTFLOWS(-) FROM FIXED GRADE NODES

PIPE NUMBER	FLOWRATE
2	4444.00

THE NET FLOW INTO THE SYSTEM FROM FIXED GRADE NODES = 4444.00
THE NET FLOW OUT OF THE SYSTEM INTO FIXED GRADE NODES = .00

FLOWRATE IS EXPRESSED IN GPM AND PRESSURE IN PSIG

A SUMMARY OF THE ORIGINAL DATA FOLLOWS

THE DARCY WEISBACH HEAD LOSS EQUATION IS USED, THE KINEMATIC VIS. = .0000029

THE SPECIFIC GRAVITY OF THIS LIQUID = .95

PIPE NO.	NODE NOS.		LENGTH (FEET)	DIAMETER (INCHES)	ROUGHNESS	MINOR LOSS K	FIXED GRADE
1	0	1	27.1	17.4	.2	1.91	782.50
LINE 1 IS CLOSED							
2	0	12	53.3	17.4	.2	1.91	782.50
3	1	2	24.0	13.5	.2	.89	
4	2	3	2.2	13.5	.2	.38	
5	3	4	7.1	10.3	.2	3.44	
6	4	5	6.0	8.1	.2	.20	
7	2	6	2.3	13.5	.2	.26	
8	6	7	19.0	13.5	.2	1.84	
9	7	8	6.5	12.3	.2	.19	
10	6	9	.4	13.5	.2	.63	
11	9	10	32.2	13.5	.2	1.73	
12	10	11	6.5	12.3	.2	.19	
13	9	13	.1	13.5	.2	.37	
14	12	13	24.8	13.5	.2	.89	
15	13	14	31.8	13.5	.2	1.24	
16	14	15	14.7	10.3	.2	1.94	
17	15	16	6.0	8.1	.2	.20	
18	14	17	23.5	13.5	.2	.75	
19	17	18	6.0	12.3	.2	.19	

JUNCTION NUMBER	DEMAND	ELEVATION	CONNECTING PIPES		
1	.00	.00	1	3	
2	.00	.00	3	4	7
3	.00	.00	4	5	
4	.00	.00	5	6	
5	1.00	760.10	6		
6	.00	.00	7	8	10
7	.00	.00	8	9	
8	1.00	761.10	9		
9	.00	.00	10	11	13
10	.00	.00	11	12	
11	1.00	761.10	12		
12	.00	.00	2	14	
13	.00	.00	13	14	15
14	.00	.00	15	16	18
15	.00	.00	16	17	
16	1150.00	760.10	17		
17	.00	.00	18	19	
18	3291.00	761.10	19		

OUTPUT SELECTION: ALL RESULTS ARE OUTPUT EACH PERIOD

THIS SYSTEM HAS 19 PIPES WITH 18 JUNCTIONS , 0 LOOPS AND 2 FGNS

THE RESULTS ARE OBTAINED AFTER 2 TRIALS WITH AN ACCURACY = .00000

RBS NPSH analysis for OSC-4467, Rev. 2. Model taken from OSC-1977, modified by removal of minor loss from 3BS-6, and addition of minor loss from sump inlet reducer. Sump temperature is 230F. No RB pressure.

PIPE NO.	NODE NOS.		FLOWRATE	HEAD LOSS	PUMP HEAD	MINOR LOSS	VELOCITY	HL/1000
LINE 1 IS CLOSED								
2	0	12	4444.00	.26	.00	1.07	6.01	4.92
3	1	2	.00	.00	.00	.00	.00	.00
4	2	3	1.00	.00	.00	.00	.00	.00
5	3	4	1.00	.00	.00	.00	.00	.00
6	4	5	1.00	.00	.00	.00	.01	.00
7	2	6	-1.00	.00	.00	.00	.00	.00
8	6	7	1.00	.00	.00	.00	.00	.00
9	7	8	1.00	.00	.00	.00	.00	.00
10	6	9	-2.00	.00	.00	.00	.00	.00
11	9	10	1.00	.00	.00	.00	.00	.00
12	10	11	1.00	.00	.00	.00	.00	.00
13	9	13	-3.00	.00	.00	.00	-.01	.00
14	12	13	4444.00	.44	.00	1.37	9.96	17.94
15	13	14	4441.00	.57	.00	1.91	9.95	17.91
16	14	15	1150.00	.08	.00	.60	4.47	5.19
17	15	16	1150.00	.10	.00	.16	7.12	17.03
18	14	17	3291.00	.23	.00	.63	7.38	9.93
19	17	18	3291.00	.10	.00	.24	8.96	16.35

JUNCTION NUMBER	DEMAND	GRADE LINE	ELEVATION	PRESSURE
1	.00	779.35		
2	.00	779.35		
3	.00	779.35		
4	.00	779.35		
5	1.00	779.35	760.10	7.94
6	.00	779.35		
7	.00	779.35		
8	1.00	779.35	761.10	7.53
9	.00	779.35		
10	.00	779.35		
11	1.00	779.35	761.10	7.53
12	.00	781.17		
13	.00	779.35		
14	.00	776.87		
15	.00	776.19		
16	1150.00	775.94	760.10	6.53
17	.00	776.01		
18	3291.00	775.67	761.10	6.01

THE NET SYSTEM DEMAND = 4444.00

SUMMARY OF INFLOWS(+) AND OUTFLOWS(-) FROM FIXED GRADE NODES

PIPE NUMBER	FLOWRATE
2	4444.00

THE NET FLOW INTO THE SYSTEM FROM FIXED GRADE NODES = 4444.00
THE NET FLOW OUT OF THE SYSTEM INTO FIXED GRADE NODES = .00

A SUMMARY OF CONDITIONS SPECIFIED FOR THE NEXT SIMULATION FOLLOWS

THE RESULTS ARE OBTAINED AFTER 1 TRIALS WITH AN ACCURACY = .00000

PIPE NO.	NODE NOS.		FLOWRATE	HEAD LOSS	PUMP HEAD	MINOR LOSS	VELOCITY	HL/1000
LINE 1 IS CLOSED								
2	0	12	4444.00	.26	.00	1.07	6.01	4.92
3	1	2	.00	.00	.00	.00	.00	.00
4	2	3	1.00	.00	.00	.00	.00	.00
5	3	4	1.00	.00	.00	.00	.00	.00
6	4	5	1.00	.00	.00	.00	.01	.00
7	2	6	-1.00	.00	.00	.00	.00	.00
8	6	7	1.00	.00	.00	.00	.00	.00
9	7	8	1.00	.00	.00	.00	.00	.00
10	6	9	-2.00	.00	.00	.00	.00	.00
11	9	10	1.00	.00	.00	.00	.00	.00
12	10	11	1.00	.00	.00	.00	.00	.00
13	9	13	-3.00	.00	.00	.00	-.01	.00
14	12	13	4444.00	.44	.00	1.37	9.96	17.94
15	13	14	4441.00	.57	.00	1.91	9.95	17.91
16	14	15	1150.00	.08	.00	.60	4.47	5.19
17	15	16	1150.00	.10	.00	.16	7.12	17.03
18	14	17	3291.00	.23	.00	.63	7.38	9.93
19	17	18	3291.00	.10	.00	.24	8.96	16.35

JUNCTION NUMBER	DEMAND	GRADE LINE	ELEVATION	PRESSURE
1	.00	779.35		
2	.00	779.35		
3	.00	779.35		
4	.00	779.35		
5	1.00	779.35	760.10	7.94
6	.00	779.35		
7	.00	779.35		
8	1.00	779.35	761.10	7.53
9	.00	779.35		
10	.00	779.35		
11	1.00	779.35	761.10	7.53
12	.00	781.17		
13	.00	779.35		
14	.00	776.87		
15	.00	776.19		
16	1150.00	775.94	760.10	6.53
17	.00	776.01		
18	3291.00	775.67	761.10	6.01

THE NET SYSTEM DEMAND = 4444.00

SUMMARY OF INFLOWS(+) AND OUTFLOWS(-) FROM FIXED GRADE NODES

PIPE NUMBER	FLOWRATE
2	4444.00

THE NET FLOW INTO THE SYSTEM FROM FIXED GRADE NODES = 4444.00
THE NET FLOW OUT OF THE SYSTEM INTO FIXED GRADE NODES = .00

FLOWRATE IS EXPRESSED IN GPM AND PRESSURE IN PSIG

A SUMMARY OF THE ORIGINAL DATA FOLLOWS

THE DARCY WEISBACH HEAD LOSS EQUATION IS USED, THE KINEMATIC VIS. = .0000029

THE SPECIFIC GRAVITY OF THIS LIQUID = .95

PIPE NO.	NODE NOS.		LENGTH (FEET)	DIAMETER (INCHES)	ROUGHNESS	MINOR LOSS K	FIXED GRADE
1	0	1	27.1	17.4	.2	1.91	782.50
LINE 1 IS CLOSED							
2	0	12	53.3	17.4	.2	1.91	782.50
3	1	2	24.0	13.5	.2	.89	
4	2	3	2.2	13.5	.2	.38	
5	3	4	7.1	10.3	.2	3.44	
6	4	5	6.0	8.1	.2	.20	
7	2	6	2.3	13.5	.2	.26	
8	6	7	19.0	13.5	.2	1.84	
9	7	8	6.5	12.3	.2	.19	
10	6	9	.4	13.5	.2	.63	
11	9	10	32.2	13.5	.2	1.73	
12	10	11	6.5	12.3	.2	.19	
13	9	13	.1	13.5	.2	.37	
14	12	13	24.8	13.5	.2	.89	
15	13	14	31.8	13.5	.2	1.24	
16	14	15	14.7	10.3	.2	1.94	
17	15	16	6.0	8.1	.2	.20	
18	14	17	23.5	13.5	.2	.75	
19	17	18	6.0	12.3	.2	.19	

JUNCTION NUMBER	DEMAND	ELEVATION	CONNECTING PIPES		
1	.00	.00	1	3	
2	.00	.00	3	4	7
3	.00	.00	4	5	
4	.00	.00	5	6	
5	1.00	760.10	6		
6	.00	.00	7	8	10
7	.00	.00	8	9	
8	1.00	761.10	9		
9	.00	.00	10	11	13
10	.00	.00	11	12	
11	1.00	761.10	12		
12	.00	.00	2	14	
13	.00	.00	13	14	15
14	.00	.00	15	16	18
15	.00	.00	16	17	
16	1150.00	760.10	17		
17	.00	.00	18	19	
18	3291.00	761.10	19		

OUTPUT SELECTION: ALL RESULTS ARE OUTPUT EACH PERIOD

THIS SYSTEM HAS 19 PIPES WITH 18 JUNCTIONS , 0 LOOPS AND 2 FGNS

THE RESULTS ARE OBTAINED AFTER 2 TRIALS WITH AN ACCURACY = .00000

RBS NPSH analysis for OSC-4467, Rev. 2. Model taken from OSC-1977, modifed by removal of minor loss from 3BS-6, and addition of minor loss from sump inlet reducer. Sump temperature is 235F. No RB pressure.

PIPE NO.	NODE NOS.		FLOWRATE	HEAD LOSS	PUMP HEAD	MINOR LOSS	VELOCITY	HL/1000
LINE	1 IS CLOSED							
2	0	12	4444.00	.26	.00	1.07	6.01	4.92
3	1	2	.00	.00	.00	.00	.00	.00
4	2	3	1.00	.00	.00	.00	.00	.00
5	3	4	1.00	.00	.00	.00	.00	.00
6	4	5	1.00	.00	.00	.00	.01	.00
7	2	6	-1.00	.00	.00	.00	.00	.00
8	6	7	1.00	.00	.00	.00	.00	.00
9	7	8	1.00	.00	.00	.00	.00	.00
10	6	9	-2.00	.00	.00	.00	.00	.00
11	9	10	1.00	.00	.00	.00	.00	.00
12	10	11	1.00	.00	.00	.00	.00	.00
13	9	13	-3.00	.00	.00	.00	-.01	.00
14	12	13	4444.00	.44	.00	1.37	9.96	17.94
15	13	14	4441.00	.57	.00	1.91	9.95	17.91
16	14	15	1150.00	.08	.00	.60	4.47	5.19
17	15	16	1150.00	.10	.00	.16	7.12	17.03
18	14	17	3291.00	.23	.00	.63	7.38	9.93
19	17	18	3291.00	.10	.00	.24	8.96	16.35

JUNCTION NUMBER	DEMAND	GRADE LINE	ELEVATION	PRESSURE
1	.00	779.35		
2	.00	779.35		
3	.00	779.35		
4	.00	779.35		
5	1.00	779.35	760.10	7.92
6	.00	779.35		
7	.00	779.35		
8	1.00	779.35	761.10	7.51
9	.00	779.35		
10	.00	779.35		
11	1.00	779.35	761.10	7.51
12	.00	781.17		
13	.00	779.35		
14	.00	776.87		
15	.00	776.19		
16	1150.00	775.94	760.10	6.51
17	.00	776.01		
18	3291.00	775.67	761.10	5.99

THE NET SYSTEM DEMAND = 4444.00

SUMMARY OF INFLOWS(+) AND OUTFLOWS(-) FROM FIXED GRADE NODES

PIPE NUMBER	FLOWRATE
2	4444.00

THE NET FLOW INTO THE SYSTEM FROM FIXED GRADE NODES = 4444.00
THE NET FLOW OUT OF THE SYSTEM INTO FIXED GRADE NODES = .00

A SUMMARY OF CONDITIONS SPECIFIED FOR THE NEXT SIMULATION FOLLOWS

THE RESULTS ARE OBTAINED AFTER 1 TRIALS WITH AN ACCURACY = .00000

LINE 1 IS CLOSED

PIPE NO.	NODE NOS.		FLOWRATE	HEAD LOSS	PUMP HEAD	MINOR LOSS	VELOCITY	HL/1000
2	0	12	4444.00	.26	.00	1.07	6.01	4.92
3	1	2	.00	.00	.00	.00	.00	.00
4	2	3	1.00	.00	.00	.00	.00	.00
5	3	4	1.00	.00	.00	.00	.00	.00
6	4	5	1.00	.00	.00	.00	.01	.00
7	2	6	-1.00	.00	.00	.00	.00	.00
8	6	7	1.00	.00	.00	.00	.00	.00
9	7	8	1.00	.00	.00	.00	.00	.00
10	6	9	-2.00	.00	.00	.00	.00	.00
11	9	10	1.00	.00	.00	.00	.00	.00
12	10	11	1.00	.00	.00	.00	.00	.00
13	9	13	-3.00	.00	.00	.00	-.01	.00
14	12	13	4444.00	.44	.00	1.37	9.96	17.94
15	13	14	4441.00	.57	.00	1.91	9.95	17.91
16	14	15	1150.00	.08	.00	.60	4.47	5.19
17	15	16	1150.00	.10	.00	.16	7.12	17.03
18	14	17	3291.00	.23	.00	.63	7.38	9.93
19	17	18	3291.00	.10	.00	.24	8.96	16.35

JUNCTION NUMBER	DEMAND	GRADE LINE	ELEVATION	PRESSURE
1	.00	779.35		
2	.00	779.35		
3	.00	779.35		
4	.00	779.35		
5	1.00	779.35	760.10	7.92
6	.00	779.35		
7	.00	779.35		
8	1.00	779.35	761.10	7.51
9	.00	779.35		
10	.00	779.35		
11	1.00	779.35	761.10	7.51
12	.00	781.17		
13	.00	779.35		
14	.00	776.87		
15	.00	776.19		
16	1150.00	775.94	760.10	6.51
17	.00	776.01		
18	3291.00	775.67	761.10	5.99

THE NET SYSTEM DEMAND = 4444.00

SUMMARY OF INFLOWS(+) AND OUTFLOWS(-) FROM FIXED GRADE NODES

PIPE NUMBER	FLOWRATE
2	4444.00

THE NET FLOW INTO THE SYSTEM FROM FIXED GRADE NODES = 4444.00
THE NET FLOW OUT OF THE SYSTEM INTO FIXED GRADE NODES = .00

FLOWRATE IS EXPRESSED IN GPM AND PRESSURE IN PSIG

A SUMMARY OF THE ORIGINAL DATA FOLLOWS

THE DARCY WEISBACH HEAD LOSS EQUATION IS USED, THE KINEMATIC VIS. = .0000028

THE SPECIFIC GRAVITY OF THIS LIQUID = .95

PIPE NO.	NODE NOS.		LENGTH (FEET)	DIAMETER (INCHES)	ROUGHNESS	MINOR LOSS K	FIXED GRADE
1	0	1	27.1	17.4	.2	1.91	782.50
LINE 1 IS CLOSED							
2	0	12	53.3	17.4	.2	1.91	782.50
3	1	2	24.0	13.5	.2	.89	
4	2	3	2.2	13.5	.2	.38	
5	3	4	7.1	10.3	.2	3.44	
6	4	5	6.0	8.1	.2	.20	
7	2	6	2.3	13.5	.2	.26	
8	6	7	19.0	13.5	.2	1.84	
9	7	8	6.5	12.3	.2	.19	
10	6	9	.4	13.5	.2	.63	
11	9	10	32.2	13.5	.2	1.73	
12	10	11	6.5	12.3	.2	.19	
13	9	13	.1	13.5	.2	.37	
14	12	13	24.8	13.5	.2	.89	
15	13	14	31.8	13.5	.2	1.24	
16	14	15	14.7	10.3	.2	1.94	
17	15	16	6.0	8.1	.2	.20	
18	14	17	23.5	13.5	.2	.75	
19	17	18	6.0	12.3	.2	.19	

JUNCTION NUMBER	DEMAND	ELEVATION	CONNECTING PIPES		
1	.00	.00	1	3	
2	.00	.00	3	4	7
3	.00	.00	4	5	
4	.00	.00	5	6	
5	1.00	760.10	6		
6	.00	.00	7	8	10
7	.00	.00	8	9	
8	1.00	761.10	9		
9	.00	.00	10	11	13
10	.00	.00	11	12	
11	1.00	761.10	12		
12	.00	.00	2	14	
13	.00	.00	13	14	15
14	.00	.00	15	16	18
15	.00	.00	16	17	
16	1150.00	760.10	17		
17	.00	.00	18	19	
18	3291.00	761.10	19		

OUTPUT SELECTION: ALL RESULTS ARE OUTPUT EACH PERIOD

THIS SYSTEM HAS 19 PIPES WITH 18 JUNCTIONS , 0 LOOPS AND 2 FGNS

THE RESULTS ARE OBTAINED AFTER 2 TRIALS WITH AN ACCURACY = .00000

RBS NPSH analysis for OSC-4467, Rev. 2. Model taken from OSC-1977, modified by removal of minor loss from 3BS-6, and addition of minor loss from sump inlet reducer. Sump temperature is 240F. No RB pressure.

PIPE NO.	NODE NOS.		FLOWRATE	HEAD LOSS	PUMP HEAD	MINOR LOSS	VELOCITY	HL/1000
LINE 1 IS CLOSED								
2	0	12	4444.00	.26	.00	1.07	6.01	4.91
3	1	2	.00	.00	.00	.00	.00	.00
4	2	3	1.00	.00	.00	.00	.00	.00
5	3	4	1.00	.00	.00	.00	.00	.00
6	4	5	1.00	.00	.00	.00	.01	.00
7	2	6	-1.00	.00	.00	.00	.00	.00
8	6	7	1.00	.00	.00	.00	.00	.00
9	7	8	1.00	.00	.00	.00	.00	.00
10	6	9	-2.00	.00	.00	.00	.00	.00
11	9	10	1.00	.00	.00	.00	.00	.00
12	10	11	1.00	.00	.00	.00	.00	.00
13	9	13	-3.00	.00	.00	.00	-.01	.00
14	12	13	4444.00	.44	.00	1.37	9.96	17.92
15	13	14	4441.00	.57	.00	1.91	9.95	17.89
16	14	15	1150.00	.08	.00	.60	4.47	5.18
17	15	16	1150.00	.10	.00	.16	7.12	17.01
18	14	17	3291.00	.23	.00	.63	7.38	9.92
19	17	18	3291.00	.10	.00	.24	8.96	16.33

JUNCTION NUMBER	DEMAND	GRADE LINE	ELEVATION	PRESSURE
1	.00	779.35		
2	.00	779.35		
3	.00	779.35		
4	.00	779.35		
5	1.00	779.35	760.10	7.90
6	.00	779.35		
7	.00	779.35		
8	1.00	779.35	761.10	7.49
9	.00	779.35		
10	.00	779.35		
11	1.00	779.35	761.10	7.49
12	.00	781.17		
13	.00	779.35		
14	.00	776.87		
15	.00	776.20		
16	1150.00	775.94	760.10	6.50
17	.00	776.01		
18	3291.00	775.67	761.10	5.98

THE NET SYSTEM DEMAND = 4444.00

SUMMARY OF INFLOWS(+) AND OUTFLOWS(-) FROM FIXED GRADE NODES

PIPE NUMBER	FLOWRATE
2	4444.00

THE NET FLOW INTO THE SYSTEM FROM FIXED GRADE NODES = 4444.00
THE NET FLOW OUT OF THE SYSTEM INTO FIXED GRADE NODES = .00

A SUMMARY OF CONDITIONS SPECIFIED FOR THE NEXT SIMULATION FOLLOWS

THE RESULTS ARE OBTAINED AFTER 1 TRIALS WITH AN ACCURACY = .00000

PIPE NO.	NODE NOS.		FLOWRATE	HEAD LOSS	PUMP HEAD	MINOR LOSS	VELOCITY	HL/1000
LINE 1 IS CLOSED								
2	0	12	4444.00	.26	.00	1.07	6.01	4.91
3	1	2	.00	.00	.00	.00	.00	.00
4	2	3	1.00	.00	.00	.00	.00	.00
5	3	4	1.00	.00	.00	.00	.00	.00
6	4	5	1.00	.00	.00	.00	.01	.00
7	2	6	-1.00	.00	.00	.00	.00	.00
8	6	7	1.00	.00	.00	.00	.00	.00
9	7	8	1.00	.00	.00	.00	.00	.00
10	6	9	-2.00	.00	.00	.00	.00	.00
11	9	10	1.00	.00	.00	.00	.00	.00
12	10	11	1.00	.00	.00	.00	.00	.00
13	9	13	-3.00	.00	.00	.00	-.01	.00
14	12	13	4444.00	.44	.00	1.37	9.96	17.92
15	13	14	4441.00	.57	.00	1.91	9.95	17.89
16	14	15	1150.00	.08	.00	.60	4.47	5.18
17	15	16	1150.00	.10	.00	.16	7.12	17.01
18	14	17	3291.00	.23	.00	.63	7.38	9.92
19	17	18	3291.00	.10	.00	.24	8.96	16.33

JUNCTION NUMBER	DEMAND	GRADE LINE	ELEVATION	PRESSURE
1	.00	779.35		
2	.00	779.35		
3	.00	779.35		
4	.00	779.35		
5	1.00	779.35	760.10	7.90
6	.00	779.35		
7	.00	779.35		
8	1.00	779.35	761.10	7.49
9	.00	779.35		
10	.00	779.35		
11	1.00	779.35	761.10	7.49
12	.00	781.17		
13	.00	779.35		
14	.00	776.87		
15	.00	776.20		
16	1150.00	775.94	760.10	6.50
17	.00	776.01		
18	3291.00	775.67	761.10	5.98

THE NET SYSTEM DEMAND = 4444.00

SUMMARY OF INFLOWS(+) AND OUTFLOWS(-) FROM FIXED GRADE NODES

PIPE NUMBER	FLOWRATE
2	4444.00

THE NET FLOW INTO THE SYSTEM FROM FIXED GRADE NODES = 4444.00
THE NET FLOW OUT OF THE SYSTEM INTO FIXED GRADE NODES = .00

FLOWRATE IS EXPRESSED IN GPM AND PRESSURE IN PSIG

A SUMMARY OF THE ORIGINAL DATA FOLLOWS

THE DARCY WEISBACH HEAD LOSS EQUATION IS USED, THE KINEMATIC VIS. = .0000035

THE SPECIFIC GRAVITY OF THIS LIQUID = .97

PIPE NO.	NODE NOS.		LENGTH (FEET)	DIAMETER (INCHES)	ROUGHNESS	MINOR LOSS K	FIXED GRADE
1	0	1	27.1	17.4	.2	1.91	782.50
LINE 1 IS CLOSED							
2	0	12	53.3	17.4	.2	1.91	782.50
3	1	2	24.0	13.5	.2	.89	
4	2	3	2.2	13.5	.2	.38	
5	3	4	7.1	10.3	.2	3.44	
6	4	5	6.0	8.1	.2	.20	
7	2	6	2.3	13.5	.2	.26	
8	6	7	19.0	13.5	.2	1.84	
9	7	8	6.5	12.3	.2	.19	
10	6	9	.4	13.5	.2	.63	
11	9	10	32.2	13.5	.2	1.73	
12	10	11	6.5	12.3	.2	.19	
13	9	13	.1	13.5	.2	.37	
14	12	13	24.8	13.5	.2	.89	
15	13	14	31.8	13.5	.2	1.24	
16	14	15	14.7	10.3	.2	1.94	
17	15	16	6.0	8.1	.2	.20	
18	14	17	23.5	13.5	.2	.75	
19	17	18	6.0	12.3	.2	.19	

JUNCTION NUMBER	DEMAND	ELEVATION	CONNECTING PIPES		
1	.00	.00	1	3	
2	.00	.00	3	4	7
3	.00	.00	4	5	
4	.00	.00	5	6	
5	1.00	760.10	6		
6	.00	.00	7	8	10
7	.00	.00	8	9	
8	1.00	761.10	9		
9	.00	.00	10	11	13
10	.00	.00	11	12	
11	1.00	761.10	12		
12	.00	.00	2	14	
13	.00	.00	13	14	15
14	.00	.00	15	16	18
15	.00	.00	16	17	
16	873.00	760.10	17		
17	.00	.00	18	19	
18	2883.00	761.10	19		

OUTPUT SELECTION: ALL RESULTS ARE OUTPUT EACH PERIOD

THIS SYSTEM HAS 19 PIPES WITH 18 JUNCTIONS , 0 LOOPS AND 2 FGNS

THE RESULTS ARE OBTAINED AFTER 2 TRIALS WITH AN ACCURACY = .00000

RBS NPSH analysis for OSC-4467, Rev. 2. Model taken from OSC-1977, modified by removal of minor loss from 3BS-6, and addition of minor loss from sump inlet reducer. Sump temperature is 195F. No RB pressure.

PIPE NO.	NODE NOS.		FLOWRATE	HEAD LOSS	PUMP HEAD	MINOR LOSS	VELOCITY	HL/1000
LINE 1 IS CLOSED								
2	0	12	3759.00	.19	.00	.77	5.09	3.58
3	1	2	.00	.00	.00	.00	.00	.00
4	2	3	1.00	.00	.00	.00	.00	.00
5	3	4	1.00	.00	.00	.00	.00	.00
6	4	5	1.00	.00	.00	.00	.01	.00
7	2	6	-1.00	.00	.00	.00	.00	.00
8	6	7	1.00	.00	.00	.00	.00	.00
9	7	8	1.00	.00	.00	.00	.00	.00
10	6	9	-2.00	.00	.00	.00	.00	.00
11	9	10	1.00	.00	.00	.00	.00	.00
12	10	11	1.00	.00	.00	.00	.00	.00
13	9	13	-3.00	.00	.00	.00	-.01	.00
14	12	13	3759.00	.32	.00	.98	8.42	12.98
15	13	14	3756.00	.41	.00	1.36	8.42	12.96
16	14	15	873.00	.05	.00	.35	3.39	3.07
17	15	16	873.00	.06	.00	.09	5.40	10.01
18	14	17	2883.00	.18	.00	.49	6.46	7.72
19	17	18	2883.00	.08	.00	.18	7.85	12.69

JUNCTION NUMBER	DEMAND	GRADE LINE	ELEVATION	PRESSURE
1	.00	780.24		
2	.00	780.24		
3	.00	780.24		
4	.00	780.24		
5	1.00	780.24	760.10	8.43
6	.00	780.24		
7	.00	780.24		
8	1.00	780.24	761.10	8.01
9	.00	780.24		
10	.00	780.24		
11	1.00	780.24	761.10	8.01
12	.00	781.54		
13	.00	780.24		
14	.00	778.46		
15	.00	778.07		
16	873.00	777.92	760.10	7.46
17	.00	777.80		
18	2883.00	777.54	761.10	6.88

THE NET SYSTEM DEMAND = 3759.00

SUMMARY OF INFLOWS(+) AND OUTFLOWS(-) FROM FIXED GRADE NODES

PIPE NUMBER	FLOWRATE
2	3759.00

THE NET FLOW INTO THE SYSTEM FROM FIXED GRADE NODES = 3759.00
THE NET FLOW OUT OF THE SYSTEM INTO FIXED GRADE NODES = .00

A SUMMARY OF CONDITIONS SPECIFIED FOR THE NEXT SIMULATION FOLLOWS

THE RESULTS ARE OBTAINED AFTER 1 TRIALS WITH AN ACCURACY = .00000

PIPE NO.	NODE NOS.		FLOWRATE	HEAD LOSS	PUMP HEAD	MINOR LOSS	VELOCITY	HL/1000
LINE 1 IS CLOSED								
2	0	12	3759.00	.19	.00	.77	5.09	3.58
3	1	2	.00	.00	.00	.00	.00	.00
4	2	3	1.00	.00	.00	.00	.00	.00
5	3	4	1.00	.00	.00	.00	.00	.00
6	4	5	1.00	.00	.00	.00	.01	.00
7	2	6	-1.00	.00	.00	.00	.00	.00
8	6	7	1.00	.00	.00	.00	.00	.00
9	7	8	1.00	.00	.00	.00	.00	.00
10	6	9	-2.00	.00	.00	.00	.00	.00
11	9	10	1.00	.00	.00	.00	.00	.00
12	10	11	1.00	.00	.00	.00	.00	.00
13	9	13	-3.00	.00	.00	.00	-.01	.00
14	12	13	3759.00	.32	.00	.98	8.42	12.98
15	13	14	3756.00	.41	.00	1.36	8.42	12.96
16	14	15	873.00	.05	.00	.35	3.39	3.07
17	15	16	873.00	.06	.00	.09	5.40	10.01
18	14	17	2883.00	.18	.00	.49	6.46	7.72
19	17	18	2883.00	.08	.00	.18	7.85	12.69

JUNCTION NUMBER	DEMAND	GRADE LINE	ELEVATION	PRESSURE
1	.00	780.24		
2	.00	780.24		
3	.00	780.24		
4	.00	780.24		
5	1.00	780.24	760.10	8.43
6	.00	780.24		
7	.00	780.24		
8	1.00	780.24	761.10	8.01
9	.00	780.24		
10	.00	780.24		
11	1.00	780.24	761.10	8.01
12	.00	781.54		
13	.00	780.24		
14	.00	778.46		
15	.00	778.07		
16	873.00	777.92	760.10	7.46
17	.00	777.80		
18	2883.00	777.54	761.10	6.88

THE NET SYSTEM DEMAND = 3759.00

SUMMARY OF INFLOWS(+) AND OUTFLOWS(-) FROM FIXED GRADE NODES

PIPE NUMBER	FLOWRATE
2	3759.00

THE NET FLOW INTO THE SYSTEM FROM FIXED GRADE NODES = 3759.00
THE NET FLOW OUT OF THE SYSTEM INTO FIXED GRADE NODES = .00

FLOWRATE IS EXPRESSED IN GPM AND PRESSURE IN PSIG

A SUMMARY OF THE ORIGINAL DATA FOLLOWS

THE DARCY WEISBACH HEAD LOSS EQUATION IS USED, THE KINEMATIC VIS. = .0000034

THE SPECIFIC GRAVITY OF THIS LIQUID = .96

PIPE NO.	NODE NOS.		LENGTH (FEET)	DIAMETER (INCHES)	ROUGHNESS	MINOR LOSS K	FIXED GRADE
1	0	1	27.1	17.4	.2	1.91	782.50
LINE 1 IS CLOSED							
2	0	12	53.3	17.4	.2	1.91	782.50
3	1	2	24.0	13.5	.2	.89	
4	2	3	2.2	13.5	.2	.38	
5	3	4	7.1	10.3	.2	3.44	
6	4	5	6.0	8.1	.2	.20	
7	2	6	2.3	13.5	.2	.26	
8	6	7	19.0	13.5	.2	1.84	
9	7	8	6.5	12.3	.2	.19	
10	6	9	.4	13.5	.2	.63	
11	9	10	32.2	13.5	.2	1.73	
12	10	11	6.5	12.3	.2	.19	
13	9	13	.1	13.5	.2	.37	
14	12	13	24.8	13.5	.2	.89	
15	13	14	31.8	13.5	.2	1.24	
16	14	15	14.7	10.3	.2	1.94	
17	15	16	6.0	8.1	.2	.20	
18	14	17	23.5	13.5	.2	.75	
19	17	18	6.0	12.3	.2	.19	

JUNCTION NUMBER	DEMAND	ELEVATION	CONNECTING PIPES		
1	.00	.00	1	3	
2	.00	.00	3	4	7
3	.00	.00	4	5	
4	.00	.00	5	6	
5	1.00	760.10	6		
6	.00	.00	7	8	10
7	.00	.00	8	9	
8	1.00	761.10	9		
9	.00	.00	10	11	13
10	.00	.00	11	12	
11	1.00	761.10	12		
12	.00	.00	2	14	
13	.00	.00	13	14	15
14	.00	.00	15	16	18
15	.00	.00	16	17	
16	873.00	760.10	17		
17	.00	.00	18	19	
18	2883.00	761.10	19		

OUTPUT SELECTION: ALL RESULTS ARE OUTPUT EACH PERIOD

THIS SYSTEM HAS 19 PIPES WITH 18 JUNCTIONS , 0 LOOPS AND 2 FGNS

THE RESULTS ARE OBTAINED AFTER 2 TRIALS WITH AN ACCURACY = .00000

RBS NPSH analysis for OSC-4467, Rev. 2. Model taken from OSC-1977, modified by removal of minor loss from 3BS-6, and addition of minor loss from sump inlet reducer. Sump temperature is 200F. No RB pressure.

PIPE NO.	NODE NOS.		FLOWRATE	HEAD LOSS	PUMP HEAD	MINOR LOSS	VELOCITY	HL/1000
LINE	1 IS CLOSED							
2	0	12	3759.00	.19	.00	.77	5.09	3.57
3	1	2	.00	.00	.00	.00	.00	.00
4	2	3	1.00	.00	.00	.00	.00	.00
5	3	4	1.00	.00	.00	.00	.00	.00
6	4	5	1.00	.00	.00	.00	.01	.00
7	2	6	-1.00	.00	.00	.00	.00	.00
8	6	7	1.00	.00	.00	.00	.00	.00
9	7	8	1.00	.00	.00	.00	.00	.00
10	6	9	-2.00	.00	.00	.00	.00	.00
11	9	10	1.00	.00	.00	.00	.00	.00
12	10	11	1.00	.00	.00	.00	.00	.00
13	9	13	-3.00	.00	.00	.00	-.01	.00
14	12	13	3759.00	.32	.00	.98	8.42	12.97
15	13	14	3756.00	.41	.00	1.36	8.42	12.95
16	14	15	873.00	.05	.00	.35	3.39	3.07
17	15	16	873.00	.06	.00	.09	5.40	10.00
18	14	17	2883.00	.18	.00	.49	6.46	7.71
19	17	18	2883.00	.08	.00	.18	7.85	12.67

JUNCTION NUMBER	DEMAND	GRADE LINE	ELEVATION	PRESSURE
1	.00	780.24		
2	.00	780.24		
3	.00	780.24		
4	.00	780.24		
5	1.00	780.24	760.10	8.41
6	.00	780.24		
7	.00	780.24		
8	1.00	780.24	761.10	7.99
9	.00	780.24		
10	.00	780.24		
11	1.00	780.24	761.10	7.99
12	.00	781.54		
13	.00	780.24		
14	.00	778.46		
15	.00	778.07		
16	873.00	777.92	760.10	7.44
17	.00	777.80		
18	2883.00	777.54	761.10	6.87

THE NET SYSTEM DEMAND = 3759.00

SUMMARY OF INFLOWS(+) AND OUTFLOWS(-) FROM FIXED GRADE NODES

PIPE NUMBER	FLOWRATE
2	3759.00

THE NET FLOW INTO THE SYSTEM FROM FIXED GRADE NODES = 3759.00
THE NET FLOW OUT OF THE SYSTEM INTO FIXED GRADE NODES = .00

A SUMMARY OF CONDITIONS SPECIFIED FOR THE NEXT SIMULATION FOLLOWS

THE RESULTS ARE OBTAINED AFTER 1 TRIALS WITH AN ACCURACY = .00000

PIPE NO.	NODE NOS.		FLOWRATE	HEAD LOSS	PUMP HEAD	MINOR LOSS	VELOCITY	HL/1000
LINE	1 IS CLOSED							
2	0	12	3759.00	.19	.00	.77	5.09	3.57
3	1	2	.00	.00	.00	.00	.00	.00
4	2	3	1.00	.00	.00	.00	.00	.00
5	3	4	1.00	.00	.00	.00	.00	.00
6	4	5	1.00	.00	.00	.00	.01	.00
7	2	6	-1.00	.00	.00	.00	.00	.00
8	6	7	1.00	.00	.00	.00	.00	.00
9	7	8	1.00	.00	.00	.00	.00	.00
10	6	9	-2.00	.00	.00	.00	.00	.00
11	9	10	1.00	.00	.00	.00	.00	.00
12	10	11	1.00	.00	.00	.00	.00	.00
13	9	13	-3.00	.00	.00	.00	-.01	.00
14	12	13	3759.00	.32	.00	.98	8.42	12.97
15	13	14	3756.00	.41	.00	1.36	8.42	12.95
16	14	15	873.00	.05	.00	.35	3.39	3.07
17	15	16	873.00	.06	.00	.09	5.40	10.00
18	14	17	2883.00	.18	.00	.49	6.46	7.71
19	17	18	2883.00	.08	.00	.18	7.85	12.67

JUNCTION NUMBER	DEMAND	GRADE LINE	ELEVATION	PRESSURE
1	.00	780.24		
2	.00	780.24		
3	.00	780.24		
4	.00	780.24		
5	1.00	780.24	760.10	8.41
6	.00	780.24		
7	.00	780.24		
8	1.00	780.24	761.10	7.99
9	.00	780.24		
10	.00	780.24		
11	1.00	780.24	761.10	7.99
12	.00	781.54		
13	.00	780.24		
14	.00	778.46		
15	.00	778.07		
16	873.00	777.92	760.10	7.44
17	.00	777.80		
18	2883.00	777.54	761.10	6.87

THE NET SYSTEM DEMAND = 3759.00

SUMMARY OF INFLOWS(+) AND OUTFLOWS(-) FROM FIXED GRADE NODES

PIPE NUMBER	FLOWRATE
2	3759.00

THE NET FLOW INTO THE SYSTEM FROM FIXED GRADE NODES = 3759.00
THE NET FLOW OUT OF THE SYSTEM INTO FIXED GRADE NODES = .00

FLOWRATE IS EXPRESSED IN GPM AND PRESSURE IN PSIG

A SUMMARY OF THE ORIGINAL DATA FOLLOWS

THE DARCY WEISBACH HEAD LOSS EQUATION IS USED, THE KINEMATIC VIS. = .0000033

THE SPECIFIC GRAVITY OF THIS LIQUID = .96

PIPE NO.	NODE NOS.		LENGTH (FEET)	DIAMETER (INCHES)	ROUGHNESS	MINOR LOSS K	FIXED GRADE
1	0	1	27.1	17.4	.2	1.91	782.50
LINE 1 IS CLOSED							
2	0	12	53.3	17.4	.2	1.91	782.50
3	1	2	24.0	13.5	.2	.89	
4	2	3	2.2	13.5	.2	.38	
5	3	4	7.1	10.3	.2	3.44	
6	4	5	6.0	8.1	.2	.20	
7	2	6	2.3	13.5	.2	.26	
8	6	7	19.0	13.5	.2	1.84	
9	7	8	6.5	12.3	.2	.19	
10	6	9	.4	13.5	.2	.63	
11	9	10	32.2	13.5	.2	1.73	
12	10	11	6.5	12.3	.2	.19	
13	9	13	.1	13.5	.2	.37	
14	12	13	24.8	13.5	.2	.89	
15	13	14	31.8	13.5	.2	1.24	
16	14	15	14.7	10.3	.2	1.94	
17	15	16	6.0	8.1	.2	.20	
18	14	17	23.5	13.5	.2	.75	
19	17	18	6.0	12.3	.2	.19	

JUNCTION NUMBER	DEMAND	ELEVATION	CONNECTING PIPES		
1	.00	.00	1	3	
2	.00	.00	3	4	7
3	.00	.00	4	5	
4	.00	.00	5	6	
5	1.00	760.10	6		
6	.00	.00	7	8	10
7	.00	.00	8	9	
8	1.00	761.10	9		
9	.00	.00	10	11	13
10	.00	.00	11	12	
11	1.00	761.10	12		
12	.00	.00	2	14	
13	.00	.00	13	14	15
14	.00	.00	15	16	18
15	.00	.00	16	17	
16	873.00	760.10	17		
17	.00	.00	18	19	
18	2883.00	761.10	19		

OUTPUT SELECTION: ALL RESULTS ARE OUTPUT EACH PERIOD

THIS SYSTEM HAS 19 PIPES WITH 18 JUNCTIONS , 0 LOOPS AND 2 FGNS

THE RESULTS ARE OBTAINED AFTER 2 TRIALS WITH AN ACCURACY = .00000

RBS NPSH analysis for OSC-4467, Rev. 2. Model taken from OSC-1977, modified by removal of minor loss from 3BS-6, and addition of minor loss from sump inlet reducer. Sump temperature is 205F. No RB pressure.

PIPE NO.	NODE NOS.		FLOWRATE	HEAD LOSS	PUMP HEAD	MINOR LOSS	VELOCITY	HL/1000
LINE	1 IS CLOSED							
2	0	12	3759.00	.19	.00	.77	5.09	3.57
3	1	2	.00	.00	.00	.00	.00	.00
4	2	3	1.00	.00	.00	.00	.00	.00
5	3	4	1.00	.00	.00	.00	.00	.00
6	4	5	1.00	.00	.00	.00	.01	.00
7	2	6	-1.00	.00	.00	.00	.00	.00
8	6	7	1.00	.00	.00	.00	.00	.00
9	7	8	1.00	.00	.00	.00	.00	.00
10	6	9	-2.00	.00	.00	.00	.00	.00
11	9	10	1.00	.00	.00	.00	.00	.00
12	10	11	1.00	.00	.00	.00	.00	.00
13	9	13	-3.00	.00	.00	.00	-.01	.00
14	12	13	3759.00	.32	.00	.98	8.42	12.95
15	13	14	3756.00	.41	.00	1.36	8.42	12.93
16	14	15	873.00	.04	.00	.35	3.39	3.06
17	15	16	873.00	.06	.00	.09	5.40	9.98
18	14	17	2883.00	.18	.00	.49	6.46	7.70
19	17	18	2883.00	.08	.00	.18	7.85	12.66

JUNCTION NUMBER	DEMAND	GRADE LINE	ELEVATION	PRESSURE
1	.00	780.24		
2	.00	780.24		
3	.00	780.24		
4	.00	780.24		
5	1.00	780.24	760.10	8.39
6	.00	780.24		
7	.00	780.24		
8	1.00	780.24	761.10	7.98
9	.00	780.24		
10	.00	780.24		
11	1.00	780.24	761.10	7.98
12	.00	781.54		
13	.00	780.24		
14	.00	778.47		
15	.00	778.07		
16	873.00	777.92	760.10	7.43
17	.00	777.80		
18	2883.00	777.54	761.10	6.85

THE NET SYSTEM DEMAND = 3759.00

SUMMARY OF INFLOWS(+) AND OUTFLOWS(-) FROM FIXED GRADE NODES

PIPE NUMBER	FLOWRATE
2	3759.00

THE NET FLOW INTO THE SYSTEM FROM FIXED GRADE NODES = 3759.00
THE NET FLOW OUT OF THE SYSTEM INTO FIXED GRADE NODES = .00

A SUMMARY OF CONDITIONS SPECIFIED FOR THE NEXT SIMULATION FOLLOWS

THE RESULTS ARE OBTAINED AFTER 1 TRIALS WITH AN ACCURACY = .00000

PIPE NO.	NODE NOS.		FLOWRATE	HEAD LOSS	PUMP HEAD	MINOR LOSS	VELOCITY	HL/1000
LINE 1 IS CLOSED								
2	0	12	3759.00	.19	.00	.77	5.09	3.57
3	1	2	.00	.00	.00	.00	.00	.00
4	2	3	1.00	.00	.00	.00	.00	.00
5	3	4	1.00	.00	.00	.00	.00	.00
6	4	5	1.00	.00	.00	.00	.01	.00
7	2	6	-1.00	.00	.00	.00	.00	.00
8	6	7	1.00	.00	.00	.00	.00	.00
9	7	8	1.00	.00	.00	.00	.00	.00
10	6	9	-2.00	.00	.00	.00	.00	.00
11	9	10	1.00	.00	.00	.00	.00	.00
12	10	11	1.00	.00	.00	.00	.00	.00
13	9	13	-3.00	.00	.00	.00	-.01	.00
14	12	13	3759.00	.32	.00	.98	8.42	12.95
15	13	14	3756.00	.41	.00	1.36	8.42	12.93
16	14	15	873.00	.04	.00	.35	3.39	3.06
17	15	16	873.00	.06	.00	.09	5.40	9.98
18	14	17	2883.00	.18	.00	.49	6.46	7.70
19	17	18	2883.00	.08	.00	.18	7.85	12.66

JUNCTION NUMBER	DEMAND	GRADE LINE	ELEVATION	PRESSURE
1	.00	780.24		
2	.00	780.24		
3	.00	780.24		
4	.00	780.24		
5	1.00	780.24	760.10	8.39
6	.00	780.24		
7	.00	780.24		
8	1.00	780.24	761.10	7.98
9	.00	780.24		
10	.00	780.24		
11	1.00	780.24	761.10	7.98
12	.00	781.54		
13	.00	780.24		
14	.00	778.47		
15	.00	778.07		
16	873.00	777.92	760.10	7.43
17	.00	777.80		
18	2883.00	777.54	761.10	6.85

THE NET SYSTEM DEMAND = 3759.00

SUMMARY OF INFLOWS(+) AND OUTFLOWS(-) FROM FIXED GRADE NODES

PIPE NUMBER	FLOWRATE
2	3759.00

THE NET FLOW INTO THE SYSTEM FROM FIXED GRADE NODES = 3759.00
THE NET FLOW OUT OF THE SYSTEM INTO FIXED GRADE NODES = .00

FLOWRATE IS EXPRESSED IN GPM AND PRESSURE IN PSIG

A SUMMARY OF THE ORIGINAL DATA FOLLOWS

THE DARCY WEISBACH HEAD LOSS EQUATION IS USED, THE KINEMATIC VIS. = .0000032

THE SPECIFIC GRAVITY OF THIS LIQUID = .96

PIPE NO.	NODE NOS.		LENGTH (FEET)	DIAMETER (INCHES)	ROUGHNESS	MINOR LOSS K	FIXED GRADE
1	0	1	27.1	17.4	.2	1.91	782.50
LINE 1 IS CLOSED							
2	0	12	53.3	17.4	.2	1.91	782.50
3	1	2	24.0	13.5	.2	.89	
4	2	3	2.2	13.5	.2	.38	
5	3	4	7.1	10.3	.2	3.44	
6	4	5	6.0	8.1	.2	.20	
7	2	6	2.3	13.5	.2	.26	
8	6	7	19.0	13.5	.2	1.84	
9	7	8	6.5	12.3	.2	.19	
10	6	9	.4	13.5	.2	.63	
11	9	10	32.2	13.5	.2	1.73	
12	10	11	6.5	12.3	.2	.19	
13	9	13	.1	13.5	.2	.37	
14	12	13	24.8	13.5	.2	.89	
15	13	14	31.8	13.5	.2	1.24	
16	14	15	14.7	10.3	.2	1.94	
17	15	16	6.0	8.1	.2	.20	
18	14	17	23.5	13.5	.2	.75	
19	17	18	6.0	12.3	.2	.19	

JUNCTION NUMBER	DEMAND	ELEVATION	CONNECTING PIPES		
1	.00	.00	1	3	
2	.00	.00	3	4	7
3	.00	.00	4	5	
4	.00	.00	5	6	
5	1.00	760.10	6		
6	.00	.00	7	8	10
7	.00	.00	8	9	
8	1.00	761.10	9		
9	.00	.00	10	11	13
10	.00	.00	11	12	
11	1.00	761.10	12		
12	.00	.00	2	14	
13	.00	.00	13	14	15
14	.00	.00	15	16	18
15	.00	.00	16	17	
16	873.00	760.10	17		
17	.00	.00	18	19	
18	2883.00	761.10	19		

OUTPUT SELECTION: ALL RESULTS ARE OUTPUT EACH PERIOD

THIS SYSTEM HAS 19 PIPES WITH 18 JUNCTIONS , 0 LOOPS AND 2 FGNS

THE RESULTS ARE OBTAINED AFTER 2 TRIALS WITH AN ACCURACY = .00000

RBS NPSH analysis for OSC-4467, Rev. 2. Model taken from OSC-1977, modified by removal of minor loss from 3BS-6, and addition of minor loss from sump inlet reducer. Sump temperature is 210F. No RB pressure.

PIPE NO.	NODE NOS.		FLOWRATE	HEAD LOSS	PUMP HEAD	MINOR LOSS	VELOCITY	HL/1000
LINE 1 IS CLOSED								
2	0	12	3759.00	.19	.00	.77	5.09	3.56
3	1	2	.00	.00	.00	.00	.00	.00
4	2	3	1.00	.00	.00	.00	.00	.00
5	3	4	1.00	.00	.00	.00	.00	.00
6	4	5	1.00	.00	.00	.00	.01	.00
7	2	6	-1.00	.00	.00	.00	.00	.00
8	6	7	1.00	.00	.00	.00	.00	.00
9	7	8	1.00	.00	.00	.00	.00	.00
10	6	9	-2.00	.00	.00	.00	.00	.00
11	9	10	1.00	.00	.00	.00	.00	.00
12	10	11	1.00	.00	.00	.00	.00	.00
13	9	13	-3.00	.00	.00	.00	-.01	.00
14	12	13	3759.00	.32	.00	.98	8.42	12.94
15	13	14	3756.00	.41	.00	1.36	8.42	12.92
16	14	15	873.00	.04	.00	.35	3.39	3.05
17	15	16	873.00	.06	.00	.09	5.40	9.97
18	14	17	2883.00	.18	.00	.49	6.46	7.69
19	17	18	2883.00	.08	.00	.18	7.85	12.64

JUNCTION NUMBER	DEMAND	GRADE LINE	ELEVATION	PRESSURE
1	.00	780.24		
2	.00	780.24		
3	.00	780.24		
4	.00	780.24		
5	1.00	780.24	760.10	8.38
6	.00	780.24		
7	.00	780.24		
8	1.00	780.24	761.10	7.96
9	.00	780.24		
10	.00	780.24		
11	1.00	780.24	761.10	7.96
12	.00	781.54		
13	.00	780.24		
14	.00	778.47		
15	.00	778.07		
16	873.00	777.92	760.10	7.41
17	.00	777.80		
18	2883.00	777.54	761.10	6.84

THE NET SYSTEM DEMAND = 3759.00

SUMMARY OF INFLOWS(+) AND OUTFLOWS(-) FROM FIXED GRADE NODES

PIPE NUMBER	FLOWRATE
2	3759.00

THE NET FLOW INTO THE SYSTEM FROM FIXED GRADE NODES = 3759.00
THE NET FLOW OUT OF THE SYSTEM INTO FIXED GRADE NODES = .00

A SUMMARY OF CONDITIONS SPECIFIED FOR THE NEXT SIMULATION FOLLOWS

THE RESULTS ARE OBTAINED AFTER 1 TRIALS WITH AN ACCURACY = .00000

PIPE NO.	NODE NOS.		FLOWRATE	HEAD LOSS	PUMP HEAD	MINOR LOSS	VELOCITY	HL/1000
LINE 1 IS CLOSED								
2	0	12	3759.00	.19	.00	.77	5.09	3.56
3	1	2	.00	.00	.00	.00	.00	.00
4	2	3	1.00	.00	.00	.00	.00	.00
5	3	4	1.00	.00	.00	.00	.00	.00
6	4	5	1.00	.00	.00	.00	.01	.00
7	2	6	-1.00	.00	.00	.00	.00	.00
8	6	7	1.00	.00	.00	.00	.00	.00
9	7	8	1.00	.00	.00	.00	.00	.00
10	6	9	-2.00	.00	.00	.00	.00	.00
11	9	10	1.00	.00	.00	.00	.00	.00
12	10	11	1.00	.00	.00	.00	.00	.00
13	9	13	-3.00	.00	.00	.00	-.01	.00
14	12	13	3759.00	.32	.00	.98	8.42	12.94
15	13	14	3756.00	.41	.00	1.36	8.42	12.92
16	14	15	873.00	.04	.00	.35	3.39	3.05
17	15	16	873.00	.06	.00	.09	5.40	9.97
18	14	17	2883.00	.18	.00	.49	6.46	7.69
19	17	18	2883.00	.08	.00	.18	7.85	12.64

JUNCTION NUMBER	DEMAND	GRADE LINE	ELEVATION	PRESSURE
1	.00	780.24		
2	.00	780.24		
3	.00	780.24		
4	.00	780.24		
5	1.00	780.24	760.10	8.38
6	.00	780.24		
7	.00	780.24		
8	1.00	780.24	761.10	7.96
9	.00	780.24		
10	.00	780.24		
11	1.00	780.24	761.10	7.96
12	.00	781.54		
13	.00	780.24		
14	.00	778.47		
15	.00	778.07		
16	873.00	777.92	760.10	7.41
17	.00	777.80		
18	2883.00	777.54	761.10	6.84

THE NET SYSTEM DEMAND = 3759.00

SUMMARY OF INFLOWS(+) AND OUTFLOWS(-) FROM FIXED GRADE NODES

PIPE NUMBER	FLOWRATE
2	3759.00

THE NET FLOW INTO THE SYSTEM FROM FIXED GRADE NODES = 3759.00
THE NET FLOW OUT OF THE SYSTEM INTO FIXED GRADE NODES = .00

FLOWRATE IS EXPRESSED IN GPM AND PRESSURE IN PSIG

A SUMMARY OF THE ORIGINAL DATA FOLLOWS

THE DARCY WEISBACH HEAD LOSS EQUATION IS USED, THE KINEMATIC VIS. = .0000032

THE SPECIFIC GRAVITY OF THIS LIQUID = .96

PIPE NO.	NODE NOS.		LENGTH (FEET)	DIAMETER (INCHES)	ROUGHNESS	MINOR LOSS K	FIXED GRADE
1	0	1	27.1	17.4	.2	1.91	782.50
LINE 1 IS CLOSED							
2	0	12	53.3	17.4	.2	1.91	782.50
3	1	2	24.0	13.5	.2	.89	
4	2	3	2.2	13.5	.2	.38	
5	3	4	7.1	10.3	.2	3.44	
6	4	5	6.0	8.1	.2	.20	
7	2	6	2.3	13.5	.2	.26	
8	6	7	19.0	13.5	.2	1.84	
9	7	8	6.5	12.3	.2	.19	
10	6	9	.4	13.5	.2	.63	
11	9	10	32.2	13.5	.2	1.73	
12	10	11	6.5	12.3	.2	.19	
13	9	13	.1	13.5	.2	.37	
14	12	13	24.8	13.5	.2	.89	
15	13	14	31.8	13.5	.2	1.24	
16	14	15	14.7	10.3	.2	1.94	
17	15	16	6.0	8.1	.2	.20	
18	14	17	23.5	13.5	.2	.75	
19	17	18	6.0	12.3	.2	.19	

JUNCTION NUMBER	DEMAND	ELEVATION	CONNECTING PIPES		
1	.00	.00	1	3	
2	.00	.00	3	4	7
3	.00	.00	4	5	
4	.00	.00	5	6	
5	1.00	760.10	6		
6	.00	.00	7	8	10
7	.00	.00	8	9	
8	1.00	761.10	9		
9	.00	.00	10	11	13
10	.00	.00	11	12	
11	1.00	761.10	12		
12	.00	.00	2	14	
13	.00	.00	13	14	15
14	.00	.00	15	16	18
15	.00	.00	16	17	
16	873.00	760.10	17		
17	.00	.00	18	19	
18	2883.00	761.10	19		

OUTPUT SELECTION: ALL RESULTS ARE OUTPUT EACH PERIOD

THIS SYSTEM HAS 19 PIPES WITH 18 JUNCTIONS , 0 LOOPS AND 2 FGNS

THE RESULTS ARE OBTAINED AFTER 2 TRIALS WITH AN ACCURACY = .00000

RBS NPSH analysis for OSC-4467, Rev. 2. Model taken from OSC-1977, modified by removal of minor loss from 3BS-6, and addition of minor loss from sump inlet reducer. Sump temperature is 215F. No RB pressure.

PIPE NO.	NODE NOS.		FLOWRATE	HEAD LOSS	PUMP HEAD	MINOR LOSS	VELOCITY	HL/1000
LINE	1 IS CLOSED							
2	0	12	3759.00	.19	.00	.77	5.09	3.56
3	1	2	.00	.00	.00	.00	.00	.00
4	2	3	1.00	.00	.00	.00	.00	.00
5	3	4	1.00	.00	.00	.00	.00	.00
6	4	5	1.00	.00	.00	.00	.01	.00
7	2	6	-1.00	.00	.00	.00	.00	.00
8	6	7	1.00	.00	.00	.00	.00	.00
9	7	8	1.00	.00	.00	.00	.00	.00
10	6	9	-2.00	.00	.00	.00	.00	.00
11	9	10	1.00	.00	.00	.00	.00	.00
12	10	11	1.00	.00	.00	.00	.00	.00
13	9	13	-3.00	.00	.00	.00	-.01	.00
14	12	13	3759.00	.32	.00	.98	8.42	12.94
15	13	14	3756.00	.41	.00	1.36	8.42	12.92
16	14	15	873.00	.04	.00	.35	3.39	3.05
17	15	16	873.00	.06	.00	.09	5.40	9.97
18	14	17	2883.00	.18	.00	.49	6.46	7.69
19	17	18	2883.00	.08	.00	.18	7.85	12.64

JUNCTION NUMBER	DEMAND	GRADE LINE	ELEVATION	PRESSURE
1	.00	780.24		
2	.00	780.24		
3	.00	780.24		
4	.00	780.24		
5	1.00	780.24	760.10	8.36
6	.00	780.24		
7	.00	780.24		
8	1.00	780.24	761.10	7.94
9	.00	780.24		
10	.00	780.24		
11	1.00	780.24	761.10	7.94
12	.00	781.54		
13	.00	780.24		
14	.00	778.47		
15	.00	778.07		
16	873.00	777.92	760.10	7.40
17	.00	777.80		
18	2883.00	777.54	761.10	6.82

THE NET SYSTEM DEMAND = 3759.00

SUMMARY OF INFLOWS(+) AND OUTFLOWS(-) FROM FIXED GRADE NODES

PIPE NUMBER	FLOWRATE
2	3759.00

THE NET FLOW INTO THE SYSTEM FROM FIXED GRADE NODES = 3759.00
THE NET FLOW OUT OF THE SYSTEM INTO FIXED GRADE NODES = .00

A SUMMARY OF CONDITIONS SPECIFIED FOR THE NEXT SIMULATION FOLLOWS

THE RESULTS ARE OBTAINED AFTER 1 TRIALS WITH AN ACCURACY = .00000

PIPE NO.	NODE NOS.		FLOWRATE	HEAD LOSS	PUMP HEAD	MINOR LOSS	VELOCITY	HL/1000
LINE	1 IS CLOSED							
2	0	12	3759.00	.19	.00	.77	5.09	3.56
3	1	2	.00	.00	.00	.00	.00	.00
4	2	3	1.00	.00	.00	.00	.00	.00
5	3	4	1.00	.00	.00	.00	.00	.00
6	4	5	1.00	.00	.00	.00	.01	.00
7	2	6	-1.00	.00	.00	.00	.00	.00
8	6	7	1.00	.00	.00	.00	.00	.00
9	7	8	1.00	.00	.00	.00	.00	.00
10	6	9	-2.00	.00	.00	.00	.00	.00
11	9	10	1.00	.00	.00	.00	.00	.00
12	10	11	1.00	.00	.00	.00	.00	.00
13	9	13	-3.00	.00	.00	.00	-.01	.00
14	12	13	3759.00	.32	.00	.98	8.42	12.94
15	13	14	3756.00	.41	.00	1.36	8.42	12.92
16	14	15	873.00	.04	.00	.35	3.39	3.05
17	15	16	873.00	.06	.00	.09	5.40	9.97
18	14	17	2883.00	.18	.00	.49	6.46	7.69
19	17	18	2883.00	.08	.00	.18	7.85	12.64

JUNCTION NUMBER	DEMAND	GRADE LINE	ELEVATION	PRESSURE
1	.00	780.24		
2	.00	780.24		
3	.00	780.24		
4	.00	780.24		
5	1.00	780.24	760.10	8.36
6	.00	780.24		
7	.00	780.24		
8	1.00	780.24	761.10	7.94
9	.00	780.24		
10	.00	780.24		
11	1.00	780.24	761.10	7.94
12	.00	781.54		
13	.00	780.24		
14	.00	778.47		
15	.00	778.07		
16	873.00	777.92	760.10	7.40
17	.00	777.80		
18	2883.00	777.54	761.10	6.82

THE NET SYSTEM DEMAND = 3759.00

SUMMARY OF INFLOWS(+) AND OUTFLOWS(-) FROM FIXED GRADE NODES

PIPE NUMBER	FLOWRATE
2	3759.00

THE NET FLOW INTO THE SYSTEM FROM FIXED GRADE NODES = 3759.00
THE NET FLOW OUT OF THE SYSTEM INTO FIXED GRADE NODES = .00

FLOWRATE IS EXPRESSED IN GPM AND PRESSURE IN PSIG

A SUMMARY OF THE ORIGINAL DATA FOLLOWS

THE DARCY WEISBACH HEAD LOSS EQUATION IS USED, THE KINEMATIC VIS. = .0000031

THE SPECIFIC GRAVITY OF THIS LIQUID = .96

PIPE NO.	NODE NOS.		LENGTH (FEET)	DIAMETER (INCHES)	ROUGHNESS	MINOR LOSS K	FIXED GRADE
1	0	1	27.1	17.4	.2	1.91	782.50
LINE 1 IS CLOSED							
2	0	12	53.3	17.4	.2	1.91	782.50
3	1	2	24.0	13.5	.2	.89	
4	2	3	2.2	13.5	.2	.38	
5	3	4	7.1	10.3	.2	3.44	
6	4	5	6.0	8.1	.2	.20	
7	2	6	2.3	13.5	.2	.26	
8	6	7	19.0	13.5	.2	1.84	
9	7	8	6.5	12.3	.2	.19	
10	6	9	.4	13.5	.2	.63	
11	9	10	32.2	13.5	.2	1.73	
12	10	11	6.5	12.3	.2	.19	
13	9	13	.1	13.5	.2	.37	
14	12	13	24.8	13.5	.2	.89	
15	13	14	31.8	13.5	.2	1.24	
16	14	15	14.7	10.3	.2	1.94	
17	15	16	6.0	8.1	.2	.20	
18	14	17	23.5	13.5	.2	.75	
19	17	18	6.0	12.3	.2	.19	

JUNCTION NUMBER	DEMAND	ELEVATION	CONNECTING PIPES		
1	.00	.00	1	3	
2	.00	.00	3	4	7
3	.00	.00	4	5	
4	.00	.00	5	6	
5	1.00	760.10	6		
6	.00	.00	7	8	10
7	.00	.00	8	9	
8	1.00	761.10	9		
9	.00	.00	10	11	13
10	.00	.00	11	12	
11	1.00	761.10	12		
12	.00	.00	2	14	
13	.00	.00	13	14	15
14	.00	.00	15	16	18
15	.00	.00	16	17	
16	873.00	760.10	17		
17	.00	.00	18	19	
18	2883.00	761.10	19		

OUTPUT SELECTION: ALL RESULTS ARE OUTPUT EACH PERIOD

THIS SYSTEM HAS 19 PIPES WITH 18 JUNCTIONS , 0 LOOPS AND 2 FGNS

THE RESULTS ARE OBTAINED AFTER 2 TRIALS WITH AN ACCURACY = .00000

RBS NPSH analysis for OSC-4467, Rev. 2. Model taken from OSC-1977, modified by removal of minor loss from 3BS-6, and addition of minor loss from sump inlet reducer. Sump temperature is 220F. No RB pressure.

PIPE NO.	NODE NOS.		FLOWRATE	HEAD LOSS	PUMP HEAD	MINOR LOSS	VELOCITY	HL/1000
LINE 1 IS CLOSED								
2	0	12	3759.00	.19	.00	.77	5.09	3.56
3	1	2	.00	.00	.00	.00	.00	.00
4	2	3	1.00	.00	.00	.00	.00	.00
5	3	4	1.00	.00	.00	.00	.00	.00
6	4	5	1.00	.00	.00	.00	.01	.00
7	2	6	-1.00	.00	.00	.00	.00	.00
8	6	7	1.00	.00	.00	.00	.00	.00
9	7	8	1.00	.00	.00	.00	.00	.00
10	6	9	-2.00	.00	.00	.00	.00	.00
11	9	10	1.00	.00	.00	.00	.00	.00
12	10	11	1.00	.00	.00	.00	.00	.00
13	9	13	-3.00	.00	.00	.00	-.01	.00
14	12	13	3759.00	.32	.00	.98	8.42	12.93
15	13	14	3756.00	.41	.00	1.36	8.42	12.91
16	14	15	873.00	.04	.00	.35	3.39	3.05
17	15	16	873.00	.06	.00	.09	5.40	9.95
18	14	17	2883.00	.18	.00	.49	6.46	7.68
19	17	18	2883.00	.08	.00	.18	7.85	12.63

JUNCTION NUMBER	DEMAND	GRADE LINE	ELEVATION	PRESSURE
1	.00	780.24		
2	.00	780.24		
3	.00	780.24		
4	.00	780.24		
5	1.00	780.24	760.10	8.34
6	.00	780.24		
7	.00	780.24		
8	1.00	780.24	761.10	7.93
9	.00	780.24		
10	.00	780.24		
11	1.00	780.24	761.10	7.93
12	.00	781.54		
13	.00	780.24		
14	.00	778.47		
15	.00	778.08		
16	873.00	777.93	760.10	7.38
17	.00	777.80		
18	2883.00	777.54	761.10	6.81

THE NET SYSTEM DEMAND = 3759.00

SUMMARY OF INFLOWS(+) AND OUTFLOWS(-) FROM FIXED GRADE NODES

PIPE NUMBER	FLOWRATE
2	3759.00

THE NET FLOW INTO THE SYSTEM FROM FIXED GRADE NODES = 3759.00
THE NET FLOW OUT OF THE SYSTEM INTO FIXED GRADE NODES = .00

A SUMMARY OF CONDITIONS SPECIFIED FOR THE NEXT SIMULATION FOLLOWS

THE RESULTS ARE OBTAINED AFTER 1 TRIALS WITH AN ACCURACY = .00000

PIPE NO.	NODE NOS.		FLOWRATE	HEAD LOSS	PUMP HEAD	MINOR LOSS	VELOCITY	HL/1000
LINE 1 IS CLOSED								
2	0	12	3759.00	.19	.00	.77	5.09	3.56
3	1	2	.00	.00	.00	.00	.00	.00
4	2	3	1.00	.00	.00	.00	.00	.00
5	3	4	1.00	.00	.00	.00	.00	.00
6	4	5	1.00	.00	.00	.00	.01	.00
7	2	6	-1.00	.00	.00	.00	.00	.00
8	6	7	1.00	.00	.00	.00	.00	.00
9	7	8	1.00	.00	.00	.00	.00	.00
10	6	9	-2.00	.00	.00	.00	.00	.00
11	9	10	1.00	.00	.00	.00	.00	.00
12	10	11	1.00	.00	.00	.00	.00	.00
13	9	13	-3.00	.00	.00	.00	-.01	.00
14	12	13	3759.00	.32	.00	.98	8.42	12.93
15	13	14	3756.00	.41	.00	1.36	8.42	12.91
16	14	15	873.00	.04	.00	.35	3.39	3.05
17	15	16	873.00	.06	.00	.09	5.40	9.95
18	14	17	2883.00	.18	.00	.49	6.46	7.68
19	17	18	2883.00	.08	.00	.18	7.85	12.63

JUNCTION NUMBER	DEMAND	GRADE LINE	ELEVATION	PRESSURE
1	.00	780.24		
2	.00	780.24		
3	.00	780.24		
4	.00	780.24		
5	1.00	780.24	760.10	8.34
6	.00	780.24		
7	.00	780.24		
8	1.00	780.24	761.10	7.93
9	.00	780.24		
10	.00	780.24		
11	1.00	780.24	761.10	7.93
12	.00	781.54		
13	.00	780.24		
14	.00	778.47		
15	.00	778.08		
16	873.00	777.93	760.10	7.38
17	.00	777.80		
18	2883.00	777.54	761.10	6.81

THE NET SYSTEM DEMAND = 3759.00

SUMMARY OF INFLOWS(+) AND OUTFLOWS(-) FROM FIXED GRADE NODES

PIPE NUMBER	FLOWRATE
2	3759.00

THE NET FLOW INTO THE SYSTEM FROM FIXED GRADE NODES = 3759.00
THE NET FLOW OUT OF THE SYSTEM INTO FIXED GRADE NODES = .00

FLOWRATE IS EXPRESSED IN GPM AND PRESSURE IN PSIG

A SUMMARY OF THE ORIGINAL DATA FOLLOWS

THE DARCY WEISBACH HEAD LOSS EQUATION IS USED, THE KINEMATIC VIS. = .0000030

THE SPECIFIC GRAVITY OF THIS LIQUID = .95

PIPE NO.	NODE NOS.		LENGTH (FEET)	DIAMETER (INCHES)	ROUGHNESS	MINOR LOSS K	FIXED GRADE
1	0	1	27.1	17.4	.2	1.91	782.50
LINE 1 IS CLOSED							
2	0	12	53.3	17.4	.2	1.91	782.50
3	1	2	24.0	13.5	.2	.89	
4	2	3	2.2	13.5	.2	.38	
5	3	4	7.1	10.3	.2	3.44	
6	4	5	6.0	8.1	.2	.20	
7	2	6	2.3	13.5	.2	.26	
8	6	7	19.0	13.5	.2	1.84	
9	7	8	6.5	12.3	.2	.19	
10	6	9	.4	13.5	.2	.63	
11	9	10	32.2	13.5	.2	1.73	
12	10	11	6.5	12.3	.2	.19	
13	9	13	.1	13.5	.2	.37	
14	12	13	24.8	13.5	.2	.89	
15	13	14	31.8	13.5	.2	1.24	
16	14	15	14.7	10.3	.2	1.94	
17	15	16	6.0	8.1	.2	.20	
18	14	17	23.5	13.5	.2	.75	
19	17	18	6.0	12.3	.2	.19	

JUNCTION NUMBER	DEMAND	ELEVATION	CONNECTING PIPES		
1	.00	.00	1	3	
2	.00	.00	3	4	7
3	.00	.00	4	5	
4	.00	.00	5	6	
5	1.00	760.10	6		
6	.00	.00	7	8	10
7	.00	.00	8	9	
8	1.00	761.10	9		
9	.00	.00	10	11	13
10	.00	.00	11	12	
11	1.00	761.10	12		
12	.00	.00	2	14	
13	.00	.00	13	14	15
14	.00	.00	15	16	18
15	.00	.00	16	17	
16	873.00	760.10	17		
17	.00	.00	18	19	
18	2883.00	761.10	19		

OUTPUT SELECTION: ALL RESULTS ARE OUTPUT EACH PERIOD

THIS SYSTEM HAS 19 PIPES WITH 18 JUNCTIONS , 0 LOOPS AND 2 FGNS

THE RESULTS ARE OBTAINED AFTER 2 TRIALS WITH AN ACCURACY = .00000

RBS NPSH analysis for OSC-4467, Rev. 2. Model taken from OSC-1977, modified by removal of minor loss from 3BS-6, and addition of minor loss from sump inlet reducer. Sump temperature is 225F. No RB pressure.

PIPE NO.	NODE NOS.		FLOWRATE	HEAD LOSS	PUMP HEAD	MINOR LOSS	VELOCITY	HL/1000
LINE 1 IS CLOSED								
2	0	12	3759.00	.19	.00	.77	5.09	3.55
3	1	2	.00	.00	.00	.00	.00	.00
4	2	3	1.00	.00	.00	.00	.00	.00
5	3	4	1.00	.00	.00	.00	.00	.00
6	4	5	1.00	.00	.00	.00	.01	.00
7	2	6	-1.00	.00	.00	.00	.00	.00
8	6	7	1.00	.00	.00	.00	.00	.00
9	7	8	1.00	.00	.00	.00	.00	.00
10	6	9	-2.00	.00	.00	.00	.00	.00
11	9	10	1.00	.00	.00	.00	.00	.00
12	10	11	1.00	.00	.00	.00	.00	.00
13	9	13	-3.00	.00	.00	.00	-.01	.00
14	12	13	3759.00	.32	.00	.98	8.42	12.91
15	13	14	3756.00	.41	.00	1.36	8.42	12.89
16	14	15	873.00	.04	.00	.35	3.39	3.04
17	15	16	873.00	.06	.00	.09	5.40	9.94
18	14	17	2883.00	.18	.00	.49	6.46	7.67
19	17	18	2883.00	.08	.00	.18	7.85	12.61

JUNCTION NUMBER	DEMAND	GRADE LINE	ELEVATION	PRESSURE
1	.00	780.24		
2	.00	780.24		
3	.00	780.24		
4	.00	780.24		
5	1.00	780.24	760.10	8.32
6	.00	780.24		
7	.00	780.24		
8	1.00	780.24	761.10	7.91
9	.00	780.24		
10	.00	780.24		
11	1.00	780.24	761.10	7.91
12	.00	781.54		
13	.00	780.24		
14	.00	778.47		
15	.00	778.08		
16	873.00	777.93	760.10	7.37
17	.00	777.80		
18	2883.00	777.54	761.10	6.80

THE NET SYSTEM DEMAND = 3759.00

SUMMARY OF INFLOWS(+) AND OUTFLOWS(-) FROM FIXED GRADE NODES

PIPE NUMBER	FLOWRATE
2	3759.00

THE NET FLOW INTO THE SYSTEM FROM FIXED GRADE NODES = 3759.00
THE NET FLOW OUT OF THE SYSTEM INTO FIXED GRADE NODES = .00

A SUMMARY OF CONDITIONS SPECIFIED FOR THE NEXT SIMULATION FOLLOWS

THE RESULTS ARE OBTAINED AFTER 1 TRIALS WITH AN ACCURACY = .00000

PIPE NO.	NODE NOS.		FLOWRATE	HEAD LOSS	PUMP HEAD	MINOR LOSS	VELOCITY	HL/1000
LINE	1 IS CLOSED							
2	0	12	3759.00	.19	.00	.77	5.09	3.55
3	1	2	.00	.00	.00	.00	.00	.00
4	2	3	1.00	.00	.00	.00	.00	.00
5	3	4	1.00	.00	.00	.00	.00	.00
6	4	5	1.00	.00	.00	.00	.01	.00
7	2	6	-1.00	.00	.00	.00	.00	.00
8	6	7	1.00	.00	.00	.00	.00	.00
9	7	8	1.00	.00	.00	.00	.00	.00
10	6	9	-2.00	.00	.00	.00	.00	.00
11	9	10	1.00	.00	.00	.00	.00	.00
12	10	11	1.00	.00	.00	.00	.00	.00
13	9	13	-3.00	.00	.00	.00	-.01	.00
14	12	13	3759.00	.32	.00	.98	8.42	12.91
15	13	14	3756.00	.41	.00	1.36	8.42	12.89
16	14	15	873.00	.04	.00	.35	3.39	3.04
17	15	16	873.00	.06	.00	.09	5.40	9.94
18	14	17	2883.00	.18	.00	.49	6.46	7.67
19	17	18	2883.00	.08	.00	.18	7.85	12.61

JUNCTION NUMBER	DEMAND	GRADE LINE	ELEVATION	PRESSURE
1	.00	780.24		
2	.00	780.24		
3	.00	780.24		
4	.00	780.24		
5	1.00	780.24	760.10	8.32
6	.00	780.24		
7	.00	780.24		
8	1.00	780.24	761.10	7.91
9	.00	780.24		
10	.00	780.24		
11	1.00	780.24	761.10	7.91
12	.00	781.54		
13	.00	780.24		
14	.00	778.47		
15	.00	778.08		
16	873.00	777.93	760.10	7.37
17	.00	777.80		
18	2883.00	777.54	761.10	6.80

THE NET SYSTEM DEMAND = 3759.00

SUMMARY OF INFLOWS(+) AND OUTFLOWS(-) FROM FIXED GRADE NODES

PIPE NUMBER	FLOWRATE
2	3759.00

THE NET FLOW INTO THE SYSTEM FROM FIXED GRADE NODES = 3759.00
THE NET FLOW OUT OF THE SYSTEM INTO FIXED GRADE NODES = .00

FLOWRATE IS EXPRESSED IN GPM AND PRESSURE IN PSIG

A SUMMARY OF THE ORIGINAL DATA FOLLOWS

THE DARCY WEISBACH HEAD LOSS EQUATION IS USED, THE KINEMATIC VIS. = .0000029

THE SPECIFIC GRAVITY OF THIS LIQUID = .95

PIPE NO.	NODE NOS.		LENGTH (FEET)	DIAMETER (INCHES)	ROUGHNESS	MINOR LOSS K	FIXED GRADE
1	0	1	27.1	17.4	.2	1.91	782.50
LINE 1 IS CLOSED							
2	0	12	53.3	17.4	.2	1.91	782.50
3	1	2	24.0	13.5	.2	.89	
4	2	3	2.2	13.5	.2	.38	
5	3	4	7.1	10.3	.2	3.44	
6	4	5	6.0	8.1	.2	.20	
7	2	6	2.3	13.5	.2	.26	
8	6	7	19.0	13.5	.2	1.84	
9	7	8	6.5	12.3	.2	.19	
10	6	9	.4	13.5	.2	.63	
11	9	10	32.2	13.5	.2	1.73	
12	10	11	6.5	12.3	.2	.19	
13	9	13	.1	13.5	.2	.37	
14	12	13	24.8	13.5	.2	.89	
15	13	14	31.8	13.5	.2	1.24	
16	14	15	14.7	10.3	.2	1.94	
17	15	16	6.0	8.1	.2	.20	
18	14	17	23.5	13.5	.2	.75	
19	17	18	6.0	12.3	.2	.19	

JUNCTION NUMBER	DEMAND	ELEVATION	CONNECTING PIPES		
1	.00	.00	1	3	
2	.00	.00	3	4	7
3	.00	.00	4	5	
4	.00	.00	5	6	
5	1.00	760.10	6		
6	.00	.00	7	8	10
7	.00	.00	8	9	
8	1.00	761.10	9		
9	.00	.00	10	11	13
10	.00	.00	11	12	
11	1.00	761.10	12		
12	.00	.00	2	14	
13	.00	.00	13	14	15
14	.00	.00	15	16	18
15	.00	.00	16	17	
16	873.00	760.10	17		
17	.00	.00	18	19	
18	2883.00	761.10	19		

OUTPUT SELECTION: ALL RESULTS ARE OUTPUT EACH PERIOD

THIS SYSTEM HAS 19 PIPES WITH 18 JUNCTIONS , 0 LOOPS AND 2 FGNS

THE RESULTS ARE OBTAINED AFTER 2 TRIALS WITH AN ACCURACY = .00000

RBS NPSH analysis for OSC-4467, Rev. 2. Model taken from OSC-1977, modified by removal of minor loss from 3BS-6, and addition of minor loss from sump inlet reducer. Sump temperature is 230F. No RB pressure.

PIPE NO.	NODE NOS.		FLOWRATE	HEAD LOSS	PUMP HEAD	MINOR LOSS	VELOCITY	HL/1000
LINE	1 IS CLOSED							
2	0	12	3759.00	.19	.00	.77	5.09	3.55
3	1	2	.00	.00	.00	.00	.00	.00
4	2	3	1.00	.00	.00	.00	.00	.00
5	3	4	1.00	.00	.00	.00	.00	.00
6	4	5	1.00	.00	.00	.00	.01	.00
7	2	6	-1.00	.00	.00	.00	.00	.00
8	6	7	1.00	.00	.00	.00	.00	.00
9	7	8	1.00	.00	.00	.00	.00	.00
10	6	9	-2.00	.00	.00	.00	.00	.00
11	9	10	1.00	.00	.00	.00	.00	.00
12	10	11	1.00	.00	.00	.00	.00	.00
13	9	13	-3.00	.00	.00	.00	-.01	.00
14	12	13	3759.00	.32	.00	.98	8.42	12.90
15	13	14	3756.00	.41	.00	1.36	8.42	12.88
16	14	15	873.00	.04	.00	.35	3.39	3.04
17	15	16	873.00	.06	.00	.09	5.40	9.92
18	14	17	2883.00	.18	.00	.49	6.46	7.66
19	17	18	2883.00	.08	.00	.18	7.85	12.60

JUNCTION NUMBER	DEMAND	GRADE LINE	ELEVATION	PRESSURE
1	.00	780.24		
2	.00	780.24		
3	.00	780.24		
4	.00	780.24		
5	1.00	780.24	760.10	8.31
6	.00	780.24		
7	.00	780.24		
8	1.00	780.24	761.10	7.89
9	.00	780.24		
10	.00	780.24		
11	1.00	780.24	761.10	7.89
12	.00	781.54		
13	.00	780.24		
14	.00	778.47		
15	.00	778.08		
16	873.00	777.93	760.10	7.35
17	.00	777.80		
18	2883.00	777.55	761.10	6.78

THE NET SYSTEM DEMAND = 3759.00

SUMMARY OF INFLOWS(+) AND OUTFLOWS(-) FROM FIXED GRADE NODES

PIPE NUMBER	FLOWRATE
2	3759.00

THE NET FLOW INTO THE SYSTEM FROM FIXED GRADE NODES = 3759.00
THE NET FLOW OUT OF THE SYSTEM INTO FIXED GRADE NODES = .00

A SUMMARY OF CONDITIONS SPECIFIED FOR THE NEXT SIMULATION FOLLOWS

THE RESULTS ARE OBTAINED AFTER 1 TRIALS WITH AN ACCURACY = .00000

PIPE NO.	NODE NOS.		FLOWRATE	HEAD LOSS	PUMP HEAD	MINOR LOSS	VELOCITY	HL/1000
LINE	1 IS CLOSED							
2	0	12	3759.00	.19	.00	.77	5.09	3.55
3	1	2	.00	.00	.00	.00	.00	.00
4	2	3	1.00	.00	.00	.00	.00	.00
5	3	4	1.00	.00	.00	.00	.00	.00
6	4	5	1.00	.00	.00	.00	.01	.00
7	2	6	-1.00	.00	.00	.00	.00	.00
8	6	7	1.00	.00	.00	.00	.00	.00
9	7	8	1.00	.00	.00	.00	.00	.00
10	6	9	-2.00	.00	.00	.00	.00	.00
11	9	10	1.00	.00	.00	.00	.00	.00
12	10	11	1.00	.00	.00	.00	.00	.00
13	9	13	-3.00	.00	.00	.00	-.01	.00
14	12	13	3759.00	.32	.00	.98	8.42	12.90
15	13	14	3756.00	.41	.00	1.36	8.42	12.88
16	14	15	873.00	.04	.00	.35	3.39	3.04
17	15	16	873.00	.06	.00	.09	5.40	9.92
18	14	17	2883.00	.18	.00	.49	6.46	7.66
19	17	18	2883.00	.08	.00	.18	7.85	12.60

JUNCTION NUMBER	DEMAND	GRADE LINE	ELEVATION	PRESSURE
1	.00	780.24		
2	.00	780.24		
3	.00	780.24		
4	.00	780.24		
5	1.00	780.24	760.10	8.31
6	.00	780.24		
7	.00	780.24		
8	1.00	780.24	761.10	7.89
9	.00	780.24		
10	.00	780.24		
11	1.00	780.24	761.10	7.89
12	.00	781.54		
13	.00	780.24		
14	.00	778.47		
15	.00	778.08		
16	873.00	777.93	760.10	7.35
17	.00	777.80		
18	2883.00	777.55	761.10	6.78

THE NET SYSTEM DEMAND = 3759.00

SUMMARY OF INFLOWS(+) AND OUTFLOWS(-) FROM FIXED GRADE NODES

PIPE NUMBER	FLOWRATE
2	3759.00

THE NET FLOW INTO THE SYSTEM FROM FIXED GRADE NODES = 3759.00
THE NET FLOW OUT OF THE SYSTEM INTO FIXED GRADE NODES = .00

FLOWRATE IS EXPRESSED IN GPM AND PRESSURE IN PSIG

A SUMMARY OF THE ORIGINAL DATA FOLLOWS

THE DARCY WEISBACH HEAD LOSS EQUATION IS USED, THE KINEMATIC VIS. = .0000029

THE SPECIFIC GRAVITY OF THIS LIQUID = .95

PIPE NO.	NODE NOS.		LENGTH (FEET)	DIAMETER (INCHES)	ROUGHNESS	MINOR LOSS K	FIXED GRADE
1	0	1	27.1	17.4	.2	1.91	782.50
LINE 1 IS CLOSED							
2	0	12	53.3	17.4	.2	1.91	782.50
3	1	2	24.0	13.5	.2	.89	
4	2	3	2.2	13.5	.2	.38	
5	3	4	7.1	10.3	.2	3.44	
6	4	5	6.0	8.1	.2	.20	
7	2	6	2.3	13.5	.2	.26	
8	6	7	19.0	13.5	.2	1.84	
9	7	8	6.5	12.3	.2	.19	
10	6	9	.4	13.5	.2	.63	
11	9	10	32.2	13.5	.2	1.73	
12	10	11	6.5	12.3	.2	.19	
13	9	13	.1	13.5	.2	.37	
14	12	13	24.8	13.5	.2	.89	
15	13	14	31.8	13.5	.2	1.24	
16	14	15	14.7	10.3	.2	1.94	
17	15	16	6.0	8.1	.2	.20	
18	14	17	23.5	13.5	.2	.75	
19	17	18	6.0	12.3	.2	.19	

JUNCTION NUMBER	DEMAND	ELEVATION	CONNECTING PIPES		
1	.00	.00	1	3	
2	.00	.00	3	4	7
3	.00	.00	4	5	
4	.00	.00	5	6	
5	1.00	760.10	6		
6	.00	.00	7	8	10
7	.00	.00	8	9	
8	1.00	761.10	9		
9	.00	.00	10	11	13
10	.00	.00	11	12	
11	1.00	761.10	12		
12	.00	.00	2	14	
13	.00	.00	13	14	15
14	.00	.00	15	16	18
15	.00	.00	16	17	
16	873.00	760.10	17		
17	.00	.00	18	19	
18	2883.00	761.10	19		

OUTPUT SELECTION: ALL RESULTS ARE OUTPUT EACH PERIOD

THIS SYSTEM HAS 19 PIPES WITH 18 JUNCTIONS , 0 LOOPS AND 2 FGNS

THE RESULTS ARE OBTAINED AFTER 2 TRIALS WITH AN ACCURACY = .00000

RBS NPSH analysis for OSC-4467, Rev. 2. Model taken from OSC-1977, modified by removal of minor loss from 3BS-6, and addition of minor loss from sump inlet reducer. Sump temperature is 235F. No RB pressure.

PIPE NO.	NODE NOS.		FLOWRATE	HEAD LOSS	PUMP HEAD	MINOR LOSS	VELOCITY	HL/1000
LINE	1 IS CLOSED							
2	0	12	3759.00	.19	.00	.77	5.09	3.55
3	1	2	.00	.00	.00	.00	.00	.00
4	2	3	1.00	.00	.00	.00	.00	.00
5	3	4	1.00	.00	.00	.00	.00	.00
6	4	5	1.00	.00	.00	.00	.01	.00
7	2	6	-1.00	.00	.00	.00	.00	.00
8	6	7	1.00	.00	.00	.00	.00	.00
9	7	8	1.00	.00	.00	.00	.00	.00
10	6	9	-2.00	.00	.00	.00	.00	.00
11	9	10	1.00	.00	.00	.00	.00	.00
12	10	11	1.00	.00	.00	.00	.00	.00
13	9	13	-3.00	.00	.00	.00	-.01	.00
14	12	13	3759.00	.32	.00	.98	8.42	12.90
15	13	14	3756.00	.41	.00	1.36	8.42	12.88
16	14	15	873.00	.04	.00	.35	3.39	3.04
17	15	16	873.00	.06	.00	.09	5.40	9.92
18	14	17	2883.00	.18	.00	.49	6.46	7.66
19	17	18	2883.00	.08	.00	.18	7.85	12.60

JUNCTION NUMBER	DEMAND	GRADE LINE	ELEVATION	PRESSURE
1	.00	780.24		
2	.00	780.24		
3	.00	780.24		
4	.00	780.24		
5	1.00	780.24	760.10	8.29
6	.00	780.24		
7	.00	780.24		
8	1.00	780.24	761.10	7.88
9	.00	780.24		
10	.00	780.24		
11	1.00	780.24	761.10	7.88
12	.00	781.54		
13	.00	780.24		
14	.00	778.47		
15	.00	778.08		
16	873.00	777.93	760.10	7.33
17	.00	777.80		
18	2883.00	777.55	761.10	6.77

THE NET SYSTEM DEMAND = 3759.00

SUMMARY OF INFLOWS(+) AND OUTFLOWS(-) FROM FIXED GRADE NODES

PIPE NUMBER	FLOWRATE
2	3759.00

THE NET FLOW INTO THE SYSTEM FROM FIXED GRADE NODES = 3759.00
THE NET FLOW OUT OF THE SYSTEM INTO FIXED GRADE NODES = .00

A SUMMARY OF CONDITIONS SPECIFIED FOR THE NEXT SIMULATION FOLLOWS

THE RESULTS ARE OBTAINED AFTER 1 TRIALS WITH AN ACCURACY = .00000

LINE 1 IS CLOSED

PIPE NO.	NODE NOS.		FLOWRATE	HEAD LOSS	PUMP HEAD	MINOR LOSS	VELOCITY	HL/1000
2	0	12	3759.00	.19	.00	.77	5.09	3.55
3	1	2	.00	.00	.00	.00	.00	.00
4	2	3	1.00	.00	.00	.00	.00	.00
5	3	4	1.00	.00	.00	.00	.00	.00
6	4	5	1.00	.00	.00	.00	.01	.00
7	2	6	-1.00	.00	.00	.00	.00	.00
8	6	7	1.00	.00	.00	.00	.00	.00
9	7	8	1.00	.00	.00	.00	.00	.00
10	6	9	-2.00	.00	.00	.00	.00	.00
11	9	10	1.00	.00	.00	.00	.00	.00
12	10	11	1.00	.00	.00	.00	.00	.00
13	9	13	-3.00	.00	.00	.00	-.01	.00
14	12	13	3759.00	.32	.00	.98	8.42	12.90
15	13	14	3756.00	.41	.00	1.36	8.42	12.88
16	14	15	873.00	.04	.00	.35	3.39	3.04
17	15	16	873.00	.06	.00	.09	5.40	9.92
18	14	17	2883.00	.18	.00	.49	6.46	7.66
19	17	18	2883.00	.08	.00	.18	7.85	12.60

JUNCTION NUMBER	DEMAND	GRADE LINE	ELEVATION	PRESSURE
1	.00	780.24		
2	.00	780.24		
3	.00	780.24		
4	.00	780.24		
5	1.00	780.24	760.10	8.29
6	.00	780.24		
7	.00	780.24		
8	1.00	780.24	761.10	7.88
9	.00	780.24		
10	.00	780.24		
11	1.00	780.24	761.10	7.88
12	.00	781.54		
13	.00	780.24		
14	.00	778.47		
15	.00	778.08		
16	873.00	777.93	760.10	7.33
17	.00	777.80		
18	2883.00	777.55	761.10	6.77

THE NET SYSTEM DEMAND = 3759.00

SUMMARY OF INFLOWS(+) AND OUTFLOWS(-) FROM FIXED GRADE NODES

PIPE NUMBER	FLOWRATE
2	3759.00

THE NET FLOW INTO THE SYSTEM FROM FIXED GRADE NODES = 3759.00
THE NET FLOW OUT OF THE SYSTEM INTO FIXED GRADE NODES = .00

FLOWRATE IS EXPRESSED IN GPM AND PRESSURE IN PSIG

A SUMMARY OF THE ORIGINAL DATA FOLLOWS

THE DARCY WEISBACH HEAD LOSS EQUATION IS USED, THE KINEMATIC VIS. = .0000028

THE SPECIFIC GRAVITY OF THIS LIQUID = .95

PIPE NO.	NODE NOS.		LENGTH (FEET)	DIAMETER (INCHES)	ROUGHNESS	MINOR LOSS K	FIXED GRADE
1	0	1	27.1	17.4	.2	1.91	782.50
LINE 1 IS CLOSED							
2	0	12	53.3	17.4	.2	1.91	782.50
3	1	2	24.0	13.5	.2	.89	
4	2	3	2.2	13.5	.2	.38	
5	3	4	7.1	10.3	.2	3.44	
6	4	5	6.0	8.1	.2	.20	
7	2	6	2.3	13.5	.2	.26	
8	6	7	19.0	13.5	.2	1.84	
9	7	8	6.5	12.3	.2	.19	
10	6	9	.4	13.5	.2	.63	
11	9	10	32.2	13.5	.2	1.73	
12	10	11	6.5	12.3	.2	.19	
13	9	13	.1	13.5	.2	.37	
14	12	13	24.8	13.5	.2	.89	
15	13	14	31.8	13.5	.2	1.24	
16	14	15	14.7	10.3	.2	1.94	
17	15	16	6.0	8.1	.2	.20	
18	14	17	23.5	13.5	.2	.75	
19	17	18	6.0	12.3	.2	.19	

JUNCTION NUMBER	DEMAND	ELEVATION	CONNECTING PIPES		
1	.00	.00	1	3	
2	.00	.00	3	4	7
3	.00	.00	4	5	
4	.00	.00	5	6	
5	1.00	760.10	6		
6	.00	.00	7	8	10
7	.00	.00	8	9	
8	1.00	761.10	9		
9	.00	.00	10	11	13
10	.00	.00	11	12	
11	1.00	761.10	12		
12	.00	.00	2	14	
13	.00	.00	13	14	15
14	.00	.00	15	16	18
15	.00	.00	16	17	
16	873.00	760.10	17		
17	.00	.00	18	19	
18	2883.00	761.10	19		

OUTPUT SELECTION: ALL RESULTS ARE OUTPUT EACH PERIOD

THIS SYSTEM HAS 19 PIPES WITH 18 JUNCTIONS , 0 LOOPS AND 2 FGNS

THE RESULTS ARE OBTAINED AFTER 2 TRIALS WITH AN ACCURACY = .00000

RBS NPSH analysis for OSC-4467, Rev. 2. Model taken from OSC-1977, modified by removal of minor loss from 3BS-6, and addition of minor loss from sump inlet reducer. Sump temperature is 240F. No RB pressure.

PIPE NO.	NODE NOS.		FLOWRATE	HEAD LOSS	PUMP HEAD	MINOR LOSS	VELOCITY	HL/1000
LINE	1 IS CLOSED							
2	0	12	3759.00	.19	.00	.77	5.09	3.54
3	1	2	.00	.00	.00	.00	.00	.00
4	2	3	1.00	.00	.00	.00	.00	.00
5	3	4	1.00	.00	.00	.00	.00	.00
6	4	5	1.00	.00	.00	.00	.01	.00
7	2	6	-1.00	.00	.00	.00	.00	.00
8	6	7	1.00	.00	.00	.00	.00	.00
9	7	8	1.00	.00	.00	.00	.00	.00
10	6	9	-2.00	.00	.00	.00	.00	.00
11	9	10	1.00	.00	.00	.00	.00	.00
12	10	11	1.00	.00	.00	.00	.00	.00
13	9	13	-3.00	.00	.00	.00	-.01	.00
14	12	13	3759.00	.32	.00	.98	8.42	12.88
15	13	14	3756.00	.41	.00	1.36	8.42	12.86
16	14	15	873.00	.04	.00	.35	3.39	3.03
17	15	16	873.00	.06	.00	.09	5.40	9.91
18	14	17	2883.00	.18	.00	.49	6.46	7.65
19	17	18	2883.00	.08	.00	.18	7.85	12.58

JUNCTION NUMBER	DEMAND	GRADE LINE	ELEVATION	PRESSURE
1	.00	780.24		
2	.00	780.24		
3	.00	780.24		
4	.00	780.24		
5	1.00	780.24	760.10	8.27
6	.00	780.24		
7	.00	780.24		
8	1.00	780.24	761.10	7.86
9	.00	780.24		
10	.00	780.24		
11	1.00	780.24	761.10	7.86
12	.00	781.54		
13	.00	780.24		
14	.00	778.47		
15	.00	778.08		
16	873.00	777.93	760.10	7.32
17	.00	777.80		
18	2883.00	777.55	761.10	6.75

THE NET SYSTEM DEMAND = 3759.00

SUMMARY OF INFLOWS(+) AND OUTFLOWS(-) FROM FIXED GRADE NODES

PIPE NUMBER	FLOWRATE
2	3759.00

THE NET FLOW INTO THE SYSTEM FROM FIXED GRADE NODES = 3759.00
THE NET FLOW OUT OF THE SYSTEM INTO FIXED GRADE NODES = .00

A SUMMARY OF CONDITIONS SPECIFIED FOR THE NEXT SIMULATION FOLLOWS

THE RESULTS ARE OBTAINED AFTER 1 TRIALS WITH AN ACCURACY = .00000

LINE 1 IS CLOSED

PIPE NO.	NODE NOS.		FLOWRATE	HEAD LOSS	PUMP HEAD	MINOR LOSS	VELOCITY	HL/1000
2	0	12	3759.00	.19	.00	.77	5.09	3.54
3	1	2	.00	.00	.00	.00	.00	.00
4	2	3	1.00	.00	.00	.00	.00	.00
5	3	4	1.00	.00	.00	.00	.00	.00
6	4	5	1.00	.00	.00	.00	.01	.00
7	2	6	-1.00	.00	.00	.00	.00	.00
8	6	7	1.00	.00	.00	.00	.00	.00
9	7	8	1.00	.00	.00	.00	.00	.00
10	6	9	-2.00	.00	.00	.00	.00	.00
11	9	10	1.00	.00	.00	.00	.00	.00
12	10	11	1.00	.00	.00	.00	.00	.00
13	9	13	-3.00	.00	.00	.00	-.01	.00
14	12	13	3759.00	.32	.00	.98	8.42	12.88
15	13	14	3756.00	.41	.00	1.36	8.42	12.86
16	14	15	873.00	.04	.00	.35	3.39	3.03
17	15	16	873.00	.06	.00	.09	5.40	9.91
18	14	17	2883.00	.18	.00	.49	6.46	7.65
19	17	18	2883.00	.08	.00	.18	7.85	12.58

JUNCTION NUMBER	DEMAND	GRADE LINE	ELEVATION	PRESSURE
1	.00	780.24		
2	.00	780.24		
3	.00	780.24		
4	.00	780.24		
5	1.00	780.24	760.10	8.27
6	.00	780.24		
7	.00	780.24		
8	1.00	780.24	761.10	7.86
9	.00	780.24		
10	.00	780.24		
11	1.00	780.24	761.10	7.86
12	.00	781.54		
13	.00	780.24		
14	.00	778.47		
15	.00	778.08		
16	873.00	777.93	760.10	7.32
17	.00	777.80		
18	2883.00	777.55	761.10	6.75

THE NET SYSTEM DEMAND = 3759.00

SUMMARY OF INFLOWS(+) AND OUTFLOWS(-) FROM FIXED GRADE NODES

PIPE NUMBER	FLOWRATE
2	3759.00

THE NET FLOW INTO THE SYSTEM FROM FIXED GRADE NODES = 3759.00
THE NET FLOW OUT OF THE SYSTEM INTO FIXED GRADE NODES = .00

NPSH REQUIREMENTS FOR RBS & LPI OPERATION
AT ELEVATED SUMP TEMPERATURES

SUMP TEMP (F)	NPSHr (Ref. 8.14) RBS (FT)	NPSHr Corrected RBS (FT)	NPSH AVAILABLE RBS (FT)	NPSHr (Ref. 8.15) LPI 13	NPSHr Corrected LPI (FT)	NPSH AVAILABLE LPI (FT)	NPSH REDUCTION FACTOR* (FT)
195	20	19.50	33.38	13	12.50	32.11	0.50
200	20	19.40	31.86	13	12.40	30.58	0.60
205	20	19.30	30.03	13	12.30	28.76	0.70
210	20	19.25	27.93	13	12.25	26.67	0.75
215	20	19.15	25.71	13	12.15	24.45	0.85
220	20	19.10	23.70	13	12.10	22.44	0.90
225	20	19.00	21.23	13	12.00	19.97	1.00
230	20	18.90	19.88	13	11.90	18.61	1.10
235	20	18.75	21.32	13	11.75	20.05	1.25
236.3	20	18.72	25.81	13	11.72	24.54	1.28

Assumptions:
LPI train B on and flowing 3291 gpm.
RBS train B on and flowing 1150 gpm.
All flow coming through sump line B.

SUMP TEMP (F)	NPSHr (Ref. 8.14) RBS (FT)	NPSHr Corrected RBS (FT)	NPSH AVAILABLE RBS (FT)	NPSHr (Ref. 8.15) LPI (FT)	NPSHr Corrected LPI (FT)	NPSH AVAILABLE LPI (FT)	NPSH REDUCTION FACTOR* (FT)
195	15	14.50	30.59	11	10.50	29.22	0.50
200	15	14.40	28.59	11	10.40	27.21	0.60
205	15	14.30	26.62	11	10.30	25.25	0.70
210	15	14.25	24.37	11	10.25	23.00	0.75
215	15	14.15	22.04	11	10.15	20.66	0.85
220	15	14.10	20.38	11	10.10	18.99	0.90
225	15	14.00	19.84	11	10.00	18.46	1.00
230	15	13.90	19.44	11	9.90	18.07	1.10
235	15	13.75	21.00	11	9.75	19.62	1.25
236	15	13.73	22.26	11	9.73	20.88	1.27
237.5	15	13.70	39.66	11	9.70	38.28	1.30

Assumptions:
LPI train B on and flowing 2883 gpm.
RBS train B on and flowing 873 gpm.
All flow coming through sump line B.

* NPSH reduction factor is found in Ref. 8.36.

BUILDING PRESSURE REQUIREMENTS FOR RBS & LPI OPERATION
AT ELEVATED SUMP TEMPERATURES

SUMP TEMP (F)	BUILDING PRESSURE REQUIRED RBS (PSIG)	AVAILABLE RBS (PSIG)	REQUIRED LPI (PSIG)	AVAILABLE LPI (PSIG)
195	-1.71	4.10	-4.11	4.10
200	-0.61	4.60	-3.01	4.60
205	0.58	5.05	-1.81	5.05
210	1.90	5.50	-0.48	5.50
215	3.33	6.05	0.95	6.05
220	4.90	6.80	2.53	6.80
225	6.58	7.50	4.21	7.50
230	8.39	8.80	6.04	8.80
235	10.34	11.40	7.99	11.40
236.3	10.88	13.80	8.52	13.80

Assumptions: LPI train B on and flowing 3291 gpm.
RBS train B on and flowing 1150 gpm.
All flow coming through sump line B.

SUMP TEMP (F)	BUILDING PRESSURE REQUIRED RBS (PSIG)	AVAILABLE RBS (PSIG)	REQUIRED LPI (PSIG)	AVAILABLE LPI (PSIG)
195	-4.63	2.10	-5.73	2.10
200	-3.54	2.40	-4.63	2.40
205	-2.33	2.80	-3.43	2.80
210	-1.00	3.20	-2.09	3.20
215	0.43	3.70	-0.66	3.70
220	2.01	4.60	0.93	4.60
225	3.69	6.10	2.61	6.10
230	5.52	7.80	4.44	7.80
235	7.47	10.45	6.39	10.45
236	7.89	11.40	6.81	11.40
237.5	8.52	19.20	7.44	19.20

Assumptions: LPI train B on and flowing 2883 gpm.
RBS train B on and flowing 873 gpm.
All flow coming through sump line B.

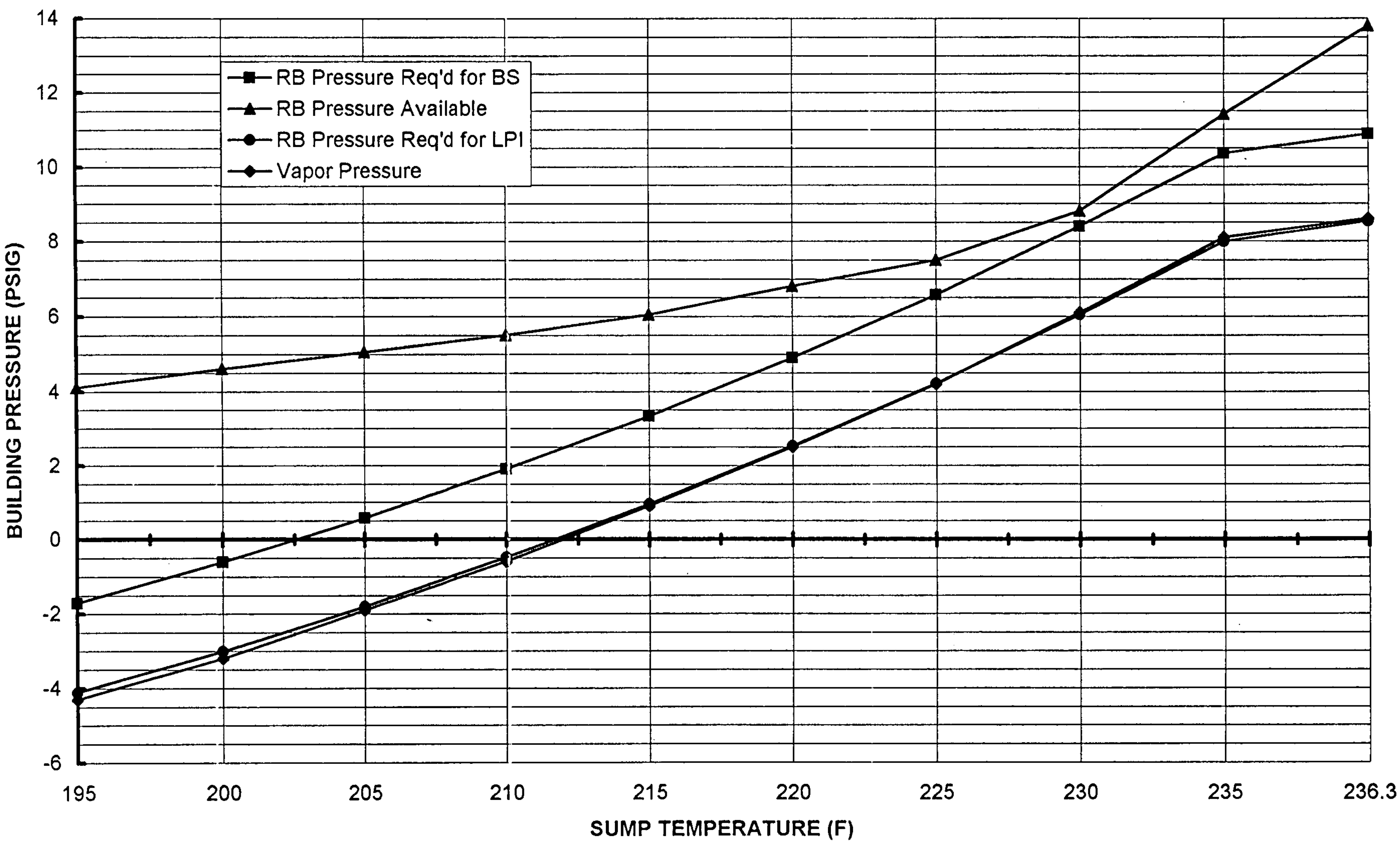
Note: Minimum available pressure is found in Ref. 8.22 (shown as Pb on page 3 of this attachment). A reduction of 0.2 psi is applied to account for operating variance in reactor building pressure. Required building pressure is found by computing NPSHa without credit for building pressure, subtracting NPSHa from NPSHr, then converting the result to psi. See page 3 for values.

DETERMINATION OF NPSHa

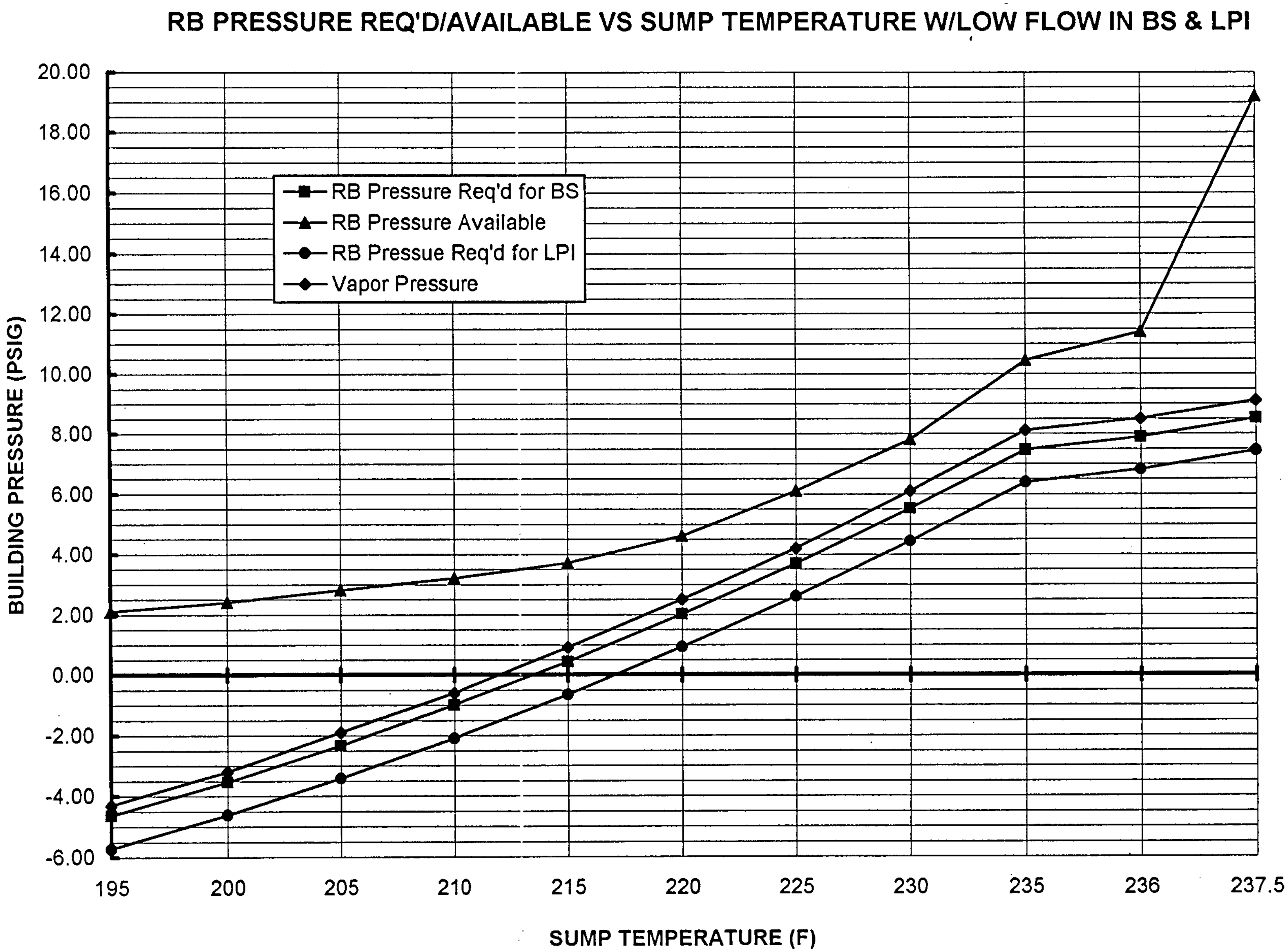
NPSHa = (Pb-0.2) x C + Pa x C + Hs - hf - Psat x C

Sump Temperature	Pb	C	Pa	Hs	hf	Psat	NPSHa
			RBS @ 1150 GPM:				
195	4.30	2.39	14.20	21.05	6.57	10.39	33.38
200	4.80	2.39	14.20	21.05	6.57	11.53	31.86
205	5.25	2.40	14.20	21.05	6.57	12.77	30.03
210	5.70	2.41	14.20	21.05	6.57	14.12	27.93
215	6.25	2.41	14.20	21.05	6.57	15.59	25.71
220	7.00	2.42	14.20	21.05	6.57	17.19	23.70
225	7.70	2.42	14.20	21.05	6.57	18.91	21.23
230	9.00	2.43	14.20	21.05	6.56	20.78	19.88
235	11.60	2.43	14.20	21.05	6.56	22.79	21.32
236.3	14.00	2.43	14.20	21.05	6.56	23.34	25.81
			LPI @ 3291 GPM:				
195	4.30	2.39	14.20	20.05	6.84	10.39	32.11
200	4.80	2.39	14.20	20.05	6.84	11.53	30.58
205	5.25	2.40	14.20	20.05	6.84	12.77	28.76
210	5.70	2.41	14.20	20.05	6.83	14.12	26.67
215	6.25	2.41	14.20	20.05	6.83	15.59	24.45
220	7.00	2.42	14.20	20.05	6.83	17.19	22.44
225	7.70	2.42	14.20	20.05	6.83	18.91	19.97
230	9.00	2.43	14.20	20.05	6.83	20.78	18.61
235	11.60	2.43	14.20	20.05	6.83	22.79	20.05
236.3	14.00	2.43	14.20	20.05	6.83	23.34	24.54
			RBS @ 873 GPM:				
195	2.30	2.39	14.20	21.05	4.58	10.39	30.59
200	2.60	2.39	14.20	21.05	4.58	11.53	28.59
205	3.00	2.40	14.20	21.05	4.58	12.77	26.62
210	3.40	2.41	14.20	21.05	4.58	14.12	24.37
215	3.90	2.41	14.20	21.05	4.58	15.59	22.04
220	4.80	2.42	14.20	21.05	4.57	17.19	20.38
225	6.30	2.42	14.20	21.05	4.57	18.91	19.84
230	8.00	2.43	14.20	21.05	4.57	20.78	19.44
235	10.65	2.43	14.20	21.05	4.57	22.79	21.00
236	11.60	2.43	14.20	21.05	4.57	23.22	22.26
237.5	19.40	2.43	14.20	21.05	4.57	23.86	39.66
			LPI @ 2883 GPM:				
195	2.30	2.39	14.20	20.05	4.96	10.39	29.22
200	2.60	2.39	14.20	20.05	4.96	11.53	27.21
205	3.00	2.40	14.20	20.05	4.96	12.77	25.25
210	3.40	2.41	14.20	20.05	4.96	14.12	23.00
215	3.90	2.41	14.20	20.05	4.96	15.59	20.66
220	4.80	2.42	14.20	20.05	4.96	17.19	18.99
225	6.30	2.42	14.20	20.05	4.96	18.91	18.46
230	8.00	2.43	14.20	20.05	4.95	20.78	18.07
235	10.65	2.43	14.20	20.05	4.95	22.79	19.62
236	11.60	2.43	14.20	20.05	4.95	23.22	20.88
237.5	19.40	2.43	14.20	20.05	4.95	23.86	38.28

RB PRESSURE REQ'D/AVAILABLE VS SUMP TEMP W/ HIGH FLOW IN BS & LPI



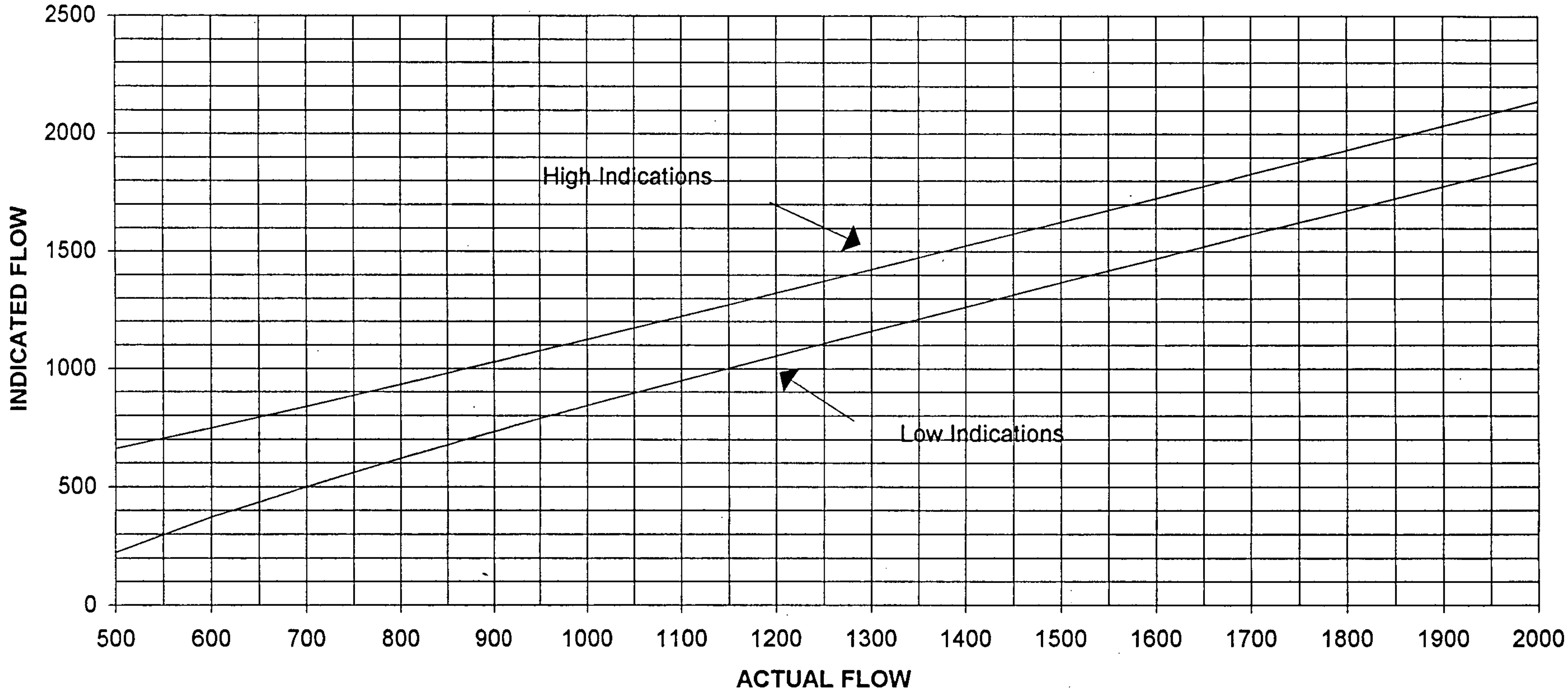
(ASSUMES 3291 GPM LPI AND 1150 GPM RBS)



(ASSUMES 2883 GPM LPI AND 873 GPM RBS)

UNIT 2&3 BS FLOW UNCERTAINTY

(Data Taken From OSC-4084)



DUKE POWER COMPANY

Form 00184 (6-81)

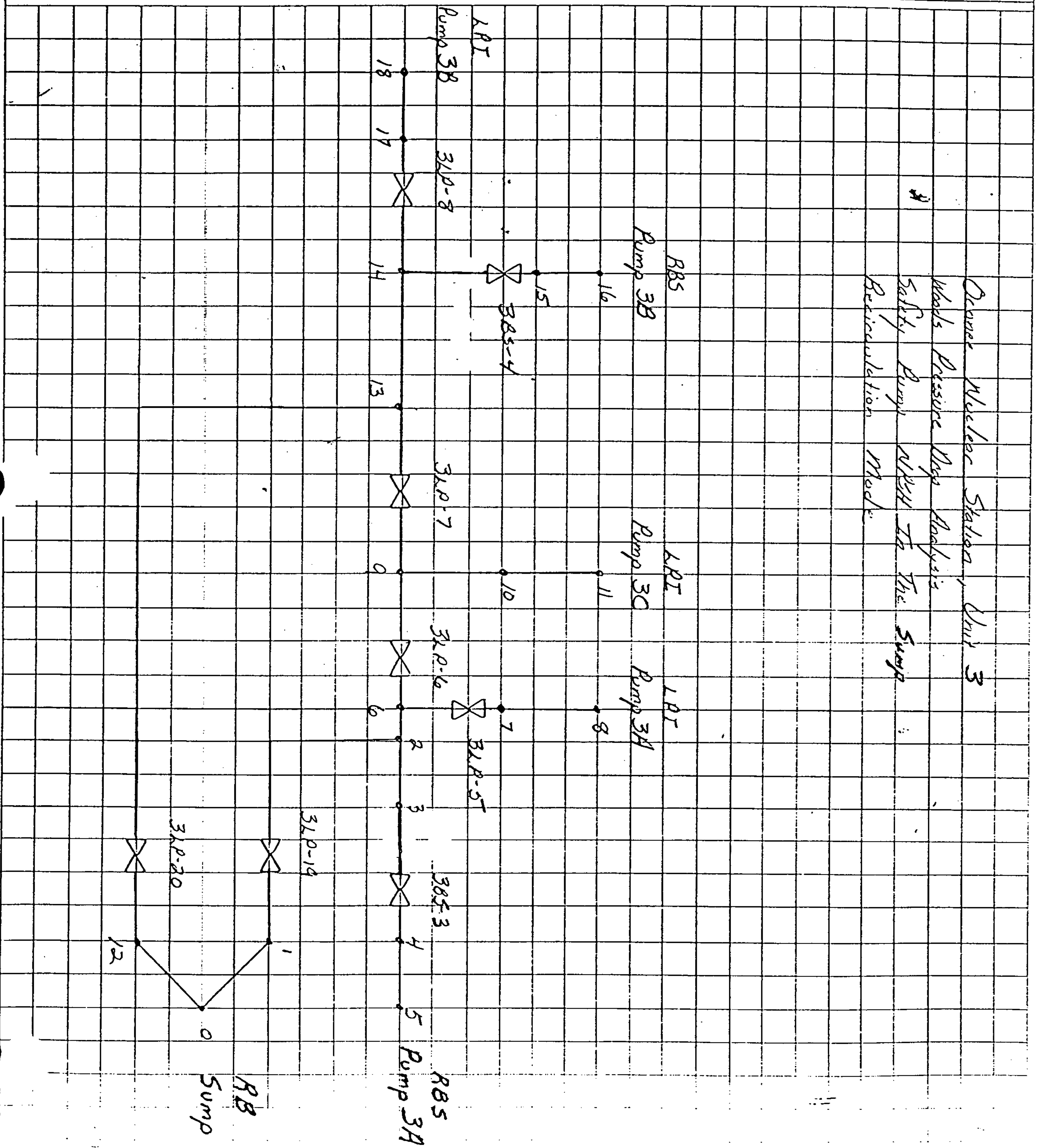
OSC-4467, Rev. 2
Attachment 6
Page 1 of 1

Dev./Station Oconee Nuclear Station Unit 3 File No. OS-210.02, -.03

Subject Safety Pump NPSH Analysis in the Sump Recirculation Mode

By [signature] Date 11-6-84

Sheet No. 12 of ____ Problem No. OSC-1977 Checked By [signature] Date 11-13-84



Post-it® Fax Note 7671	Date 3-26	# of pages ▶ 4
To Russ Oakley	From Tom Yadon	
Co./Dept. ONS	Co. NGO	
Phone # 885-3829	Phone # 382-7637	
Fax # 885-3411	Fax # 382-7852	

OSC-4467, Rev. 1
Attachment 7
Page 1 of 4

ONS Hot Leg Break Analysis

Building Pressure Vs. Sump Temperature for Building NPSH

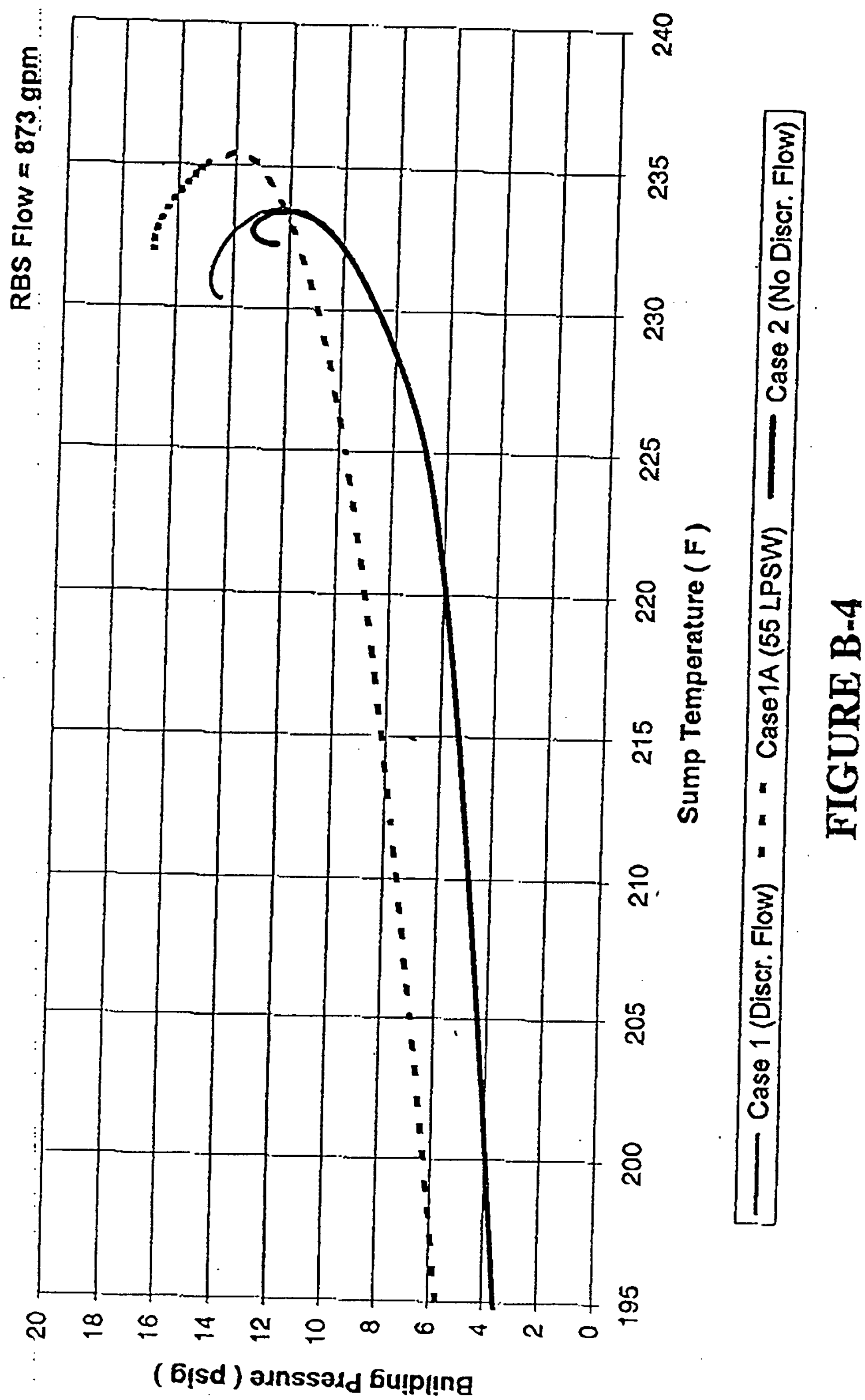


FIGURE B-4

OSC-4467, Rev. 1
Attachment 7
Page 2 of 4

ONS Hot Leg Break Analysis

Building Pressure Vs. Sump Temperature for Building NPSH

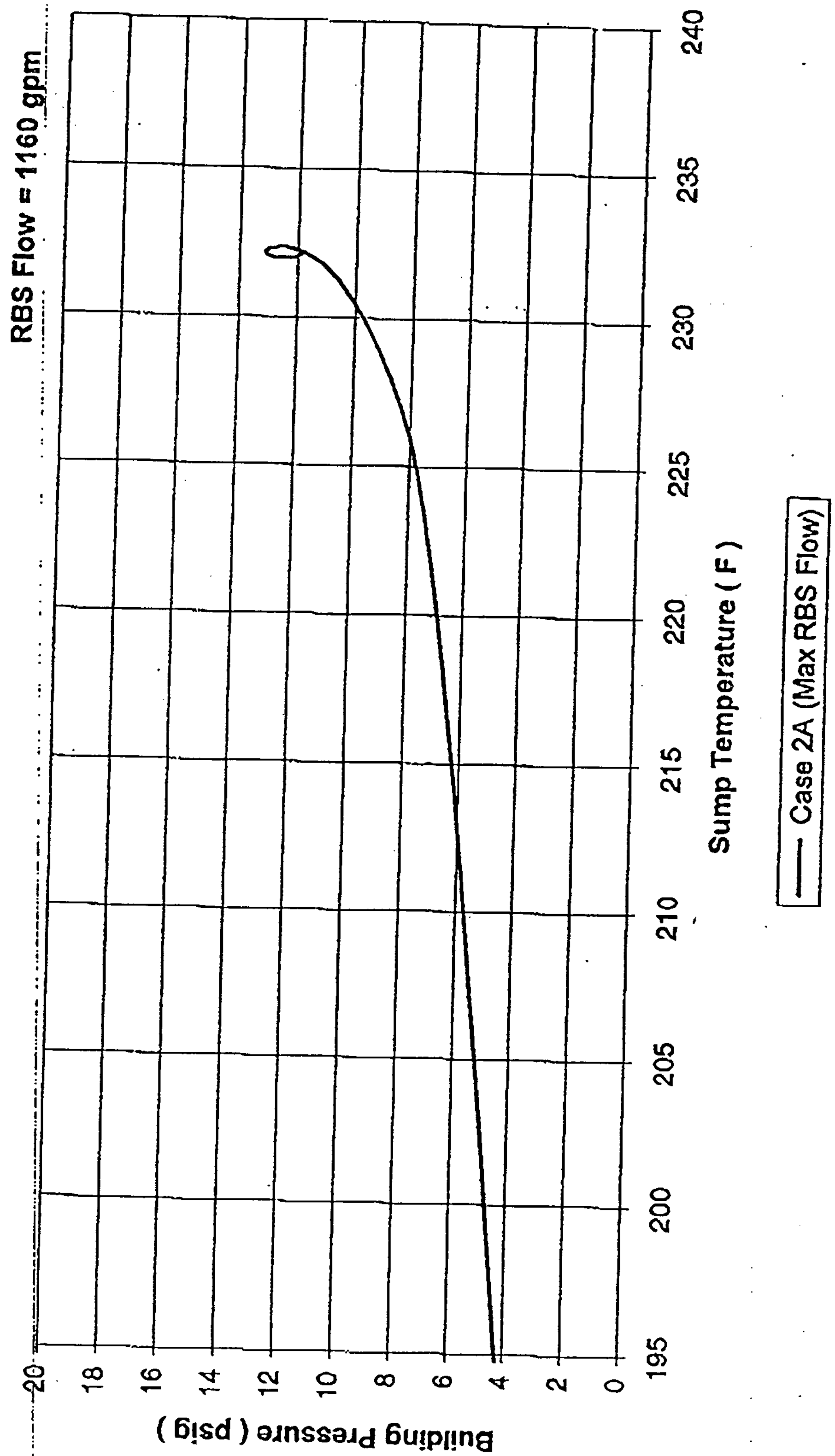


FIGURE B-5

OSC-4467, Rev. 1
Attachment 7
Page 3 of 4

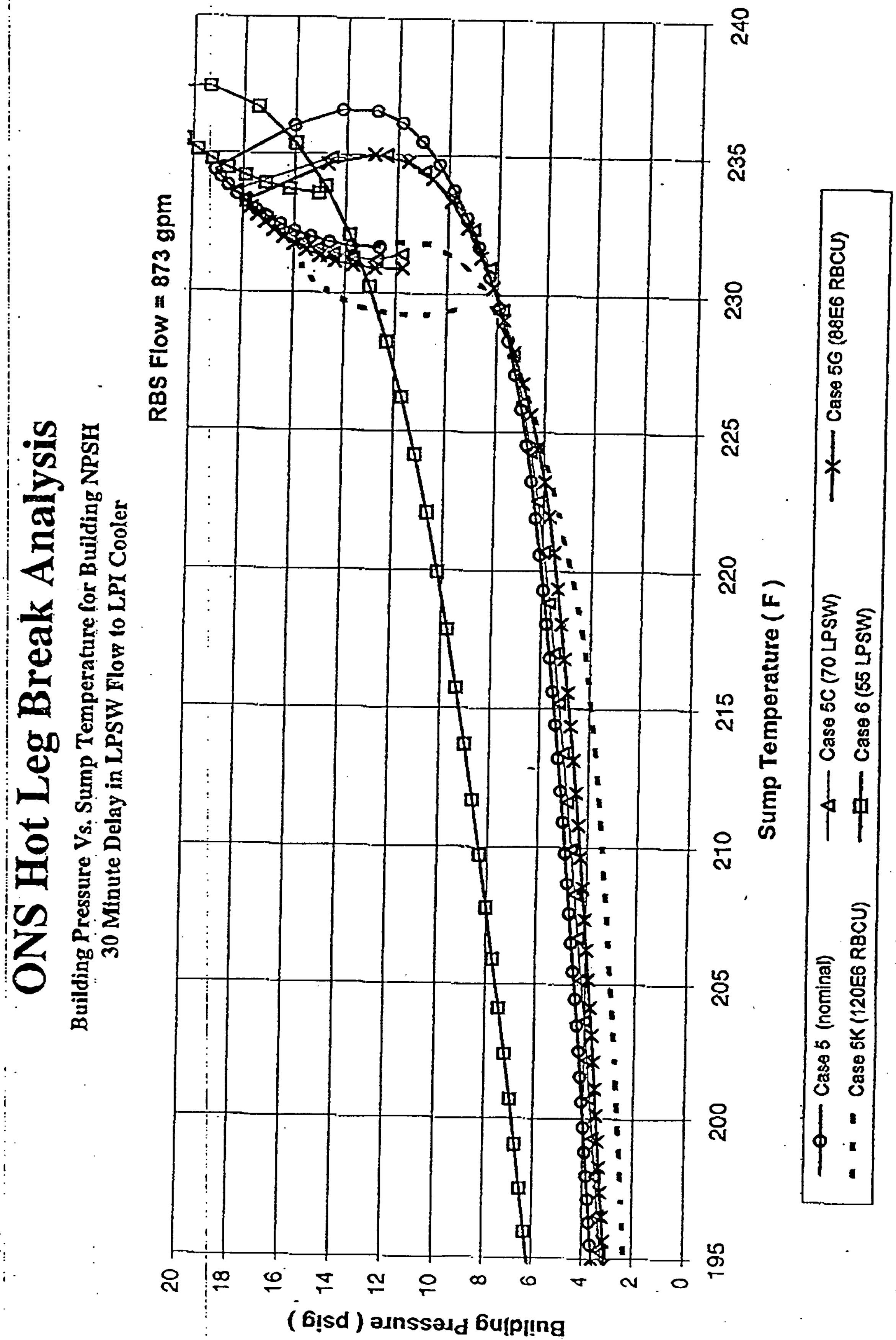


FIGURE B-6

OSC-4467, Rev. 1
Attachment 7
Page 4 of 4

ONS Hot Leg Break Analysis

Building Pressure Vs. Sump Temperature for Building NPSH
30 Minute Delay in LPSW Flow to LPI Cooler

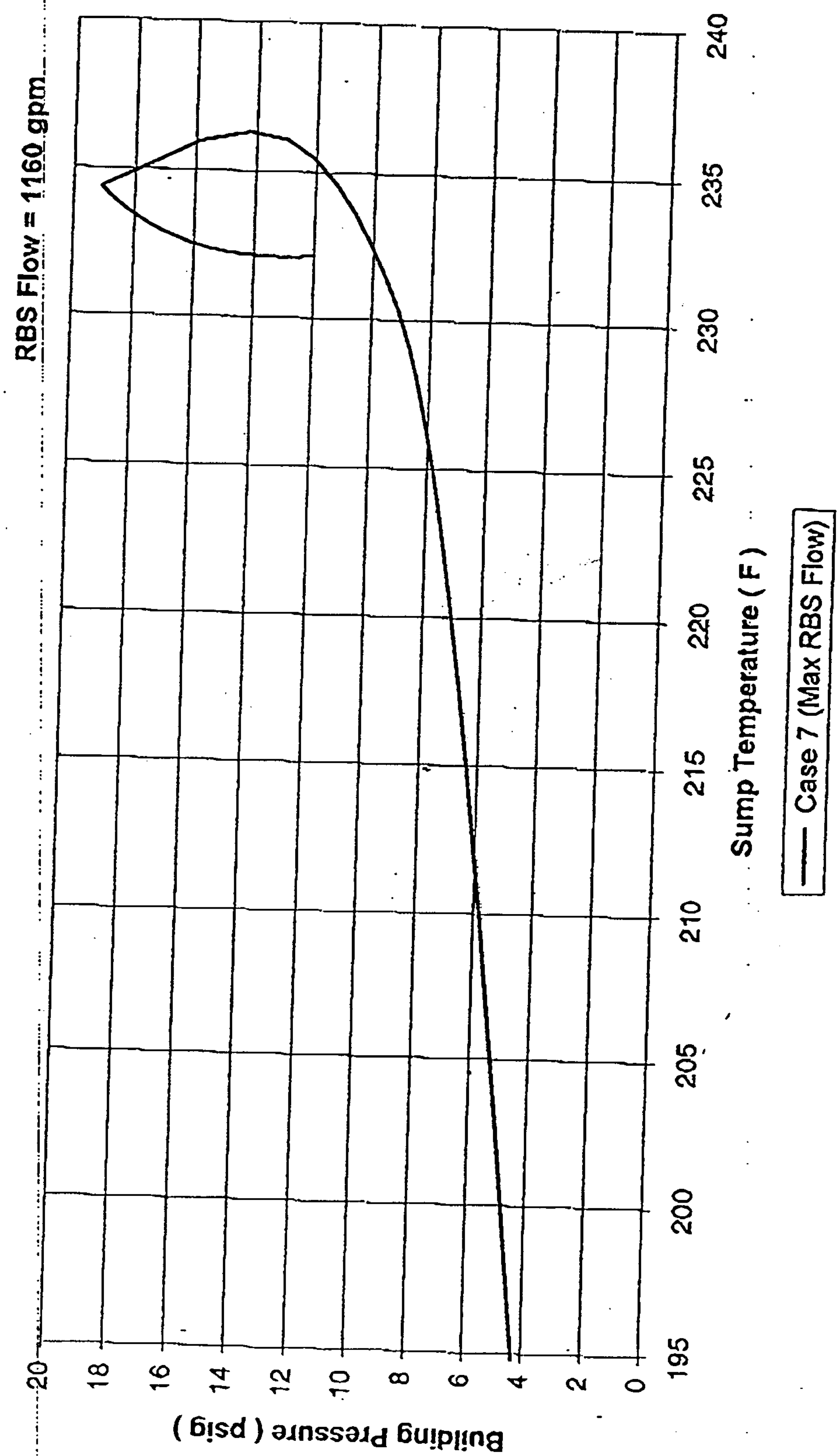


FIGURE B-7

From: TPY8371 --PRDC Date and time 04/16/96 11:36:02
To: RLO8372 --PRDC

Subject: ONS Building Spray NPSH

Ref: PROFS Note, R.L. Oakley to T.P. Yadon, 12/15/94

In the referenced note, you requested that Safety Analysis provide data for the building response with RBS actuation which yielded conservative results with respect to NPSH. In a response to that note, on 12/21/94, we stated that the cold leg break analyses already documented at that time were not limiting with respect to NPSH, and that a hot leg break analysis would be necessary to provide lower post-accident building pressures and higher sump temperatures.

With the completion of revised LPI and BS flow uncertainty calculations, we were able to complete these hot leg break analyses. They are documented in OSC-6521, Appendix B. This calculation is titled, "Containment Response with 30 Minute Delay in LPSW Flow". This delay has an impact on the building response following sump re-circ initiation, which impacts the limiting NPSH conditions.

At the bottom of the first paragraph of this Appendix, it states, "This hot leg break scenario creates a combination of low post-accident building pressures and warm sump temperatures, which is more limiting for NPSH concerns than that (combination) created by the cold leg break." Various building cooling assumptions were made in the analyses documented in OSC-6521, and the figures contained within the appendix give a bounding response with respect to NPSH.

Note: The completion of these analyses closes out corrective action #2 in PIP 4-091-0054.

Let me know if these are more questions or concerns regarding this issue.

Tom Yadon - Safety Analysis
Nuclear Engineering

DUKE POWER COMPANY
Form 00184 (6-81)

Dev./Station Oconee Nuclear Station Unit 3 File No. OS-220.02, -.03
Subject Safety Pump NPSH Analysis in The Sump Recirculation Mode
By DNB Date 10-29-84
Sheet No. 19 of ___ Problem No. OSC-1977 Checked By STN Date 11-13-84

Pipe 0-1

18" Sch 20

✓ ~~Bell shaped reducer inlet~~ 18" X 30" 45° Reducer Inlet

1-6

✓ Short radius 90° elbow

25-7

✓ 48°-31' elbow cut from 90° long radius elbow (assume 45° elbow)

3-1

✓ 41°-69' elbow cut from 90° long radius elbow (assume 45° elbow)

✓ Long radius 90° elbow

Pipe

37-1

Minor loss coefficients

✓ 1-Long radius 90° elbow	0.17	
✓ 1-Short radius 90° elbow	0.24	
✓ 2-Long radius 45° elbow 2(0.20)	0.40	
Entrance losses	~~0.10~~	1.1
	~~0.91~~	1.91

Pipe 1-2

14" Sch 10

18 x 14 reducer (15' pipe equivilent)

14" gate valve

9-0

Tee 14x14x14 branch

Pipe

24-0

DUKE POWER COMPANY
Form 00184 (6-81)

Dev./Station Oconee Nuclear Station Unit 3 File No. OS-310.03, -.03
Subject Safety Pump NPSH Analysis in The Sump Recirculation Mode By [illegible] Date 10-29-84
Sheet No. 24 of ___ Problem No. OSC-1977 Checked By [illegible] Date 11-13-84

Pipe 10-11

12 Sch 20

Reducer 14x12 (6' equivilent)
0-6
Long radius 90° elbow

Pipe
16-6
Minor loss coefficient
1-Long radius 90° elbow = 0.19

Pipe 9-13

14" Sch 10

Tee 14x14x14 thru
14" gate valve

Pipe
0.1
Minor loss coefficient
1- Tee 14x14x14 thru = 0.26
1- 14" gate valve = 0.11
0.37

Pipe 0-12

18" Sch 20

~~Bell shaped reducer inlet~~ 18" x 30" 45° Reducer Inlet
1-6
Short radius 90° elbow
25-7
48°-31' elbow cut from 90° long radius elbow (ie ≅ 45° elbow)
3-1
41°-69' elbow cut from 90° long radius elbow (ie ≅ 45° elbow)
16-4

Form 00184 (6-81) DUKE POWER COMPANY

Dev./Station Oconee Nuclear Station Unit 3 File No. 03-210.02, .03
Subject Safety Pump NPSH Analysis in The Sump Recirculation Mode By DMB Date 10-29-84
Sheet No. 25 of ___ Problem No. OSC-1477 Checked By SLN Date 11-13-84

Pipe 0-12 (cont)

18" Sch 20

Long radius 90° elbow
6-10

Pipe
53-4

Minor loss coefficients

1-Long radius 90° elbow	= 0.17	
1-Short radius 90° elbow	= 0.24	
2-Long radius 45° elbow 2(0.20)	= 0.40	
Entrance loss	= ~~0.10~~	1.1
	~~0.91~~	1.91

Pipe 12-13

14" Sch 10

Reducer 18x14 (15' pipe equivilent)
14" gate valve
9-9
Tee 14x14x14 branch

Pipe
24-9

Minor loss coefficient

1-Tee 14x14x14 branch	= 0.78
1-14 gate valve	= 0.11
	0.89

Dev./Station Oconee Nuclear Station Unit 3 File No. OS-210.02, -.03
Subject Safety Pump NPSH Analysis in The Sump Recirculation Mode By DNS Date 10-29-84
Sheet No 21 of ____ Problem No. OSC-1977 Checked By SLn Date 11-13-84

Pipe 14-15 (cont)

10" Sch 20

Pipe

14-8

Minor piping losses

1- Tee 14x14x10 branch	=	0.84
1- Tee 10x10x3 thru	=	0.28
1- 10" gate valve	=	0.12
~~1- 10" swing check valve~~	=	~~0.70~~
1- Expansion joint	=	0.30
2- Long radius 90° elbow 2(0.20)	=	0.40
		~~2.64~~ 1.94

Pipe 15-16

8" Sch 20

Reducing elbow 10"x8" (model as 10x8 reducer 6' pipe equivilent and a long radius 90° elbow)

Pipe

6-0

Minor loss coefficient

1- Long radius 90° elbow = 0.20

Pipe 14-17

14" Sch 10

Tee 14x14x14 thru

13-7

Long radius 90° elbow ✓

14" gate valve

8-8

Long radius 90° elbow ✓

1-3

DETERMINATION OF VOLUME TRAPPED IN REACTOR VESSEL CAVITY

During the assumed LOCA , water will enter the reactor vessel annulus between the vessel and the primary shield wall as well as the cavity below the reactor vessel due to reactor building spray initiation. A small amount of water will accumulate on the shallow end of the fuel transfer canal floor. This water will be just enough to create flow through the vessel seal plate annulus equal to the spray flow coming into the FTC shallow end. This flow then passes into the vessel annulus area underneath. Drain lines are located within the reactor vessel annulus which empty into the cavity below the reactor vessel. There will be some residual level above the annulus drain required in order to pass the assumed BS flow from the annulus to the cavity below the vessel. A drain line is located within the cavity underneath the vessel, which leads to the normal sump. Removal of flanges from the end of these drain lines (on all units) will allow the water level in the vessel cavity to nearly equalize with that in the Reactor Building basement if flow rates are small. The difference in elevations will be equal to the head loss through the drain line at the assumed inflow to the vessel cavity from the BS system. The access door and ladder cavity will be assumed to fill with water, even though the outer access door is not water tight. (Mr. Jim Turner of QC reports that there is approximately a ¼" clearance around this door on the three sides opposite the hinge side, and a slightly smaller clearance on the hinge side.) Nevertheless, since the shield bricks provide partial blockage of this flow path, it will not be credited as a flowpath.

Flow Rate Into Vessel Annulus:

Flow rate into vessel annulus from BS system will be assumed to be in proportion to the area of BS flow coverage represented by the FTC shallow end. All BS flow falling into the deep end will be assumed to drain to the normal sump. The BS system is throttled to 1000 gpm prior to sump recirculation alignment. With instrument error, the flow rate is potentially as high as 1160 gpm (Ref. 8.7). A single train of BS flow will be assumed for consistency with the single failure assumption used in the hot leg break analysis (Ref. 8.22). The area covered by the BS spray pattern is approximated as:

$Abs = \pi Dsh^2/4$

Dsh is taken as the diameter of the smallest circle which would cover all nozzles of a single header, which is conservatively 100 ft. per Ref. 8.31 (typical for all units). No credit is taken for the additional spray area created by the fan-shaped expansion of the flow stream exiting the perimeter nozzles. Therefore,

$Abs = \pi(100)^2/4 = 7854\ ft^2$

The area of the shallow end of the transfer canal is given by the product of the length and width, which are as follows:

Lse = 52.0 ft. (Ref. 8.29)
Wse = 24 ft. (Ref. 8.29)
$Ase = Lse \times Wse = 52.0 \times 24.0 = 1248\ ft^2$

Then:

Qse = Qbs x Ase/Abs = 1160 x 1248/7854 = 184 gpm

Conservatively assume all of this flow passes through the vessel seal plate gap and into the vessel annulus area (ie, no flow to deep end of FTC).

Volume Trapped On FTC Shallow End Floor (Vse):

Ref. 8.43 shows the details of the annulus around the vessel flange, as follows:

Outside Radius, Ro = 8'-8" = 104"
Inside Radius, Ri = 8'-7" = 103"
Flow Area, $A = \pi (Ro^2 - Ri^2) = 650.3 \text{ in}^2$
Flow perimeter, $P = 2\pi Ro = 653$ in. = 54.42 ft.

Flow through this annulus will be appoximated by assuming weir flow over a weir of width equal to the perimeter of the annulus. From Cameron Hydraulic Data, Seventeenth Edition, Copyright 1988 by Ingersoll-Rand Company, page 2-10, a weir will pass a flow as given by the following relationship:

$$Q = 3.33 (L - 0.2 H)H^{1.5}$$

where Q = flow in cubic feet per second = 184 gal/min x 1/60 min/sec x 1/7.48 ft^3/gal = 0.41 ft^3/sec
L = length of weir in feet = 54.42 ft
H = height of water in feet

Solving for H in the above equation, we find that:

$$0.41 = 3.33 (54.42 - 0.2H) H^{1.5}$$
$$0.123 H^{-1.5} = 54.42.- 0.2H$$
$$0.123 H^{-1.5} + 0.2H - 54.42 = 0$$

Solving for H, we find :

H = 0.0172 ft.

Water trapped on the shallow end floor is then given by :

Vse = L x W x H

where: L = Length of shallow end = 52.0 ft. (Ref. 8.29)
W = Width of shallow end = 24.0 ft. (Ref. 8.29)
H = depth of water in shallow end, given above

So, Vse = 52.0 x 24.0 x 0.0172 = 21.47 ft^3

Volume Trapped in the Stairwell Area (V1):

This volume will be unchanged from that determined in Rev. 2, which assumed the stairwell area filled completely. See page 6 of this attachment.

V1 = 125.5 ft^3

Volume Trapped Below Reactor Vessel And Incore Tunnel Entrance (V2):

Part of the water within the area below the reactor vessel and at the incore instrumentation entrance is assumed to be lost. This includes the additional depth required to overcome head losses from the discharge of the flow coming into the cavity from the annulus, as well as the portion of the cavity that is below the mean floor level (776.88 ft. See page 6 in main body of calculation). (The additional area of the cavity is added to the total building floor area elsewhere in the calculation to account for the water inside the cavity.) The 4", schedule 10 (Ref. 8.27 and 8.42) drain line will allow free communication between the volumes inside and outside of this area. Since both ends of the drain piping are submerged, there will be full flow in the line. The head losses in this line will be calculated based upon a flow of 184 gpm (as determined above). Head losses will be evaluated at a sump temperature of 230F, since this is the area of minimum NPSH margin.

L = 30.0 ft (Conservative for all 3 Units. See Ref. 8.27, 8.37, 8.42, 8.43)
D = 4.26 in = 0.355 ft
A = 0.09898 ft^2
V = Q/448.8A = 184/(448.8 x 0.09898) = 4.14 ft/sec
Re = $D V \rho / \mu$ = 0.355 x 4.14 x 59.35 / (0.2599 x 0.000672) = 499,429
f = 0.017

Pipe Losses (Hp): $= (fL/D)(V^2/2g)$
$= (0.017 \times 30 / 0.355)(4.14^2/(2 \times 32.2))$
= 0.38 ft

Elbow Losses (He) :

Assume two 45° elbows for conservatism.

$K = 16f_T = 16 \times 0.017 = 0.272$

$He = 2 \times KV^2/2g = KV^2/g = 0.272 \times 4.14^2 / 32.2 = 0.14$ ft

Entrance Loss (Hen): $= KV^2 / 2g$ (K = 0.5)
$= 0.5 \times 4.14^2 / (2 \times 32.2) = 0.13$ ft

Exit Loss (Hex): $= KV^2 / 2g$ (K = 1.0)
$= 4.14^2 / (2 \times 32.2) = 0.27$ ft

Total Friction Losses: = Piping Losses + Elbow Losses + Entrance Loss + Exit Loss
= 0.38 + 0.14 + 0.13 + 0.27 = 0.92 ft

Therefore, the water level in the cavity area needs to be 0.92 ft higher than the water level in the normal sump in order to make the drain flow equal to the inflow from the BS system. This water will reside in the 12 ft diameter space below the vessel. The volume of water trapped in this area that is below mean floor level also does not contribute to the final water level. The depth of this water is the difference between the cavity floor level (775.5 ft. from Ref. 8.24) and the mean floor level of 776.88 as determined

in the body of the calculation. This additional depth is then 776.88 - 775.5 = 1.38 ft. The total height of the the additional volumes of water held in the vessel cavity is then 0.92 + 1.38 = 2.30 ft. Volume of water retained in the circular portion of the vessel cavity is then given by:

$Vc = H \times \pi D^2/4$

where: H = depth of water as determined above = 2.30 ft.
D = diameter of vessel cavity area = 12 ft.

So:

$Vc = 2.30 \times \pi \times 12^2/4 = 260.1\ ft^3$

The additional volume of water in the incore trench portion of the cavity is given by:

$Vi = L \times W \times D$

where: L = length of incore tunnel = 9.62 ft. (Ref. 8.24)
W = width of incore tunnel = 10.0 ft. (Ref. 8.24)
D = depth of incore tunnel below mean floor level = 776.88 - 775.5 = 1.38 ft.

So:

$Vi = 9.62 \times 10.0 \times 1.38 = 132.8\ ft^3$

Now,

$V2 = Vc + Vi = 260.1 + 132.8 = 392.9\ ft^3$

Volume of Water Trapped in Annulus Area (V3):

Water level in the annulus area:

There are two reactor vessel foundation drain lines from the annulus area. Due to the low flow rate and large pipe diameter in these drains, the level retained in the annulus area is governed by the head loss through the two drain line cover plates. A flow rate of one half of the total flow, or 92 gpm will be passed through each drain. So, a head loss for one drain passing this amount of flow will be determined.

Details of the drains inlets are not available, but will be modeled as 6 x 3 reducers with an included angle of 45 degrees (see Ref. 8.37) which are covered with grid plates of the following description:

Thickness, t = 0.25 in. (note thickness is designated l in Reference 8.39)
Outside Diameter, D = 6.25 in.
Orifice dia., d = 0.4375 in.
Number of orifices, n = 37

The above information was measured by Russ Oakley on 12/21/97. The measurements were made on a floor drain just inside the reactor building hatch. Per Robbie Clamp of Bartlett, this drain cover is identical to those inside the vessel annulus. Mr. Clamp performed inspection and cleanup of the annulus area on 12/20/97 and observed the annulus drain covers first hand.

The following parameters can be found from the above information:

Cover Plate Area, $Ac = \pi D^2/4 = \pi \times 6.25^2/4 = 30.68\ in^2 = 0.213\ ft^2$ (denoted F_1 in Ref. 8.39)
Approach diameter, $D_a = 4.25$ in (Smallest diameter which encloses all orifices.)
Approach area, $A_a = \pi D_a^2/4 = \pi \times 4.25^2 / 4 = 14.19\ in^2 = 0.0985\ ft^2$
Approach Velocity to cover plate, $Vc = Q/448.8 \times Ac = 92 / (448.8 \times 0.0985) = 2.08$ ft/sec
Orifice area, $a_o = \pi d^2/4 = \pi \times 0.4375^2/4 = 0.15\ in^2$
Total Orifice Area, $A_o = n \times a_o = 37 \times 0.15 = 5.55\ in^2$ (denoted F_0 in Ref. 8.39)
Flow through each orifice, $Q_o = Q/n = 92 / 37 = 2.49$ gpm
Velocity through each orifice, $V_o = Q_o / (448.8 \times a_o) = 2.49 / (448.8 \times 0.15/144) = 5.33$ ft/sec

From Ref. 8.39, page 518, the following data can be found:

$F_1 = \pi D_a^2/4 = \pi \times 4.25^2/4 = 14.19\ in^2$
$F_0 = n \times f_o = 37 \times 0.15 = 5.55\ in^2$
$f^* = F_0 / F_1 = 5.55 / 14.19 = 0.39$ (denoted as f bar in the Ref. 8.39)
$t^* = t / d_h = t / d = 0.25 / 0.4375 = 0.57$ (denoted as l bar in the Ref. 8.39)

$$\varphi t^* = 0.25 + 0.535\,(t^*)^8 / [0.05 + (t^*)^7]$$
$$= 0.25 + 0.535 \times 0.57^8 / (0.05 + 0.57^7)$$
$$= 0.25 + 0.00596 / (0.05 + 0.0195) = 0.336$$

$$\tau = (2.4 - t^*)^{\varphi t^*} = (2.4 - 0.57)^{0.336} = 1.225$$

$\lambda = 0.03$ (friction factor at fully turbulent flow for pipe of diameter d, see Ref. 8.33)

$$K = [0.5(1-f^*)^{0.75} + \tau(1-f^*)^{1.375} + (1-f^*)^2 + \lambda/d_h)] / (f^*)^2$$
$$= [0.5(1-0.39)^{0.75} + 1.225(1-0.39)^{1.375} + (1-0.39)^2 + 0.03/0.4375] / 0.39^2$$
$$= [0.5(0.69) + 1.225(0.507) + 0.372 + 0.069] / 0.152$$
$$= [0.345 + 0.621 + 0.372 + 0.069] / 0.152 = 9.26$$

Minor loss through cover plate is then:

$$Hc = KV_1^2 / 2g = 9.26 \times 2.08^2 / (2 \times 32.2) = 0.62 \text{ ft}$$

The volume of water trapped in the annulus area is given by:

$V3 = A \times d$

where: A = the floor area in the annulus area
d = depth of water in the annulus area = 0.62 ft.

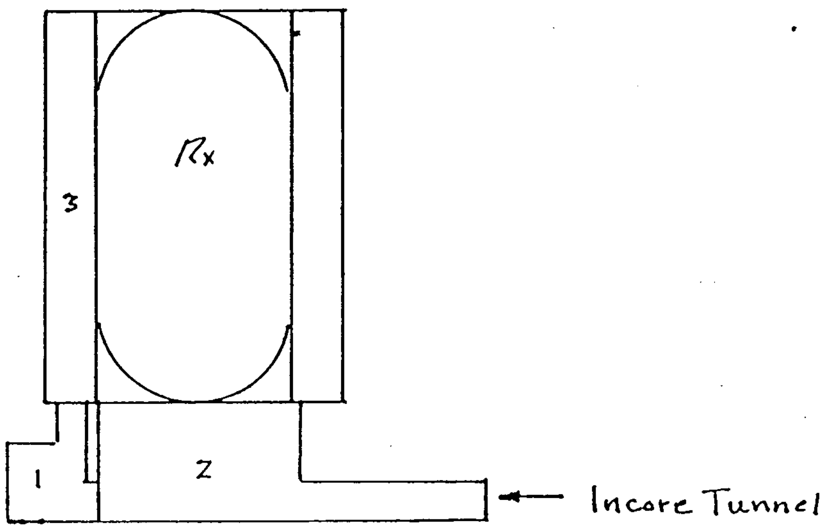
and $A = \pi[(23/2)^2 - (15.6/2)^2]$
$= \pi(132.25 - 60.84) = 224.34\ ft^2$

So: $V3 = 0.62 \times 224.34 = 139.1\ ft^3$

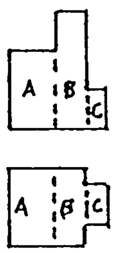
Total Volume = Vse + V1 + V2 + V3
= 21.47 + 125.5 + 392.9 + 139.1 = 679.0 ft^3

Vvc = 679.0 ft^3

Volume Trapped In Reactor Vessel Cavity

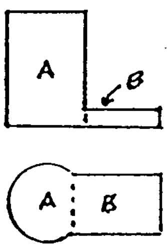


Volume 1:
0-68A Rev. 1B



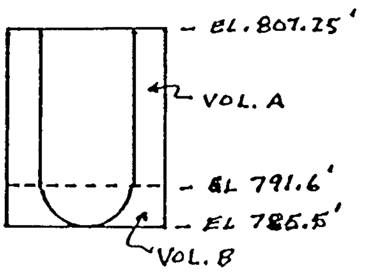
A: $1.17 \times 4 \times 4.2 = 19.6\ ft^3$
B: $9.48 \times 2.33 \times 4 = 88.4\ ft^3$
C: $2.5 \times 2.33 \times 3 = 17.5\ ft^3$
$125.5\ ft^3$

Volume 2:
0-68A, Rev. 1B



A = $\pi (12/2)^2 \times$ ~~4.48~~ 2.30 = ~~1077.2~~ 260.1 ft^3
B = $9.62 \times 10 \times$ ~~4.42~~ 1.38 = ~~286.4~~ 132.8 ft^3
~~1353.1~~ 392.9 ft^3

Volume 3:
OM 201-3153
0-69D Rev. 1L



A: ~~15.65~~ 0.62' $\left(\pi\left(\frac{23}{2}\right)^2 - \pi\left(\frac{15.6}{2}\right)^2\right)$ = ~~3509.2~~ 139.1

~~B: $\left[6.1\pi\left(\frac{23}{2}\right)^2\right] - \left[\frac{1}{3}\pi \times 6.1^2(3(7.69)-6.1)\right]$~~
~~= 1873.1~~
~~5382.3 ft^3~~

~~Total Volume = 125.5 + 1353.1 + 5382.3 = 6860.9 ft^3~~

DETERMINATION OF VOLUME IN FTC

Basket strainers in the FTC deep end drains are now removed prior to unit startup. The deep end of the FTC will therefore not completely fill with water as previously assumed. The volume in the Fuel Transfer Canal is now determined by assuming level to be that which will produce full flow in the floor drain. Then it will be shown that this level will produce a driving head sufficient to pass all flow entering the FTC from the BS system.

Flow Rate Into FTC:

Flow rate into the fuel transfer canal from the BS system will be assumed to be in proportion to the area of BS flow coverage represented by the FTC. All BS flow falling into the shallow end will be assumed to flow to the deep end for conservatism. The BS system is throttled to 1000 gpm prior to sump recirculation alignment. With instrument error, the flow rate is potentially as high as 1160 gpm (Ref. 8.7). The area covered by the BS spray pattern is approximated as:

Abs = $\pi Dsh^2/4$

Dsh is taken as the diameter of the smallest circle which would cover all nozzles of a single header, which is conservatively 100 ft. per Ref. 8.31 (verified typical for Units 2 and 3 as well). Therefore:

Abs = $\pi(100)^2/4 = 7854\ ft^2$

The area of the transfer canal is given by the product of the length and width, which are as follows:

Lde = deep end length = 17.5 ft. (Ref. 8.29)
Lse = shallow end length = 52.0 ft. (Ref. 8.29)
Wftc = FTC width = 24 ft. (Ref. 8.29)
Aftc = (Lse + Lde) x Wftc = (17.5 + 52.0) x 24.0 = 1668 ft^2

Then:

Qftc = Qbs x Aftc/Abs = 1160 x 1668 / 7854 = 246.4 gpm

Full Flow Depth in FTC Deep End:

The depth required to establish full flow in the FTC drains is given by the following relationship from page 40 of the American Institute of Chemical Engineering Journal, Vol. 23, No. 1, dated January 1977 (Ref. 8.38):

$$H > D \times (Fr/1.6)^{0.5}$$

where: D = inside diameter of drain, in. (4" Sch. 10S per Ref. 840
= 4.26" (Ref. 8.33)
Fr = Froude No. = $V/(gD)^{0.5}$
V = Velocity of flow in drain = Q/(448.8 x A) , ft/sec
g = acceleration due to gravity = 32.2 ft/sec^2
Q = flow rate in drain, gpm = 246.4/2 = 123.2 gpm/drain (assumes flow equally split)
A = cross sectional area of drain = 0.09898 ft^2

$V = 123.2 / (448.8 \times 0.09898) = 2.77$ ft/sec

$Fr = 2.77 / (32.2 \times 4.26/12)^{0.5} = 0.82$

$Hmin = 4.26 \times (0.82 / 1.6)^{0.5} = 3.05$

Flow Out of Deep End:

Now, we must determine that a drain of this size and geometry will pass 123.2 gpm with the available driving head. This will occur if the elevation of water in the canal exceeds the water elevation in the normal sump (RB basement) by more than the total friction losses in the drain line.

Piping Losses:

The longest drain line will be evaluated for conservatism. From Ref. 8.41, the following data can be found for the drain line:

$L = 6.00 + 4.95 + 5.88 + 7.79 + 18.50 + 3.52 = 46.64$ ft
$D = 4.26" = 0.355$ ft.
$Re = DV\rho/\mu = 0.355 \times 2.77 \times 59.35 / (0.2599 \times 0.000672) = 334{,}159$
$f = 0.0175$

Piping Losses $= fLV^2/2gD$
$= 0.0176 \times 46.64 \times 2.77^2 / (2 \times 32.2 \times 0.355)$
$= 0.275$ ft

Entrance Losses $= KV^2 / 2g$ (K = 0.5 for sharp edged flush entrance per Ref. 8.33)
$= 0.5 \times 2.77^2 / (2 \times 32.2)$
$= 0.06$ ft

Exit Losses $= KV^2 / 2g$ (K = 1.0 for sharp edged projecting exit per Ref. 8.33)
$= 1.0 \times 2.77^2 / (2 \times 32.2)$
$= 0.12$ ft

Elbow Losses $= nKV^2 / 2g$ (n = number of 90° elbows = 4)

$K = 30f_T = 30 \times 0.017 = 0.51$
$n = 4$
$f_T = 0.017$ (from Ref. 8.33)
$V = 2.77$ ft/sec

Elbow Losses $= 4 \times 0.51 \times 2.77^2 / (2 \times 32.2)$
$= 0.24$ ft

Valve Losses = $nKV^2/2g$ (n = number of gate valves = 2)

$K = 8f_T = 8 \times 0.017 = 0.136$

So: Valve Losses = $2 \times 0.136 \times 2.77^2 / (2 \times 32.2)$
=0.03 ft

Tee Losses = $(Kb + 2Kr)V^2/2g$ (One with flow through branch, two with flow through run.)

$Kb = 60\ f_T = 1.02$ (flow through branch)
$Kr = 20\ f_T = 0.34$ (flow through run)

Tee Loss = $(1.02 + 2 \times 0.34) \times 2.77^2 /(2 \times 32.2)$
= 0.20 ft

Total Friction Losses = Pipe Losses + Entrance Losses + Exit Losses + Elbow Losses + Valve Losses + Tee Losses
= 0.275 + 0.06 + 0.12 + 0.24 + 0.03 + 0.20
= 0.925 ft

Available Driving Head = Canal Water Elevation - Basement Water Elevation

Canal Water Elevation = Canal Floor Elevation + Water Depth
Canal Floor Elevation = 802 ft. (Ref. 8.29)
Water Depth = 3.05 in. = 0.25 ft. (from above)
Canal Water Elevation = 802 + 0.25 = 802.25 ft

Basement Water Elevation = Basement Floor Elevation + Basement Water Depth
Basement Floor Elevation = (777.5 + 777.25 + 777.17 + 777.0 + 776.42 + 776.0 + 776.67 + 777.08 + 776.92 + 776.75 + 776.75 + 777.08) / 12 = 776.88 ft. (Average elevation based upon assumed constant slope. See Ref. 8.27 and 8.42)
Basement Water Depth = 5 ft. conservatively assumed)
Basement Water Elevation = 776.88 + 5 = 781.88 ft.

Available Driving Head = 802.25 - 781.88 = 20.37 ft.

Since the available driving head (20.37 ft.) exceeds the predicted head losses (0.925 ft.) for the assumed flowrate, the assumed flowrate can be passed. Therefore, it is concluded that water will not accumulate in this area to a depth exceeding 3.05 inches. Canal deep end volume is then determined as follows:

Vd = Dd x Wd x Ld

where: Vd = deep end volume
Dd = deep end water depth = 0.25 ft.
Wd = deep end width = 24.0 ft (Ref. 8.29)
Ld = deep end length = 17.5 ft. (Ref. 8.29)

Thus Vd = 0.25 x 24.0 x 17.5 = 105.0 ft^3

So: **Vftc = 105.0 ft^3**

DETERMINATION OF VOLUME SHRINKAGE IN RCS

As the RCS is cooled from normal operating temperature of 579F (Tave), the specific volume decreases, and the total volume occupied by the coolant is reduced. This shrinkage will be replaced by water injected from the BWST, and this volume of water will not be available to the RBES for recirculation to support ECCS and BS pump NPSH. The shrinkage of the RCS is determined by the ratio of specific volumes of the coolant at full power and at cooldown temperature. For purposes of this analysis, the reduction in volume will be determined at a cooldown temperature of 150F, as given by the following equation:

Vs = Vfp - Vcd
= Vfp- Vfp x (vcd / vfp)
= Vfp x (1 - vcd / vfp)

where: Vs = RCS volume shrinkage
Vfp = RCS volume at full power = 12014 ft^3 (Ref. 8.30)
Vcd = RCS volume at cooldown temperature (150F assumed for conservatism)
vcd = specific volume of water at 150F = 0.016343 ft^3/lb
vfp = specific volume of water at full power operation (taken as Tave =579F) = 0.022752

The shrinkage volume in the Reactor Coolant System is determined from the equation above to be:

Vs = 12014 x (1 - 0.016343 / 0.022752)
= 12014 x (1 - 0.7183)
= 12014 x 0.2817
= 3384 ft^3

Vs = 3384 ft^3

VOLUME IN BS HEADER PIPING

From inside RB at RB wall up to the "branch" portion of the 8" pipe "T" on the "Spray Header"

Pipe dia	Pipe sch.	Length (ft)	Pipe Area	Volume	Notes
8"	20	1.33	0.3601	0.4801	
1"	40	2.00	0.00600	0.0120	
8"	10s	6.90	0.3784	2.6094	Assume check valve ~ same as 8" pipe
8"	10s	19.08	0.3784	7.2211	
8"	10s	4.75	0.3784	1.7974	
0.5"	40	30.00	0.00211	0.0633	21' shown on dwg, last leg isn't dimensioned
8"	10s	39.50	0.3784	14.9468	el 851.5' to el. 812'
8"	10s	4.25	0.3784	1.6082	
8"	10s	7.50	0.3784	2.8380	
8"	10s	7.08	0.3784	2.6803	
8"	10s	2.00	0.3784	0.7568	elbow to elbow @ el. 859'
8"	10s	78.50	0.3784	29.7044	el 937.5' to el. 859'
8"	10s	2.00	0.3784	0.7568	elbow to elbow @ el. 859'
8"	10s	6.50	0.3784	2.4596	el 944' to el. 937.5'
8"	10s	5.00	0.3784	1.8920	up to spray header (including "inlet" of "T")
Sub-total				69.8263	

Spray header piping is shown on drawing O-477 (rev.12)

Pipe dia	Pipe sch.	Length (ft)	Pipe Area	Volume	Notes
4"	10	35.21	0.09898	3.4849	
4"	10	64.96	0.09898	6.4296	
4"	10	94.71	0.09898	9.3742	
4"	10	102.46	0.09898	10.1413	
4"	10	102.46	0.09898	10.1413	
4"	10	99.83	0.09898	9.8815	
4"	10	79.83	0.09898	7.9019	
4"	10	50.08	0.09898	4.9572	
4"	10	19.83	0.09898	1.9631	(assume a little longer than shown)
4"	10	19.83	0.09898	1.9631	(assume a little longer than shown)
6"	10	19.83	0.2204	4.3713	
6"	10	2.00	0.2204	0.4408	(to allow for uncertainty of dimensions
6"	10	2.00	0.2204	0.4408	vs. where pipe starts/stops)
6"	10	13.44	0.2204	2.9616	
6"	10	5.00	0.2204	1.1020	
8"	10s	2.00	0.3784	0.7568	
8"	10s	3.54	0.3784	1.3402	
8"	10s	22.00	0.3784	8.3248	
8"	10s	21.00	0.3784	7.9464	(conservative estimate)
Sub-total				93.9229	

From valve 1BS-1 to inside wall of the RB: (from drawing O-439A rev. 55)

No dimensions on drawing for distance, so will "scale" from drawing.
Will include entire length of valve as shown on drawing

Pipe dia	Pipe sch.	Length (ft)	Pipe Area	Volume
8"	20	12.50	0.3601	4.5013
Sub-total				4.5013

Total of the three "segments" = 168.2504 ft^3

Volume In BS Header = 168.3 cu. ft.

NOTES:
Drawing O-477, Rev. 12 (Ref. 8.31) shows the Unit 1 RB piping.
Auxiliary Building Piping is shown on drawing O-439A, Rev. 55 (Ref. 8.32)
"Pipe area" is pipe internal cross-sectional area from Crane Tech Paper 410, p. B-16 (Ref. 8.33)
'olume = cross-sectional area * length
Elbows are conservatively approximated as continued lengths of pipe

DETERMINATION OF VOLUME IN PRESSURIZER

The volume adjustment to be used for the pressurizer in determination of Reactor Building Level is given by:

Vpzr = Vt - Vfp

where: Vpzr = Volume adjustment for refilling the pressurizer
Vt = Total volume of the pressurizer vessel = 1532 ft^3 (Ref. 8.30)
Vfp = Pressurizer volume occupied by water at full power operation = 800 ft^3 (Ref. 8.34)

Therefore:

Vpzr = 1532 - 800 = 732 ft^3

DETERMINATION OF WATER LOST TO VAPORIZATION

Find partial pressure of air and water vapor initially in the reactor building at switchover from BWST to RBES:

Assume initial RB temperature of 130F (conservative).

Assume RB temperature of 200F for conservatism. Actual temperature would be expected to be higher since sump is at approximately 250F when RB pressure is 20 psig.

The ideal gas law will be applied to determine the post-accident conditions in the atmosphere, as shown below:

$P1 / T1 = P2 / T2$

where: P1 = Air pressure prior to accident = 14.2 psia
T1 = Air temperature prior to accident = 130F = 590R (assumed)
P2 = Pressure of air after accident = 34.2 psia (from Ref. 8.22)
T2 = Temperature of air after accident = 200F = 660R (assumed)

So: $P2 = P1 \times T2/T1 = 14.2 \times 660 / 590 = 15.88$ psia

Since RB pressure at start of sump recirc is 20 psig (34.2 psia), an additional pressure of 34.2 - 15.88, or 18.32 psi must be provided by steam (water vapor). From the ideal gas law:

$PV = n RT$

where: P = partial pressure of additional vapor = 18.32 psia
V = volume of water vapor = 1.832×10^6 ft^3
n = number of pound-moles of vapor
R = ideal gas constant = 10.73 psi-ft^3 / lb-mole-R
T = vapor temperature = 660R

so: $n = PV/RT = 18.32 \times 1.832 \times 10^6 / 10.73 \times 660 = 4739$ lb-moles

One pound-mole of water equals 18 pounds of mass. Therefore, we need 18 x 4739 = 85,306 lb of vapor to create the pressure in the building. At 200F, the volume of water is given by:

Vv = 85306lb x vv

where: Vv = Volume of vapor
vv = specific volume of vapor at 200F = 0.016637 ft^3/lb

so: $Vv = 85306 \times 0.016637 = 1419$ ft^3

Vv = 1419 ft^3

DETERMINATION OF WATER LOST TO INCORE TRENCH

The water level in the Reactor Building is determined by taking volumes contributed by the BWST and CFT's, reduced by the total volumes of trapped or lost fluid, and dividing that volume by the cross sectional area of the Reactor Building. One of the areas that fluid can be lost and not contribute to level increase is the portion of the incore instrumentation trench below the finished floor level. This is represented by the following expression:

Vit = Lit x Wit x Dit

where: Lit = Length of incore trench outside the primary shield wall = 23.92 ft. (Ref. 8.27 and 8.42)
Wit = Width of incore trench = 10.0 ft (Ref. 8.27 and 8.42)
Dit = Depth ot incore trench below the finished floor level

Bottom elevation of incore trench = 775.67 ft (Ref. 8.27 and 8.42)
Finished floor elevation at incore trench = 776.88 ft (Floor elevation varies, used mean floor elevation.)

Dit = 776.88 - 775.67 = 1.21 ft.

Vit = 23.92 x 10.0 x 1.21 = 289.4 ft^3

Vit = 289.4 ft^3

WATER LOST TO SUMPS

The normal and emergency sumps are below the finished grade of the reactor building floor. The volumes of water contained below mean floor level in each of these sumps will not contribute to increasing level in the building above mean floor level. These volumes are calculated below.

Normal Sump:

Length, L = 6.0 ft. (Ref. 8.27 & 8.42)
Width, W = 4.0 ft. (Ref. 8.27 & 8.42)
Depth, D = 2.0 ft. (Ref. 8.27 & 8.42)

Volume, $Vn = L \times W \times D = 48 \text{ ft}^3$

Emergency Sump:

Length, L = 18.0 ft. (Ref. 8.27 & 8.42)
Width, W = 10.0 ft. (Ref. 8.27 & 8.42)
Depth, D = 3.0 ft. (Ref. 8.27 & 8.42)

Volume, $Ve = L \times W \times D = 540 \text{ ft}^3$

Total Volume Lost to Sumps:

$Vs = Vn + Ve = 588 \text{ ft}^3$

$\mathbf{Vs = 588 \text{ ft}^3}$

DETERMINATION OF WATER LEVEL IN RB BASEMENT

The water level in the Reactor Building is determined by taking volumes contributed by the BWST and CFT's, reduced by the total volumes of trapped fluid and RCS shrinkage, and dividing that volume by the cross sectional area of the Reactor Building. This is represented by the following expression:

Lrb = (Vbwst x vh/vc + Vcft - Vvc -Vftc -Vrcs -Vpzr - Vbsp - Vv -Vit - Vs) / Arb

where: Lrb = reactor building water level
Vbwst = volume of water drawn from the BWST
vc = specific volume of water at normal BWST temp of 115F = 0.0.016184 ft^3/lb
vh = specific volume of water at worst case sump temperature of 237F = 0.016900 ft^3/lb
Vcft = volume of water contributed from the CFT's = 2020 ft^3 (Ref. 8.21)
Vvc = volume of water trapped in reactor vessel cavity within primary shield wall = 679.0 ft^3 (Ref. Attachment 10)
Vftc = volume of water trapped in the fuel transfer canal = 105.0 ft^3 (Ref. Attachment 11)
Vrcs = volume of water required to make up for RCS shrinkage during cooldown = 3384 ft^3 (Ref. Attachment 12)
Vpzr = vapor space in the pressurizer to be refilled = 732 ft^3 (Ref. Attachment 14)
Vbsp = volume of water required to refill the BS header = 168.3 ft^3 (Ref. Attachment 13)
Vv = Volume of water lost to vaporization = 1419 ft^3 (Ref. Attachment 15)
Vit = Volume of water lost to incore trench = 289.4 ft^3 (Ref. Attachment 16)
Vs = Volume of water lost to sumps = 588 ft^3 (See Attachment 17)
Arb = net cross sectional area of the reactor building at the basement level = 8715.3 ft^2 (See below.)

Arb will be adjusted for the area added inside the reactor vessel cavity as noted in attachment 10. The additional RB floor area contributed by the circular area in the cavity is:

$A1 = \pi D^2 / 4 = \pi \times 12^2 / 4 = 113.1\ ft^2$

The area contributed by the incore trench area inside the vessel cavity is:

$A2 = L \times W = 9.62 \times 10.0 = 96.2\ ft^2$ (Ref. 8.24)

The total area, At, to be added is then:

$At = A1 + A2 = 113.1 + 96.2 = 209.3\ ft^2$

Arb is then given as the original value (8506 ft^2 from Ref. 8.21. Original RB floor area is conservative for use in this evaluation, since water level is lower than evaluated in Ref. 8.21. Inward curvature of RB walls at this level will decrease the effective floor area.) plus the adjustment, At:

$Arb = 8506 + 209.3 = 8715.3\ ft^2$

The Technical Specification requires a minimum level in the BWST of 46 ft., and the EOP guidance for isolating the BWST is when BWST level is less than or equal to 6 ft. and greater than 2 ft. Therefore Vbwst may be calculated from the following expression:

Vbwst = (Lts - Ltr) x Abwst

where: Lts = minimum Technical Specification level of the BWST = 46 ft.
Ltr = maximum level remaining in BWST at completion of transfer of suction from BWST to RBES = 6 ft. (Ref. EOP)
Abwst = 1018 ft^2 (Ref. 8.21)

Therefore: Vbwst = (46 - 6) x 1018 = 40,720 ft^3

So, from the level equation above:

Lrb = (40720 x 0.01690 / 0.016184 + 2020 - 679.0 - 105.0 - 3384 - 732 - 168.3 - 1419 - 289.4 - 588.0) / 8715.3
= 4.27 ft.

Lrb = 4.27 ft.

DETERMINATION OF LIMITING BS TRAIN

This attachment will determine the limiting BS train for purposes of bounding the NPSH analysis. The limiting BS train will be the train with worst-case friction losses in the suction piping to the BS pumps. Pages 3 through 58 show the WOODS models and computer runs performed in previous calculations OSC-1938, OSC-1954, and OSC-1977. From these analyses, the hydraulic grade line at the suction of each BS pump is found to be as shown below:

Train 1A:	778.46
Train 1B:	778.83
Train 2A:	779.52
Train 2B:	776.86
Train 3A:	779.41
Train 3B:	775.93

By comparison of the hydraulic grade lines for all trains with equal flows, it can be seen that the 3B train is limiting since it has the lowest fluid energy available to support NPSH requirements for the pumps.

The above numbers must be adjusted for specific differences between the as-built configuration of the plant and the models presented in the following pages. Specifically, the entrance of each flow path from the RBES was modeled as a bell shaped reducer inlet, while in reality, the 1A suction piping has an 18" x 18" x 18" tee inlet (Ref. O-479B) while all other trains have an 18" x 30" x 45° reducer inlet (Ref. O-59M). Since the 3B train was modeled identically to all other trains except 1A, and 3B yielded the lowest value, only the hydraulic grade line for 3B and 1A need to be adjusted to better account for the inlet configuration. This comparison is presented below:

New K value for inlet of train 1A:

Kn = K1 + K2

where: K1 = loss coefficient for 18 x 18 x 18 tee branch = 60 f_T (Ref. 8.33)

K2 = entrance loss coefficient = 0.78 (Ref. 8.33)

$f_T = 0.012$

$Kn = 60 \times 0.012 + 0.78 = 1.50$

Old K value for inlet of train 1A: Ko = 0.1

Flow velocity, V = Q/(448.8 x A)
= 4000/(448.8 x 1.6703)
= 5.34 ft/sec

Increased friction losses:

$Hl = (Kn-Ko) \times V^2 / 2g$
$= (1.50 - 0.1) \times 5.34^2 / (2 \times 32.2)$
$= 0.62$ ft.

New K value for train 3B:

Kn = K1 + K2

where: K1 = entrance loss = 0.78 (Ref. 8.33, p A-29)
K2 = form loss for sudden contraction = 0.27 (Ref. 8.33, p A-26)

Kn = 0.78 + 0.27 = 1.05

Old K value for train 3B: Ko = 0.1

Increased friction loss:

$Hl = (Kn - Ko) \times V^2 / 2g$
$= (0.1.05 - 0.1) \times 5.34^2 / (2 \times 32.2)$
$= 0.42$ ft.

Therefore, the hydraulic grade lines for the two trains become:

1A: 778.46 - 0.62 = 777.84 ft.
3B: 775.93 - 0.42 = 775.51 ft.

Since the hydraulic grade line is still lower on the 3B train, it can be concluded that this is the limiting train for purposes of NPSH evaluation.

Dev./Station Oconee Nuclear Station Unit 1 File No.
Subject Safety Pump NPSH Analysis in the Recirculation Mode By DMS
Sheet No. 16 of ____ Problem No. OSC-1938 Checked By ____ Date ____

References

1) Woods Pressure Drop Program QA Approved IBM Version as identified in A.L. Sudduth letter of 1-26-84
2) Cameron Hydraulic Data, Copyright 1979, Ingersoll Rand Co.
3) Crane Technical Paper 410, Copyright 1979, Crane Co.
4) Oconee FSAR Section 6.0.3.1
5) Nureg 897 "Containment Emergency Sump Performance" Published for comment April 1983

Drawings

1) O-435 B Plan Elevation 758'-0" Auxiliary Building Rev 48
2) O-435 K Enlarged Plan Misc. Piping 758'-0" Auxiliary Building Rev 7
3) OFD-102A-1.1 Low Pressure Injection System Flow Diagram Rev 0
OFD-102A-1.2 " " " "
4) OM-201-2366 Pump Curve for RBS Pump 1A
(Also see OM-2201-428 for extended NPSH curve for RBS pumps)
5) OM-201-1083 Pump Curve for RBS Pump 1B
6) OM-201-1029 Pump Curve for LPI Pump 1C
7) OM-201-1030 Pump Curve for LPI Pump 1B

Attachments

1) Nureg 897 Table 5.2
2) Nureg 897 Table 5.3
Nureg 897 Table 5.4
4) Woods Analysis Computer Printout

Form 00184 (6-81)

DUKE POWER COMPANY

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Attachment 19
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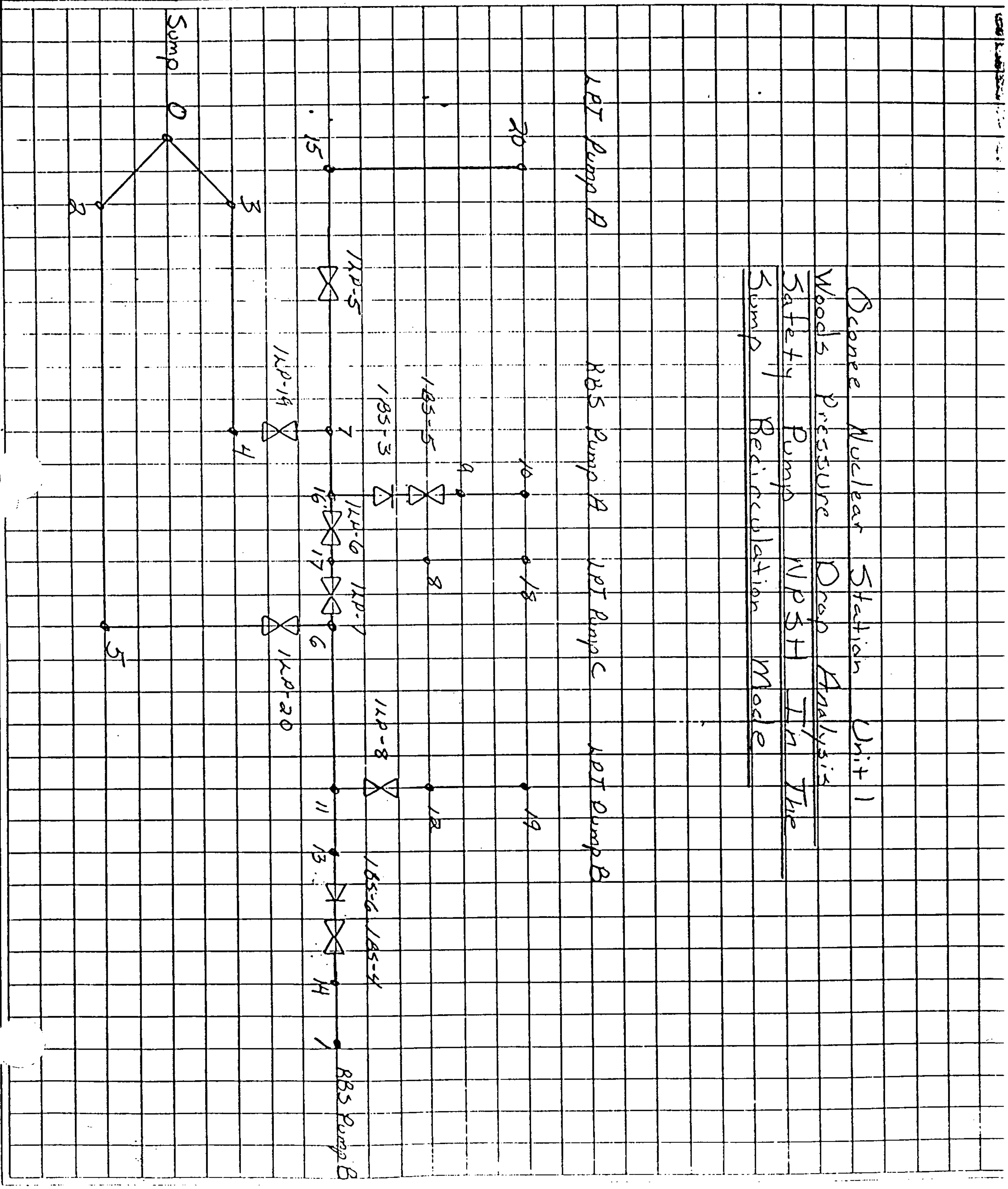
Dev./Station Oconee Nuclear Station Unit 1 File No

Subject Safety Pump NPSH in the Sump Mode By [signature]

Sheet No. 12 of ____ Problem No. OSC-1938 Checked By ____



Dev./Station Oconee Nuclear Station Unit 1 File No.

Subject Safety Pump NPSH Analysis in the Su. Mode By DNS

Sheet No. 18 of ____ Problem No. OSC-1938 Checked By ____

Minor Loss Coefficients

18 inch

Long radius 90° elbow	$14 f_t = (14)(0.012)$	$= 0.168$ ~	0.17
Short radius 90° elbow	$20 f_t = (20)(0.012)$	=	0.24
45° elbow	$16 f_t = (16)(0.012)$	$= 0.192$ ~	0.20
Tee thru	$20 f_t = (20)(0.012)$	=	0.24
branch	$60 f_t = (60)(0.012)$	=	0.72

14 inch and 12 inch

Long radius 90° elbow	$14 f_t = (14)(0.013)$	$= 0.182$ ~	0.19
Short radius 90° elbow	$20 f_t = (20)(0.013)$	=	0.26
45° elbow	$16 f_t = (16)(0.013)$	$= 0.208$ ~	0.21
Tee thru	$20 f_t = (20)(0.013)$	=	0.26
branch	$60 f_t = (60)(0.013)$	=	0.78
Gate valve	$8 f_t = (8)(0.013)$	$= 0.104$ ~	0.11

10 inch and 8 inch

Long radius 90° elbow	$14 f_t = (14)(0.014)$	$= 0.196$ ~	0.20
Short radius 90° elbow	$20 f_t = (20)(0.014)$	=	0.28
45° elbow	$16 f_t = (16)(0.014)$	=	0.23
Tee thru	$20 f_t = (20)(0.014)$	=	0.28
branch	$60 f_t = (60)(0.014)$	=	0.84
Gate valve	$8 f_t = (8)(0.014)$	$= 0.112$ ~	0.12
Swing check valve	$50 f_t = 50(0.014)$	=	0.70
Expansion joint			0.30

1) All values from Crane Technical Paper 410 except expansion joint
2) Values for tees for standard tees
Values for 90° elbows are for butt welding elbows
3) Values for 45° elbows for standard 45° elbows
5) Expansion joint value taken from Woods Users Manual

Dev./Station Oconee Nuclear Unit 1 File No.
Subject Safety Pump NPSH in the Sump Mode By DMB
Sheet No. 19 of Problem No. OSC-1938 Checked By

Node 0-2

Pipe
0

Minor loss coefficient
0

Node 0-3

Pipe
0

Minor loss coefficient
0

Node 2-5

18" Sch 10
Bell shaped reducer inlet
1-6
Short radius 90° elbow
25-7
48° 31' elbow cut from 90° long radius elbow (Assume 45°)
3-1
41° 69' elbow cut from 90° long radius elbow (Assume 45°)
16-4
Long radius 90° elbow
6-10

Pipe
53-4

Minor loss coefficients

1 - Long radius 90° elbow		0.17
1 - Short radius 90° elbow		0.24
2 - Long radius 45° elbow	2(0.20)	0.40
Entrance losses		0.10
		0.91

Form 00184 (6-81)

DUKE POWER COMPANY

Dev./Station Oconee Nuclear Station Unit 1 File No.

Subject Safety Pump NPSH in the Sump Re[illegible] Mode By DMS

Sheet No. 20 of ____ Problem No. OSC-1938 Checked By ____ Date ____

Node 3-4

18" Sch 10

Bell shaped reducer inlet

1-6

Short radius 90° elbow

25-7

48" 31° elbow cut from 90° long radius elbow (Assume 45°)

41" 69° elbow cut from 90° long radius elbow (Assume 45°)

Long radius 90° elbow

Pipe

27-1

Minor loss coefficients

1-Long radius 90° elbow		0.17
1-Short radius 90° elbow		0.24
2-Long radius 45° elbow	2(0.2)	0.40
Entrance losses		0.10
		0.91

Node 5-6

14" Sch 10:

18"x14" reducer (15' pipe equivilent)

14" gate valve

9-2

14x14x14 tee branch

Pipe

24-2

Minor loss coefficient

1-14" gate valve	0.11
1-14x14x14 tee branch	0.78
	0.89

Dev./Station Oconee Nuclear Station Unit 1 File No.
Subject Safety Pump NPSH Analysis in Recirculation Mode By DMS
Sheet No. 21 of ___ Problem No. OSC-1938 Checked By ___ Date ___

Pipe 16-7

14" Sch 10
3-5

Pipe
3-5

Pipe 7-15

14" Sch 10
0-9
Long radius 90° elbow
14x14x14 tee thru
2-4
14x14x14 tee thru
3-5
14 inch gate valve
5-11
Long radius 90° elbow
8-6
Long radius 90° elbow
Long radius 90° elbow

Pipe
17-11

Minor loss coefficients		Loss
2-14x14x14 tee thru	2(0.26)	0.52
1-14 gate valve		0.11
4-Long radius 90° elbows	4(0.19)	0.76
		1.39

Dev./Station Oconee Nuclear Station Unit 1 File No.
Subject Safety Pump NPSH Analysis in the Su Mode By EMB
Sheet No. 22 of ___ Problem No. OSC - 1938 Checked By ___ Date ___

Pipe 16-17

14" Sch 10
0-6
14" gate valve
14x14x14 tee thru
0-7
Pipe
1-1

Minor loss coefficients	Loss
1- 14x14x14 tee thru	0.26
1- 14" gate valve	0.11
	0.37

Pipe 17-16

14" Sch 10
0-3
14" gate valve
0-10
14x14x14 tee thru

Pipe
1-1

Minor loss coefficients	Loss
1- 14x14x14 tee thru	0.26
1- 14 gate valve	0.11
	0.37

Dev./Station: Oconee Nuclear Station Unit: 1 File No.
Subject: Safety Pump NPSH Analysis in the S Mode By: DMS
Sheet No. 23 of ___ Problem No. OSC-1938 Checked By: ___

Pipe 16-9

10 Sch 10S

14x14x10 reducing tee branch

10" check valve

3-10

Long radius 90° elbow

0-7

Long radius 90° elbow

0-9

Long radius 90° elbow

3-6

Long radius 90° elbow

Long radius 90° elbow

1-5

10x10x3 tee thru

10" gate valve

0-6

Coupling

0-6

Pipe

11-1

Minor loss coefficients		Loss
1-14x14x10 tee branch		0.84
1-10 check valve		0.70
1-10 gate valve		0.12
5-Long radius 90° elbows	5(0.20)	1.00
1-10x10x3 tee thru		0.28
1-Coupling		0.30
		3.24

Dev./Station Oconee Nuclear Station Unit 1 File No.
Subject Safety Pump NPSH Analysis in the Recirculation Mode By DMB
Sheet No. 24 of ___ Problem No. OSC-1938 Checked By ___

Pipe 17-8

14" Sch 10:

8-6
Long radius 90° elbow
Long radius 90° elbow
4-8
Long radius 90° elbow
7-7b
Long radius 90° elbow
Long radius 90° elbow

Pipe
30-4

Minor loss coefficients		Loss
5 - Long radius 90° elbow	5(0.19)	0.95

Pipe 8-18

12" Sch 20

14x12 reducing elbow (model as 14x12 reducer 6' pipe equivilent and Long radius 90° elbow)

Pipe
6.0

Minor loss coefficients	Loss
1 - Long radius 90° elbow	0.19

Form 00184 (6-81)

DUKE POWER COMPANY

Dev./Station Oconee Nuclear Station Unit 1 File No.
Subject Safety Pump NPSH Analysis in the Su... Mode By [illegible]
Sheet No. 35 of ___ Problem No. OSC-1938 Checked By

Node 11-12

14 Sch 10.

14 x 14 x 14 tee branch
6-3
14" gate valve
Long radius 90° elbow
9-8
Long radius 90° elbow
4-1
Long radius 90° elbow
8-9
Long radius 90° elbow
Long radius 90° elbow
7-5

Pipe
30-6

Minor loss coefficients		Loss
1 - 14x14x14 tee branch		0.78
1 - 14" gate valve		0.11
5 - Long radius 90° elbow	5(0.19)	0.95
		1.84

Node 12-19

12" Sch 80

14x12 reducing elbow (model as reducer 6' pipe equivalent and a 90° elbow)

Pipe
16-0

Minor loss coefficient	Loss
1 - Long radius 90° elbow	0.19

Form 00184 (6-81)

DUKE POWER COMPANY

Dev./Station Oconee Nuclear Station Unit 1 File No.
Subject Safety Pumps NPSH Analysis in the Recirculation Mode By [illegible]
Sheet No. 26 of ___ Problem No. OSC-1938 Checked By ___

Pipe 11-13

14 Sch 10.
14x14x14 tee thru
2-6

Pipe
2-6

Minor loss coefficients	Loss
1-14x14x14 tee thru	0.26

Pipe 13-14

10 Sch 10S
14x10 reducer (13' pipe equivilent)
10" check valve
Long radius 90° elbow
9-2
Long radius 90° elbow
2-8
Long radius 90° elbow
9-0
Long radius 90° elbow
Long radius 90 elbow
10" gate valve
1-11
Coupling
0-6

Pipe	Minor loss coefficients	Losses
37-3	1-10" check valve	0.70
	1-10" gate valve	0.12
	1-Coupling	0.30
	5-Long radius elbows 5(0.20)	1.00
		2.12

DUKE POWER COMPANY

Form 00184 (6-81)

Dev./Station Oconee Nuclear Station Unit 1 File No.

Subject Safety Pump NPSH Analysis in the Sun Mode By DMB

Sheet No. 37 of ___ Problem No. OSC-1938 Checked By ___ Date ___

Node 4-7

14" Sch 10

18"x14" reducer (15' pipe equivilent)

14" gate valve

9-0

14x14x14 tee branch

Pipe

24-0

Minor loss coefficients	Losses
1-14" gate valve	0.11
1-14x14x14 tee branch	0.78
	0.89

Node 6-11

14" Sch 10

14x14x14 tee thru

3-8

14x14x14 tee thru

Pipe

3-8

Minor loss coefficient		Loss
2-14x14x14 tees thru	2(0.26)	0.52

DUKE POWER COMPANY

Form 00184 (6-81)

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Dev./Station Oconee Nuclear Station Unit 1 File No.

Subject Safety Pump NPSH Analysis in the Su[illegible] Mode By DMS

Sheet No. 28 of ____ Problem No. OSC-1938 Checked By ____

Pipe 9-10

8" Sch 20

10x8 reducing elbow (model as 10x8 reducer 6' pipe equivilent and a long radius 90° elbow)

Pipe

6-0

Minor loss coefficient:	Loss
1- Long radius 90° elbow	0.20

Pipe 14-1

8" Sch 20

10x8 reducing elbow (model as 10x8 reducer 6' pipe equivilent and a long radius 90° elbow)

Pipe

6-6

Minor loss coefficient	Loss
1- Long radius 90° elbow	0.20

Pipe 20-15

12 Sch 20

14x12 reducing elbow (model as 14x12 reducer 6' pipe equivilent and a long radius 90° elbow)

Pipe

6-0

Minor loss coefficients	Loss
1- Long radius 90° elbow	0.19

RUN 21
OSC- 8
Attach 4
Page 92

```
!>FAIRVI(
LOGON
IKJ5670(  `NTER USERID -
DNS8374
ENTER CURRENT PASSWORD FOR DNS8374-
:WUFF
:ICH70001I DNS8374  LAST ACCESS AT 09:15:48 ON TUESDAY, JULY 3, 1984
DNS8374 LOGON IN PROGRESS AT 09:17:53 ON JULY 3, 1984
 *** tso will be down on mon 07/02/84 from 1730 to 1800*****
 TSO ON SYSTEM G WILL BE DOWN FROM 19:00 TO 23:00 ON 07/01/84
READY
FREE F(FT05F001)
READY
ALLOC DA(DNS8374I.DATA) F(FT05F001)
READY
CALL 'SYS1.DUK2LOAD(RUN03445)'
 FLOWRATE IS EXPRESSED IN GPM AND PRESSURE IN PSIG
```

THE DARCY WEISBACH HEAD LOSS EQUATION IS USED, THE KINEMATIC VISCOSITY = 0.0000120

PIPE NUMBER	NODE NUMBERS		LENGTH (FEET)	DIAMETER (INCHES)	ROUGHNESS	MINOR LOSS K	FIXED GRADE
1	0	2	0.1	17.500	0.15	0.0	782.50
2	0	3	0.1	17.500	0.15	0.0	782.50

THE FLOW IN LINE NUMBER 2 IS RESTRICTED

PIPE NUMBER	NODE NUMBERS		LENGTH (FEET)	DIAMETER (INCHES)	ROUGHNESS	MINOR LOSS K	FIXED GRADE
3	2	5	53.3	17.500	0.15	0.91	
4	3	4	27.1	17.500	0.15	0.91	
5	5	6	24.2	13.500	0.15	0.89	
6	4	7	24.0	13.500	0.15	0.89	
7	7	15	17.9	13.500	0.15	1.39	
8	7	16	3.4	13.500	0.15	0.0	
9	16	17	1.1	13.500	0.15	0.37	
10	16	9	11.1	10.420	0.15	3.24	
11	9	10	6.0	8.125	0.15	0.20	
12	17	8	20.3	13.500	0.15	0.95	
13	11	12	30.5	13.500	0.15	1.84	
14	8	18	6.0	12.250	0.15	0.19	
15	12	19	6.0	12.250	0.15	0.19	
16	17	6	1.1	13.500	0.15	0.37	
17	11	13	2.5	13.500	0.15	0.26	
18	13	14	37.3	10.420	0.15	2.12	
19	14	1	6.0	8.125	0.15	0.20	
20	6	11	3.7	13.500	0.15	0.52	
21	15	20	6.0	12.250	0.15	0.19	

JUNCTION NUMBER DEMAND ELEVATION CONNECTING PIPES

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RUN OSC-3
Attach 4
Page 93

	1000.00	760.10	-19		
	0.0	0.0	-1		
	0.0	0.0	-2	4	
	0.0	0.0	-4	6	
5	0.0	0.0	-3	5	
6	0.0	0.0	-5	-16	20
7	0.0	0.0	-6	7	8
8	0.0	0.0	-12	14	
9	0.0	0.0	-10	11	
10	0.0	0.0	-11		
11	0.0	0.0	13	17	-20
12	0.0	0.0	-13	15	
13	0.0	0.0	-17	18	
14	0.0	0.0	-18	19	
15	0.0	0.0	-7	21	
16	0.0	0.0	-8	9	10
17	0.0	0.0	-9	12	16
18	0.0	0.0	-14		
19	3000.00	761.10	-15		
20	0.0	0.0	-21		

THIS SYSTEM HAS 21 PIPES WITH 20 JUNCTIONS , 0 LOOPS AND 2 FIXED GRADE NODES

THESE ARE THE RESULTS FOR THE ORIGINAL DATA

OCONEE NUCLEAR STATION UNIT 1 0000000
ECCS SUMP RECIRCULATION 0000000
SAFETY PUMP NPSH ANALYSIS 0000000

THE FOLLOWING RESULTS ARE OBTAINED AFTER 2 TRIALS

PIPE NO.	NODE NUMBERS		FLOWRATE	HEAD LOSS	PUMP HEAD	MINOR LOSS	VELOCITY	HL/1000
1	0	2	4000.000	0.000	0.0	0.0	5.335	4.257
THE FLOW IN LINE NUMBER 2 IS RESTRICTED								
3	2	5	4000.000	0.227	0.0	0.402	5.335	4.2
4	3	4	0.0	0.0	0.0	0.0	0.0	0.C
5	5	6	4000.000	0.378	0.0	1.111	8.965	15.6
6	4	7	0.0	0.0	0.0	0.0	0.0	0.0
7	7	15	0.0	0.0	0.0	0.0	0.0	0.0
8	7	16	0.0	0.0	0.0	0.0	0.0	0.0
9	16	17	0.0	0.0	0.0	0.0	0.0	0.C
10	16	9	0.0	0.0	0.0	0.0	0.0	0.0
11	9	10	0.0	0.0	0.0	0.0	0.0	0.0
12	17	8	0.0	0.0	0.0	0.0	0.0	0.0
13	11	12	3000.000	0.275	0.0	1.292	6.724	9.0

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1[illegible]	12	19	3000.000	0.088	0.0	0.197	8.166	14.677	
1[illegible]	17	6	0.0	0.0	0.0	0.0	0.0	0.0	
[illegible]	11	13	1000.000	0.003	0.0	0.020	2.241	1.14[illegible]	JUN 21
1[illegible]	13	14	1000.000	0.153	0.0	0.466	3.762	4.10[illegible]	OSC-1938
19	14	1	1000.000	0.085	0.0	0.119	6.188	14.182	Attach 4
20	6	11	4000.000	0.057	0.0	0.649	8.965	15.622	Page 94
21	15	20	0.0	0.0	0.0	0.0	0.0	0.0	

JUNCTION NUMBER	DEMAND	GRADE LINE	ELEVATION	PRESSURE	
1	1000.00	778.83	760.10	8.12 = 18.7572	Head loss = 3.6428 HL +20% = 4.37136
2	0.0	782.50			
3	0.0	780.38			
4	0.0	780.38			
5	0.0	781.87			
6	0.0	780.38			
7	0.0	780.38			
8	0.0	780.38			
9	0.0	780.38			
10	0.0	780.38			
11	0.0	779.68			
12	0.0	778.11			
13	0.0	779.65			
14	0.0	779.03			
15	0.0	780.38			
16	0.0	780.38			
17	0.0	780.38			
18	0.0	780.38			
19	3000.00	777.82	761.10	7.25 = 16.7475	Head loss = 4.6525 HL+20% = 5.583
20	0.0	780.38			

THE RELATIVE CHANGE IN FLOWRATE FROM THE PREVIOUS TRIAL = 0.00360

READY
LOGOFF
DNS8374 LOGGED OFF TSO AT 09:19:38 ON JULY 3, 1984

RUN 8
OSC-14
Attach 4
Page 98

!`FAIRVI
LOGON
IKJ5670 NTER USERID -
DNS83764
IKJ56710I INVALID USERID, DNS83764
IKJ56703A REENTER -
DNS8374
ENTER CURRENT PASSWORD FOR DNS8374-
:WUFF
:ICH70001I DNS8374 LAST ACCESS AT 08:42:38 ON TUESDAY, JULY 3, 1984
DNS8374 LOGON IN PROGRESS AT 08:44:56 ON JULY 3, 1984
*** tso will be down on mon 07/02/84 from 1730 to 1800*****
TSO ON SYSTEM G WILL BE DOWN FROM 19:00 TO 23:00 ON 07/01/84
READY
FREE F(FT05F001)
READY
ALLOC DA(DNS8374I.DATA) F(FT05F001)
READY
CALL 'SYS1.DUK2LOAD(RUN03445)'
FLOWRATE IS EXPRESSED IN GPM AND PRESSURE IN PSIG

THE DARCY WEISBACH HEAD LOSS EQUATION IS USED, THE KINEMATIC VISCOSITY = 0.0000120

PIPE NUMBER	NODE NUMBERS		LENGTH (FEET)	DIAMETER (INCHES)	ROUGHNESS	MINOR LOSS K	FIXED GRADE
1	0	2	0.1	17.500	0.15	0.0	782.50
2	0	3	0.1	17.500	0.15	0.0	782.50

THE FLOW IN LINE NUMBER 2 IS RESTRICTED

PIPE NUMBER	NODE NUMBERS		LENGTH (FEET)	DIAMETER (INCHES)	ROUGHNESS	MINOR LOSS K	FIXED GRADE
3	2	5	53.3	17.500	0.15	0.91	
4	3	4	27.1	17.500	0.15	0.91	
5	5	6	24.2	13.500	0.15	0.89	
6	4	7	24.0	13.500	0.15	0.89	
7	7	15	17.9	13.500	0.15	1.39	
8	7	16	3.4	13.500	0.15	0.0	
9	16	17	1.1	13.500	0.15	0.37	
10	16	9	11.1	10.420	0.15	3.24	
11	9	10	6.0	8.125	0.15	0.20	
12	17	8	20.3	13.500	0.15	0.95	
13	11	12	30.5	13.500	0.15	1.84	
14	8	18	6.0	12.250	0.15	0.19	
15	12	19	6.0	12.250	0.15	0.19	
16	17	6	1.1	13.500	0.15	0.37	
17	11	13	2.5	13.500	0.15	0.26	
18	13	14	37.3	10.420	0.15	2.12	
19	14	1	6.0	8.125	0.15	0.20	

15	20	6.0	12.250	.15	0.19

Rui[illegible]3
OSC [illegible]38
Attach 4
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JUNCTION NUMBER	DEMAND	ELEVATION	CONNECTING PIPES		
1	0.0	0.0	-19		
2	0.0	0.0	-1	3	
3	0.0	0.0	-2	4	
4	0.0	0.0	-4	6	
5	0.0	0.0	-3	5	
6	0.0	0.0	-5	-16	20
7	0.0	0.0	-6	7	8
8	0.0	0.0	-12	14	
9	0.0	0.0	-10	11	
10	1000.00	760.10	-11		
11	0.0	0.0	13	17	-20
12	0.0	0.0	-13	15	
13	0.0	0.0	-17	18	
14	0.0	0.0	-18	19	
15	0.0	0.0	-7	21	
16	0.0	0.0	-8	9	10
17	0.0	0.0	-9	12	16
18	0.0	0.0	-14		
19	0.0	0.0	-15		
20	3000.00	761.10	-21		

THIS SYSTEM HAS 21 PIPES WITH 20 JUNCTIONS , 0 LOOPS AND 2 FIXED GRADE NODES

THESE ARE THE RESULTS FOR THE ORIGINAL DATA

OCONEE NUCLEAR STATION UNIT 1 0000000
ECCS SUMP RECIRCULATION 0000000
SAFETY PUMP NPSH ANALYSIS 0000000

THE FOLLOWING RESULTS ARE OBTAINED AFTER 2 TRIALS

PIPE NO.	NODE NUMBERS		FLOWRATE	HEAD LOSS	PUMP HEAD	MINOR LOSS	VELOCITY	HL/1000
1	0	2	4000.000	0.000	0.0	0.0	5.335	4.2
THE FLOW IN LINE NUMBER 2 IS RESTRICTED								
3	2	5	4000.000	0.227	0.0	0.402	5.335	4.2
4	3	4	0.0	0.0	0.0	0.0	0.0	0.0
5	5	6	4000.000	0.378	0.0	1.111	8.965	15.6
6	4	7	0.0	0.0	0.0	0.0	0.0	0.0
7	7	15	3000.000	0.161	0.0	0.976	6.724	9.0
8	7	16	-3000.000	-0.031	0.0	0.0	-6.724	-9.0
9	16	17	-4000.000	-0.017	0.0	-0.462	-8.965	-15.6
10	16	9	1000.000	0.046	0.0	0.712	3.762	4.1
[illegible]	[illegible]	[illegible]	1000.000	0.025	0.0	0.119	[illegible]	[illegible]

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1[illegible]	17	8	0.0	0.0	0.0	0.0	0.0	0.0
1[illegible]	11	12	0.0	0.0	0.0	0.0	0.0	0.0
[illegible]	8	18	0.0	0.0	0.0	0.0	0.0	0.0
1[illegible]	12	19	0.0	0.0	0.0	0.0	0.0	0.0
16	17	6	-4000.000	-0.017	0.0	-0.462	-8.965	-15.622
17	11	13	0.0	0.0	0.0	0.0	0.0	0.0
18	13	14	0.0	0.0	0.0	0.0	0.0	0.0
19	14	1	0.0	0.0	0.0	0.0	0.0	0.0
20	6	11	0.0	0.0	0.0	0.0	0.0	0.0
21	15	20	3000.000	0.088	0.0	0.197	8.166	14.677

RUN 23
OSC-1938
Attach 4
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JUNCTION NUMBER	DEMAND	GRADE LINE	ELEVATION	PRESSURE
1	0.0	780.38		
2	0.0	782.50		
3	0.0	779.39		
4	0.0	779.39		
5	0.0	781.87		
6	0.0	780.38		
7	0.0	779.39		
8	0.0	779.90		
9	0.0	778.67		
10	1000.00	778.46	760.10	7.96 = 18.3876 Head loss = 4.0124 HL+20% = 4.814
11	0.0	780.38		
12	0.0	780.38		
13	0.0	780.38		
14	0.0	780.38		
15	0.0	778.26		
16	0.0	779.42		
17	0.0	779.90		
18	0.0	779.90		
19	0.0	780.38		
20	3000.00	777.97	761.10	7.31 = 16.8861 Head loss = 4.5139 HL + 20% = 5.4166

THE RELATIVE CHANGE IN FLOWRATE FROM THE PREVIOUS TRIAL = 0.00214

READY
LOGOFF
DNS8374 LOGGED OFF TSO AT 08:46:44 ON JULY 3, 1984

DUKE POWER COMPANY

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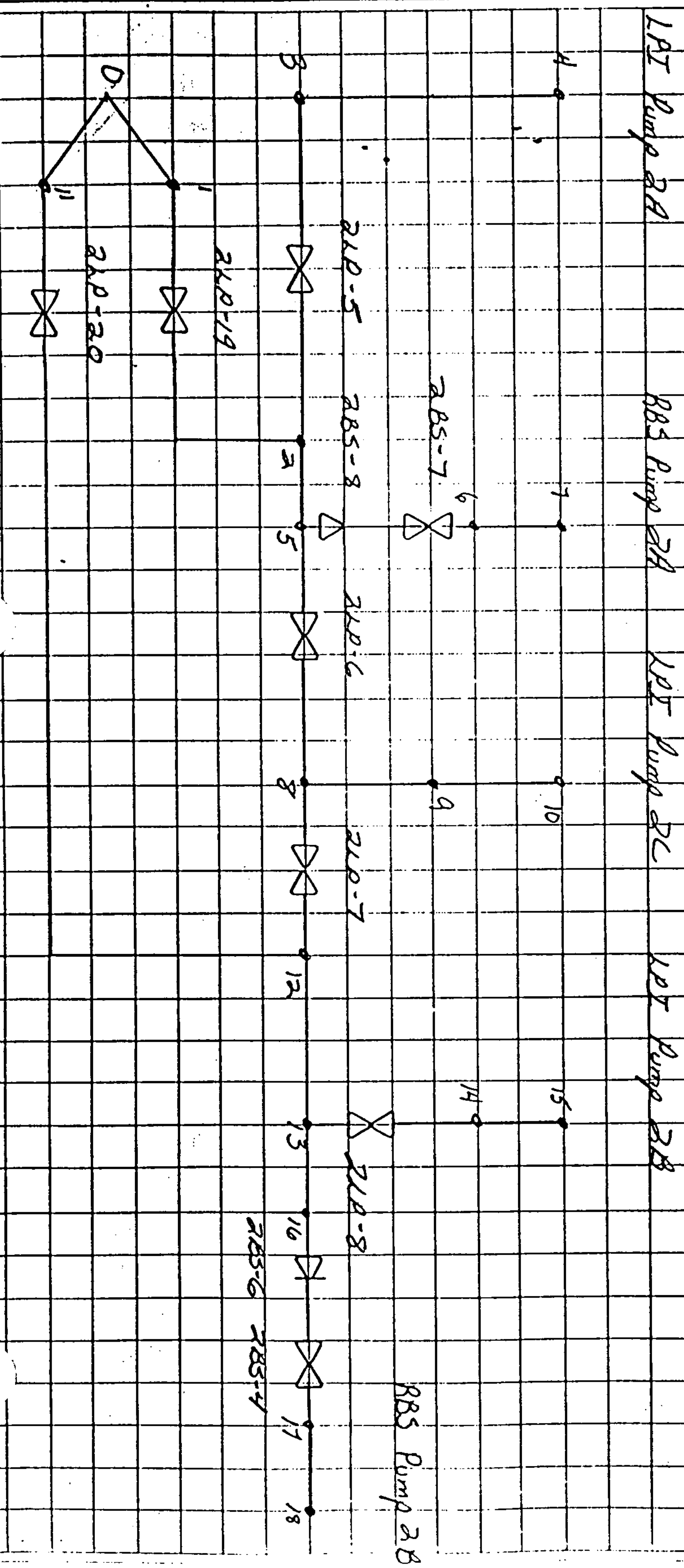
Dev./Station Oconee Nuclear Station Unit 2 File No.

Subject Safety Pumps NPSH Analysis in the Sump Mode By [illegible]

Sheet No. 12 of ___ Problem No. OSC-1954 Checked By ___



Oconee Nuclear Station, Unit 2
Nodal Pressure Drop Analysis
Safety Pumps NPSH In The
Sump Recirculation Mode

Dev./Station Oconee Nuclear Station Unit 2 File No.
Subject Safety Pump NPSH Analysis in the Sump Mode By DMS
Sheet No. 17 of ___ Problem No. OSC-1954 Checked By ___

References

1) Woods Pressure Drop Program, QA Approved IBM Version as identified in A.L. Siddlith letter of 1-26-84
2) Cameron Hydraulic Data, Copyright 1979, Ingersoll Rand Co.
3) Crane Technical Paper 410, Copyright 1979, Crane Co.
4) Oconee FSAR Section 6.0.3.1
5) NUREG 897 "Containment Emergency Sump Performance" Published for comment April 1983

Drawings

1) O-1435B Plan Elevations 758'-0" and 764'-0" Auxiliary Building Rev 1
2) O-435C Sections Elevations 758'-0" and 764'-0" Auxiliary Building Rev 39
3) OFD-102A-2.1 Low Pressure Injection System Flow Diagram Rev 0
OFD-102A-2.2 Low Pressure Injection System Flow Diagram Rev 0
4) OM-1201-114 Pump Curve for RBS Pump 2A
(Also see OM-2201-428 for extended NPSH curve for RBS pumps)
5) OM-1201-112 Pump Curve for RBS Pump 2B
6) OM-1201-106 Pump Curve for LPI Pump 2A
7) OM-1201-111 Pump Curve for LPI Pump 2C

Attachments

1) NUREG 897 Table 5.2
2) NUREG 897 Table 5.3
3) NUREG 897 Table 5.4
4) Woods Analysis Computer Printout

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Dev./Station Oconee Nuclear Station Unit 2 File No.

Subject Safety Pump NPSH Analysis in the Sump Mode By DMS

Sheet No. 18 of ____ Problem No. OSC-1954 Checked By ____

Minor Loss Coefficients

18 inch

Long radius 90° elbow	$14 f_t = (14)(0.012)$	= 0.168 ~	0.17
Short radius 90° elbow	$20 f_t = (20)(0.012)$	=	0.24
45° elbow	$16 f_t = (16)(0.012)$	= 0.192 ~	0.20
Tee thru	$20 f_t = (20)(0.012)$	=	0.24
branch	$60 f_t = (60)(0.012)$	=	0.72

14 inch and 12 inch

Long radius 90° elbow	$14 f_t = (14)(0.013)$	= 0.182 ~	0.19
Short radius 90° elbow	$20 f_t = (20)(0.013)$	=	0.26
45° elbow	$16 f_t = (16)(0.013)$	= 0.208 ~	0.21
Tee thru	$20 f_t = (20)(0.013)$	=	0.26
branch	$60 f_t = (60)(0.013)$	=	0.78
Gate valve	$8 f_t = (8)(0.013)$	= 0.104 ~	0.11

10 inch and 8 inch

Long radius 90° elbow	$14 f_t = (14)(0.014)$	= 0.196 ~	0.20
Short radius 90° elbow	$20 f_t = (20)(0.014)$	=	0.28
45° elbow	$16 f_t = (16)(0.014)$	0.224 ~	0.23
Tee thru	$20 f_t = (20)(0.014)$	=	0.28
branch	$60 f_t = (60)(0.014)$	=	0.84
Gate valve	$8 f_t = (8)(0.014)$	= 0.112 ~	0.12
Swing check valve	$50 f_t = (50)(0.014)$	=	0.70
Expansion joint			0.30

1) All values from Crane Technical Paper 410 except expansion joint from Woods Manual
Values for tees for standard tees
3) Values for 90° elbows are for butt welding elbows
4) Values for 45° elbows are for standard 45° elbows
5) Expansion joint value taken from Woods Users Manual

Dev./Station Oconee Nuclear Station Unit 2 File No.
Subject Safety Pump NPSH Analysis in the Sump Re
By DMS
Sheet No. 19 of ___ Problem No. OSC-1954 Checked By ___ Date ___

Pipe 0-1 ✓

18" Sch 20

✓ Bell shaped reducer inlet
1-6
✓ Short radius 90° elbow
25-7
✓ 48°-31' elbow cut from 90° long radius elbow (assume 45° elbow)
3-1
✓ 41°-69' elbow cut from 90° long radius elbow (assume 45° elbow)
Long radius 90° elbow

Pipe
20-2

Minor loss coefficients

1-Long radius 90° elbow		0.17
1-Short radius 90° elbow		0.24
2-Long radius 45° elbows	2(0.20)	0.40
Entrance losses		0.10
		0.91

Pipe 1-2 ✓

14" Sch 10

✓ 18 x 14 reducer (15' pipe equivalent)
✓ 14" gate valve
✓ 9-0
✓ Tee 14x14x 14 branch

Pipe
✓ 24-0

Minor loss coefficients

✓ 1- 14" gate valve	0.11
✓ 1-Tee 14x14x14 branch	0.78
	0.89

Dev./Station Oconee Nuclear Station Unit 2 File No.
Subject Safety Pump NPSH Analysis in the Sump Mode By DMS
Sheet No. 20 of ___ Problem No. OSC-1954 Checked By ___ Date ___

Pipe 2-5 ✓

14" Sch 20

✓ Tee 14x14x14 thru
✓ 1-5
✓ Tee 14x14x14 thru

Pipe
✓ 1-5

Minor loss coefficient

✓ 2 - Tee 14x14x14 thru 2(0.26) = 0.52

Pipe 5-6 ✓

10" Sch 20

✓ Tee 14x14x10 branch ✓ 10" gate valve 1-5
✓ 10" Swing check valve
4-2
✓ Long radius 90° elbow
2-4
✓ Long radius 90° elbow
1-1
✓ Long radius 90° elbow
1-6
✓ Long radius 90° elbow
✓ Short radius 90° elbow
Pipe
13-6

Minor loss coefficients

4- Long radius 90° elbows	4(0.20)	= 0.80
1- Short radius 90° elbow		= 0.28
1- Swing check valve		= 0.70
1- 14x14x10 tee branch		= 0.84
1- gate valve		= 0.12
		2.74

Dev./Station Oconee Nuclear Station Unit 2 File No.
Subject Safety Pump NPSH Analysis in the Sump Mode By DMS
Sheet No. 21 of ___ Problem No. OSC-1954 Checked By ___

Pipe 6-7 ✓

8" Sch 20

✓ Reducing elbow 10x8 (model as 10x8 reducer 6' pipe equivilent and a long radius 90° elbow)

Pipe
✓ 6-0
Minor loss coefficient
✓ 1 - long radius 90° elbow = 0.20

Pipe 5-8 ✓

14" Sch 20

Tee 14x14x14 thru
✓ Tee 14x14x14 thru
✓ 14" gate valve
✓ 0-5

Pipe
✓ 0-5
Minor loss coefficient
✓ 2 - Tee 14x14x14 thru 2(0.26) = 0.52
✓ 1 - 14" gate valve = 0.11

0.63

Pipe 8-9

14" Sch 20

✓ Tee 14x14x14 branch
8-6
Long radius 90° elbow
4-11
✓ Long radius 90° elbow
3-9
✓ Long radius 90° elbow

Dev./Station Oconee Nuclear Station Unit 2 File No.

Subject Safety Pump NPSH Analysis in the Sump Mode By DMS

Sheet No. 22 of ____ Problem No. OSC-1954 Checked By ____ Date ____

Pipe 8-9 ✓ (cont'd)

14" Sch 20

7-7
✓ long radius 90° elbow
✓ long radius 90° elbow
1-5

Pipe
✓ 36-2
Minor loss coefficient
✓ 1-Tee 14x14x14 branch = 0.78
✓ 5-long radius 90° elbow 5(0.19) = 0.95
1.73

Pipe 9-10 ✓

12" Sch 20

Reducing elbow 14x12 (model as 14x12 reducer 6' equivilent and long radius 90° elbow)

Pipe
✓ 6-0
Minor loss coefficient
✓ 1-long radius 90° elbow = 0.19

Pipe 0-11

18" Sch 20

✓ Bell shaped reducer inlet
✓ 1-6
✓ Short radius 90° elbow
✓ 25-7
✓ 48°-31' elbow cut from 90° long radius elbow (Assume 45° elbow)
✓ 3-1

Dev./Station Oconee Nuclear Station Unit 3 File No.
Subject Safety Pump NPSH Analysis in the Sump Recircu
By DMS
Sheet No. 23 of ___ Problem No. OSC-1954 Checked By ___ Date ___

Pipe 3-11 ✓ (cont'd)

18" Sch 20

✓ 41°-69' elbow cut from 90° long radius elbow (Assume 45° elbow)
✓ 16-4
✓ Long radius 90° elbow
✓ 6-6

Pipe
✓ 53-0

Minor loss coefficient

✓ 1-Long radius 90° elbow	=	0.17
✓ 1-Short radius 90° elbow	=	0.24
2-Long radius 45° elbow 2(0.20)	=	0.40
Entrance loss	=	0.10
		0.91

Pipe 11-12 ✓

14" Sch 10

✓ Reducer 18x14 (15' pipe equivilent)
✓ 14" gate valve
✓ 9-6
✓ Tee 14x14x14 branch

Pipe
✓ 24-6

Minor loss coefficients

✓ 1-Tee 14x14x14 branch	=	0.78
✓ 1-14" gate valve	=	0.11
		0.89

Dev./Station Oconee Nuclear Station Unit 3 File No.
Subject Safety Pump NPSH Analysis in the Sump Be Mode By [initials]
Sheet No. 24 of ___ Problem No. OSC-1954 Checked By ___ Date ___

Pipe 8-12 ✓

14" Sch 20

✓ Tee 14x14x14 thru
✓ 0-5
✓ 14" gate valve

Pipe
✓ 0-5
Minor loss coefficients
✓ 1-Tee 14x14x14 thru = 0.26
✓ 1-14" gate valve = 0.11
0.37

Pipe 12-13 ✓

14" Sch 20

✓ Tee 14x14x14 thru
✓ 3-8
✓ Tee 14x14x14 thru

Pipe
3-8
✓ Minor loss coefficients
2-Tee 14x14x14 thru 2(0.26) = 0.52

Pipe 13-14

14" Sch 20

Tee 14x14x14 branch
4-3
14" gate valve
7-0
Long radius 90° elbow
8-16
Long radius 90° elbow
Long radius 90° elbow

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DUKE POWER COMPANY

Dev./Station Oconee Nuclear Station Unit 2 File No

Subject Safety Pump NPSH Analysis in the Sump Mode By DTB

Sheet No 35 of ___ Problem No. OSC-1954 Checked By ___ Date ___

Pipe 13-14 ✓

14" Sch 20

1-5

Pipe

✓ 21-6

Minor loss coefficients

✓ 1-Tee 14x14x14 branch = 0.78

✓ 3-Long radius 90° elbows 3(0.19) = 0.57

✓ 1-14" gate valve = 0.11

1.46

Pipe 14-15 ✓

12" Sch 20

Reducing elbow 14x12 (model a 14x12 reducer 6' pipe equivilent and a long radius 90° elbow)

Pipe

✓ 6-0

Minor loss coefficients

✓ 1-Long radius 90° elbow = 0.20

Pipe 13-16 ✓

14 Sch 20

Tee 14x14x14 thru

Pipe

0.1

Minor loss coefficient

✓ 1-Tee 14x14x14 thru = 0.26

Dev./Station Oconee Nuclear Station Unit 2 File No.
Subject Safety Pump NPSH Analysis in the Sump Mode
By DMS
Sheet No. 76 of ____ Problem No. OSC-1954 Checked By ____ Date ____

Pipe 16-17

10" Sch 20
Reducer 14x10 (13' pipe equivalent)
✓ 10" swing check valve
✓ Long radius 90° elbow
7-1
✓ Long radius 90° elbow
3-3
✓ Long radius 90° elbow
7-1
✓ Long radius 90° elbow
0-9
✓ Long radius 90° elbow
10" gate valve
Expansion joint

Pipe
✓ 32-2

Minor loss coefficients

✓ 5-Long radius 90° elbows	5(0.20)	= 1.00
✓ 1-10" gate valve		= 0.12
✓ 1-10" swing check valve		= 0.70
– 1-Expansion joint		= 0.30
		2.12

Pipe 17-18

8" Sch 20

Reducing elbow 10x8 (model as 10x8 reducer 6' pipe equivalent and long radius 90° elbow)

Pipe
✓ 6-0

Minor loss coefficients

✓ 1-Long radius 90° elbow = 0.20

DUKE POWER COMPANY

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Dev./Station Oconee Nuclear Station Unit 2 File No.

Subject Safety Pump NPSH Analysis in the Sump Mode By DMB

Sheet No. 27 of ____ Problem No. OSC-1954 Checked By ____ Date ____

Pipe 2-3

14" Sch 20

✓ Tee 14x14x14 thru

Long radius 90° elbow

2-4

✓ Tee 14x14x14 thru

1-0

14" gate valve

✓ Long radius 90° elbow

7-8

✓ Long radius 90° elbow

3-9

Long radius 90° elbow

7-7

✓ Long radius 90° elbow

✓ Long radius 90° elbow

1-3

Pipe

23-7

Minor loss coefficient

2-Tee 14x14x14 thru	2(0.26)	=	0.52
6-Long radius 90° elbows	6(0.19)	=	1.14
1-14" gate valve		=	0.11
			1.77

Pipe 3-4

12" Sch 20

Reducing elbow 14x12 (model as 14x12 reducer 6' pipe equivalent plus long radius 90° elbow)

Pipe

6-0

Minor loss coefficient

1-Long radius 90° elbow = 0.19

OSC-44 4
RUN 16
Attachment 4
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```
FAIRVIEW
LOGOFF
LOGON
IKJ56700A ENTER USERID -
DNS8374
ENTER CURRENT PASSWORD FOR DNS8374-
:BARK
:ICH70001I DNS8374  LAST ACCESS AT 08:29:52 ON WEDNESDAY, AUGUST 29, 1984
DNS8374 LOGON IN PROGRESS AT 08:31:18 ON AUGUST 29, 1984
 *** tso will be down sunday, aug.26 from 08:00 to 22:00 ***
READY
FREE F(FT05F001)
READY
ALLOC DA(DNS8374H.DATA) F(FT05F001)
READY
CALL 'SYS1.DUK2LOAD(RUN03445)'
 FLOWRATE IS EXPRESSED IN GPM AND PRESSURE IN PSIG
```

THE DARCY WEISBACH HEAD LOSS EQUATION IS USED, THE KINEMATIC VISCOSITY = 0.0000120

PIPE NUMBER	NODE NUMBERS		LENGTH (FEET)	DIAMETER (INCHES)	ROUGHNESS	MINOR LOSS K	FIXED GRADE
1	0	1	30.2	17.376	0.15	0.91	782.50
2	0	11	53.0	17.376	0.15	0.91	782.50

THE FLOW IN LINE NUMBER 2 IS RESTRICTED

PIPE NUMBER	NODE NUMBERS		LENGTH (FEET)	DIAMETER (INCHES)	ROUGHNESS	MINOR LOSS K	FIXED GRADE
3	1	2	24.0	13.500	0.15	0.89	
4	2	3	23.6	13.376	0.15	1.77	
5	3	4	6.0	12.250	0.15	0.19	
6	2	5	1.4	13.376	0.15	0.52	
7	5	6	13.5	10.250	0.15	2.74	
8	6	7	6.0	8.125	0.15	0.20	
9	5	8	0.4	13.376	0.15	0.63	
10	8	9	26.2	13.376	0.15	1.73	
11	9	10	6.0	12.250	0.15	0.19	
12	8	12	0.4	13.376	0.15	0.37	
13	12	13	3.7	13.376	0.15	0.52	
14	13	14	21.5	13.376	0.15	1.46	
15	14	15	6.0	12.250	0.15	0.20	
16	13	16	0.1	13.376	0.15	0.26	
17	16	17	32.2	10.250	0.15	2.12	
18	17	18	6.0	8.125	0.15	0.20	
19	11	12	24.5	13.500	0.15	0.89	

JUNCTION NUMBER	DEMAND	ELEVATION	CONNECTING PIPES	
1	0.0	0.0	-1	3

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RUN 16
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	0.0	0.0	-3	4	6
	0.0	0.0	-4		
	0.0	0.0	-5		
	0.0	0.0	-6	7	9
6	0.0	0.0	-7	8	
7	0.0	0.0	-8		
8	0.0	0.0	-9	10	12
9	0.0	0.0	-10	11	
10	0.0	0.0	-11		
11	0.0	0.0	-2	19	
12	0.0	0.0	-12	13	-19
13	0.0	0.0	-13	14	16
14	0.0	0.0	-14	15	
15	3000.00	761.10	-15		
16	0.0	0.0	-16	17	
17	0.0	0.0	-17	18	
18	1000.00	760.10	-18		

THIS SYSTEM HAS 19 PIPES WITH 18 JUNCTIONS , 0 LOOPS AND 2 FIXED GRADE NODES

THESE ARE THE RESULTS FOR THE ORIGINAL DATA

OCONEE UNIT 2
SUMP RECIRCULATION MODE
SAFETY PUMP NPSH CALCULATIONS

0000000
0000000
0000000

THE FOLLOWING RESULTS ARE OBTAINED AFTER 2 TRIALS

PIPE NO.	NODE NUMBERS		FLOWRATE	HEAD LOSS	PUMP HEAD	MINOR LOSS	VELOCITY	HL/1000
1	0	1	4000.000	0.133	0.0	0.414	5.412	4.411
THE FLOW IN LINE NUMBER 2 IS RESTRICTED								
3	1	2	4000.000	0.375	0.0	1.111	8.965	15.622
4	2	3	0.0	0.0	0.0	0.0	0.0	0.0
5	3	4	0.0	0.0	0.0	0.0	0.0	0.0
6	2	5	4000.000	0.023	0.0	0.673	9.132	16.3
7	5	6	0.0	0.0	0.0	0.0	0.0	0.0
8	6	7	0.0	0.0	0.0	0.0	0.0	0.0
9	5	8	4000.000	0.007	0.0	0.816	9.132	16.3
10	8	9	0.0	0.0	0.0	0.0	0.0	0.0
11	9	10	0.0	0.0	0.0	0.0	0.0	0.0
12	8	12	4000.000	0.007	0.0	0.479	9.132	16.3
13	12	13	4000.000	0.060	0.0	0.673	9.132	16.3
14	13	14	3000.000	0.203	0.0	1.063	6.849	9.4
15	14	15	3000.000	0.088	0.0	0.207	8.166	14.6
16	13	16	1000.000	0.000	0.0	0.021	2.283	1.1

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1	16	17	1000.000	0.143	0.0	0.498	3.888	4.457
1	17	18	1000.000	0.085	0.0	0.119	6.188	14.182
	11	12	0.0	0.0	0.0	0.0	0.0	0.0

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JUNCTION NUMBER	DEMAND	GRADE LINE	ELEVATION	PRESSURE		
1	0.0	781.95				
2	0.0	780.47				
3	0.0	780.47				
4	0.0	780.47				
5	0.0	779.77				
6	0.0	779.77				
7	0.0	779.77				
8	0.0	778.95				
9	0.0	778.95				
10	0.0	778.95				
11	0.0	778.46				
12	0.0	778.46				
13	0.0	777.73				
14	0.0	776.46				
15	3000.00	776.17	761.10	6.53 = 15.084	HL=6.316	HL+20% = 7.579
16	0.0	777.71				
17	0.0	777.07				
18	1000.00	776.86	760.10	7.26 = 16.771	HL=5.629	HL+20% = 6.755

THE RELATIVE CHANGE IN FLOWRATE FROM THE PREVIOUS TRIAL = 0.00011

READY
LOGOFF
DNS8374 LOGGED OFF TSO AT 08:32:51 ON AUGUST 29, 1984

OSC-4467, Rev 4
Attachment 19
Page 156 of 158

OSC-19
RUN 18
Attachment 4
Page 83

```
FAIRVIEW
LOGON
IKJ56700I ENTER USERID -
DNS8374
ENTER CURRENT PASSWORD FOR DNS8374-
:BARK
:ICH70001I DNS8374  LAST ACCESS AT 08:38:11 ON WEDNESDAY, AUGUST 29, 1984
DNS8374 LOGON IN PROGRESS AT 08:39:20 ON AUGUST 29, 1984
 *** tso will be down sunday, aug.26 from 08:00 to 22:00 ***
READY
FREE F(FT05F001)
READY
ALLOC DA(DNS8374H.DATA) F(FT05F001)
READY
CALL 'SYS1.DUK2LOAD(RUN03445)'
 FLOWRATE IS EXPRESSED IN GPM AND PRESSURE IN PSIG
```

THE DARCY WEISBACH HEAD LOSS EQUATION IS USED, THE KINEMATIC VISCOSITY = 0.0000120

PIPE NUMBER	NODE NUMBERS		LENGTH (FEET)	DIAMETER (INCHES)	ROUGHNESS	MINOR LOSS K	FIXED GRADE
1	0	1	30.2	17.376	0.15	0.91	782.50
2	0	11	53.0	17.376	0.15	0.91	782.50

THE FLOW IN LINE NUMBER 2 IS RESTRICTED

PIPE NUMBER	NODE NUMBERS		LENGTH (FEET)	DIAMETER (INCHES)	ROUGHNESS	MINOR LOSS K
3	1	2	24.0	13.500	0.15	0.89
4	2	3	23.6	13.376	0.15	1.77
5	3	4	6.0	12.250	0.15	0.19
6	2	5	1.4	13.376	0.15	0.52
7	5	6	13.5	10.250	0.15	2.74
8	6	7	6.0	8.125	0.15	0.20
9	5	8	0.4	13.376	0.15	0.63
10	8	9	26.2	13.376	0.15	1.73
11	9	10	6.0	12.250	0.15	0.19
12	8	12	0.4	13.376	0.15	0.37
13	12	13	3.7	13.376	0.15	0.52
14	13	14	21.5	13.376	0.15	1.46
15	14	15	6.0	12.250	0.15	0.20
16	13	16	0.1	13.376	0.15	0.26
17	16	17	32.2	10.250	0.15	2.12
18	17	18	6.0	8.125	0.15	0.20
19	11	12	24.5	13.500	0.15	0.89

JUNCTION NUMBER	DEMAND	ELEVATION	CONNECTING PIPES		
1	0.0	0.0	-1	3	
2	0.0	0.0	-3	4	6

OSC-4467 Rev. 4
Attachment N
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	0.0	0.0	-4	5	
	3000.00	761.10	-5		
	0.0	0.0	-6		9
	0.0	0.0	-7	8	
7	1000.00	760.10	-8		
8	0.0	0.0	-9	10	12
9	0.0	0.0	-10	11	
10	0.0	0.0	-11		
11	0.0	0.0	-2	19	
12	0.0	0.0	-12	13	-19
13	0.0	0.0	-13	14	16
14	0.0	0.0	-14	15	
15	0.0	0.0	-15		
16	0.0	0.0	-16	17	
17	0.0	0.0	-17	18	
18	0.0	0.0	-18		

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Rev 18
Attachment 4
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THIS SYSTEM HAS 19 PIPES WITH 18 JUNCTIONS , 0 LOOPS AND 2 FIXED GRADE NODES

THESE ARE THE RESULTS FOR THE ORIGINAL DATA

OCONEE UNIT 2
SUMP RECIRCULATION MODE
SAFETY PUMP NPSH CALCULATIONS

0000000
0000000
0000000

THE FOLLOWING RESULTS ARE OBTAINED AFTER 2 TRIALS

PIPE NO.	NODE NUMBERS		FLOWRATE	HEAD LOSS	PUMP HEAD	MINOR LOSS	VELOCITY	HL/1000
1	0	1	4000.000	0.133	0.0	0.414	5.412	4.411
THE FLOW IN LINE NUMBER 2 IS RESTRICTED								
3	1	2	4000.000	0.375	0.0	1.111	8.965	15.622
4	2	3	3000.000	0.223	0.0	1.289	6.849	9.439
5	3	4	3000.000	0.088	0.0	0.197	8.166	14.677
6	2	5	1000.000	0.002	0.0	0.042	2.283	1.199
7	5	6	1000.000	0.060	0.0	0.643	3.888	4.4[illegible]
8	6	7	1000.000	0.085	0.0	0.119	6.188	14.1[illegible]
9	5	8	0.0	0.0	0.0	0.0	0.0	0.0
10	8	9	0.0	0.0	0.0	0.0	0.0	0.0
11	9	10	0.0	0.0	0.0	0.0	0.0	0.0
12	8	12	0.0	0.0	0.0	0.0	0.0	0.0
13	12	13	0.0	0.0	0.0	0.0	0.0	0.0
14	13	14	0.0	0.0	0.0	0.0	0.0	0.0
15	14	15	0.0	0.0	0.0	0.0	0.0	0.0
16	13	16	0.0	0.0	0.0	0.0	0.0	0.0
17	16	17	0.0	0.0	0.0	0.0	0.0	0.0

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1[illegible]	17	18	0.0	0.0	0.0	0.0	0.0	0.0
1[illegible]	11	12	0.0	0.0	0.0	0.0	0.0	0.0

OSC-1954
Run 18
Attachment 4
Page 84

JUNCTION NUMBER	DEMAND	GRADE LINE	ELEVATION	PRESSURE	
1	0.0	781.95			
2	0.0	780.47			
3	0.0	778.96			
4	3000.00	778.67	761.10	7.61 = 17.579	HL = 3.821 HL+20% = 4.585
5	0.0	780.42			
6	0.0	779.72			
7	1000.00	779.52	760.10	8.41 = 19.427	HL = 2.973 HL+20% = 3.568
8	0.0	780.42			
9	0.0	780.42			
10	0.0	780.42			
11	0.0	780.42			
12	0.0	780.42			
13	0.0	780.42			
14	0.0	780.42			
15	0.0	780.42			
16	0.0	780.42			
17	0.0	780.42			
18	0.0	780.42			

THE RELATIVE CHANGE IN FLOWRATE FROM THE PREVIOUS TRIAL = 0.00013

READY
LOGOFF
DNS8374 LOGGED OFF TSO AT 08:40:52 ON AUGUST 29, 1984

DUKE POWER COMPANY

Form 00184 (6-81)

OSC-4467, Rev. 4
Attachment 19
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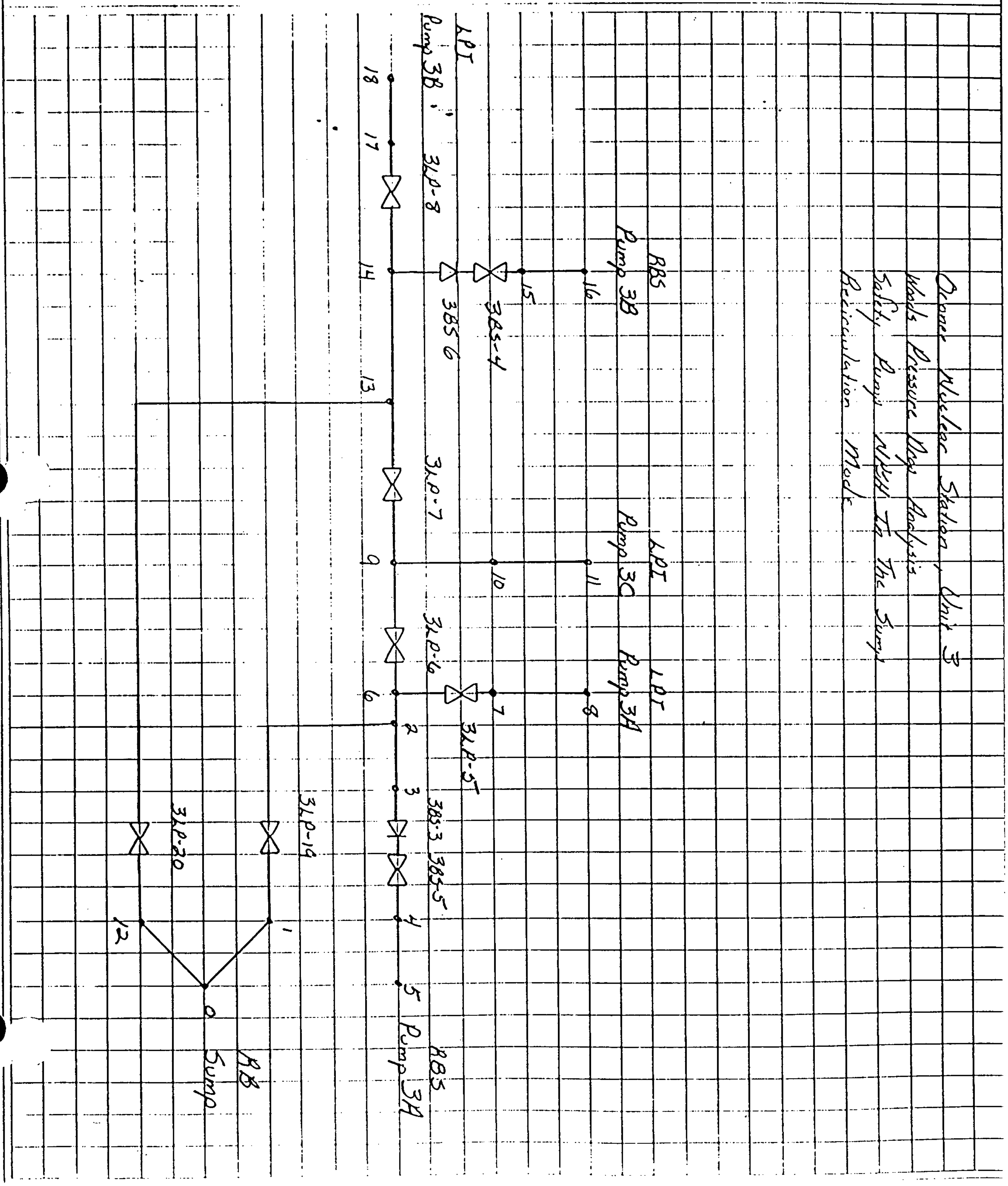
Dev./Station Oconee Nuclear Station Unit 3 File No.

Subject Safety Pump NPSH Analysis in the Sump Recircul

By [signature]

Sheet No. 12 of Problem No. OSC-1977 Checked By [signature]



DUKE POWER COMPANY

Form 00184 (6-81)

OSC-4467, Rev. 4
Attachment 19
Page 41 of 58

Dev./Station Oconee Nuclear Station Unit 3 File No.

Subject Safety Pump NPSH Analysis in The Sump Mode

By DNS

Sheet No. 17 of ____ Problem No. OSC-1977 Checked By SZN

References

1) Woods Pressure Drop Program QA Approved IBM Version as identified in A.L. Sidduth letter of 1-26-84.
2) Cameron Hydraulic Data, Copyright 1979, Ingersoll Rand Co.
3) Crane Technical Paper 410, Copyright 1979, Crane Co.
4) Oconee FSAR Section 6.0.3.1
5) NUREG 897 "Containment Emergency Sump Performance" Published for comment April 1983

Drawings

O-2435B Plan Elevation 758-0 Auxiliary Building Rev 18
O-2435C Sections Elevation 758-0 Auxiliary Building Rev 20
3) OFD-102A-3.1 Low Pressure Injection System Flow Diagram Rev 1
OFD-102A-3.2 Low Pressure Injection System Flow Diagram Rev 0
4) OM-2201-427 RBS Pump Curve
5) OM-2201-428 RBS Pump Curve
6) OM-2201-572 LPI Pump Curve
7) OM-2201-573 LPI Pump Curve
8) OM-2201-574 LPI Pump Curve

Attachments

1) NUREG 897 Table 5.2
2) NUREG 897 Table 5.3
3) NUREG 897 Table 5.4
4) Woods Analysis Computer Printout

Dev./Station Oconee Nuclear Station Unit 3 File No.
Subject Safety Pump NPSH Analysis in the Sump Recirc
By DWS
Sheet No. 18 of ____ Problem No. OSC-1977 Checked By SLA

Minor loss coefficients

18 inch

Long radius 90° elbow	14 (f_t)	= 14 (0.012)	= 0.168	~	0.17
Short radius 90° elbow	20 (f_t)	= 20 (0.012)	=		0.24
45° elbow	16 (f_t)	= 16 (0.012)	= 0.192	~	0.20
Tee thru	20 (f_t)	= 20 (0.012)	=		0.24
branch	60 (f_t)	= 60 (0.012)	=		0.72
Entrance					0.10

14 inch and 12 inch

Long radius 90° elbow	14 (f_t)	= 14 (0.013)	= 0.182	~	0.19
Short radius 90° elbow	20 (f_t)	= 20 (0.013)	=		0.26
45° elbow	16 (f_t)	= 16 (0.013)	= 0.208	~	0.21
Tee thru	20 (f_t)	= 20 (0.013)	=		0.26
branch	60 (f_t)	= 60 (0.013)	=		0.78
Gate valve	8 (f_t)	= 8 (0.013)	= 0.104	~	0.11

10 inch and 8 inch

Long radius 90° elbow	14 (f_t)	= 14 (0.014)	= 0.196	~	0.20
Short radius 90° elbow	20 (f_t)	= 20 (0.014)	=		0.28
45° elbow	16 (f_t)	= 16 (0.014)	= 0.224	~	0.23
Tee thru	20 (f_t)	= 20 (0.014)	=		0.28
branch	60 (f_t)	= 60 (0.014)	=		0.84
Gate valve	8 (f_t)	= 8 (0.014)	= 0.112	~	0.12
Swing check valve	50 (f_t)	= 50 (0.014)	=		0.70
Expansion joint					0.30

Dev./Station Oconee Nuclear Station Unit 3 File No.

Subject Safety Pump NPSH Analysis in The Sump R

By DMB

Sheet No. 19 of ____ Problem No. OSC-1977 Checked By SIN Date

Pipe 0-1

18" Sch 20

✓ Bell shaped reducer inlet
1-6
✓ Short radius 90° elbow
25-7
✓ 48°-31' elbow cut from 90° long radius elbow (assume 45° elbow)
3-1
✓ 41°-69' elbow cut from 90° long radius elbow (assume 45° elbow)
✓ Long radius 90° elbow

Pipe
27-1

Minor loss coefficients

✓ 1-Long radius 90° elbow	0.17
✓ 1-Short radius 90° elbow	0.24
✓ 2-Long radius 45° elbow 2(0.20)	0.40
Entrance losses	0.10
	0.91

Pipe 1-2

14" Sch 10

18 x 14 reducer (15' pipe equivilent)
14" gate valve
9-0
Tee 14x14x14 branch

Pipe
24-0

Dev./Station Oconee Nuclear Station Unit 3 File No.
Subject Safety Pump NPSH Analysis in The Sump B
By DMS
Sheet No. 20 of ___ Problem No. OSC-1977 Checked By SLN

Minor loss coefficients

1-14 gate valve	0.11
1-Tee 14x14x14 branch	0.78
	0.89

2-3

14" Sch 10:

Long radius 90° elbow
2-2
Long radius 90° elbow
Pipe
2-2

Minor loss coefficients
2-Long radius 90° elbows 2(0.19) = 0.38

3-4

10" Sch 20

✓ Tee 14x14x10 branch
✓ Long radius 90° elbow
1-8
✓ Long radius 90° elbow
✓ 10" Swing check valve
✓ Long radius 90° elbow
✓ Tee 10x10x3 thru
✓ Long radius 90° elbow
✓ Long radius 90° elbow
3-8
✓ Long radius 90° elbow
✓ 10" gate valve
1-11
Coupling

DUKE POWER COMPANY

Form 00184 (6-81)

Dev./Station Oconee Nuclear Station Unit 3 File No.
Subject Safety Pump NPSH Analysis in The Sump Mode By DWS
Sheet No. 21 of ___ Problem No. OSC-1977 Checked By SLn Date

Pipe 3-4 (cont)

10" Sch 20

40-6

Pipe
7-1

Minor loss coefficient

6-Long radius 90° elbows 6(0.20)	= 1.20
1-Tee 14x14x10 branch	= 0.84
1-Tee 10x10x3 thru	= 0.28
1-10" Swing check valve	= 0.70
1-10" Gate	= 0.12
1-Expansion joint	= 0.30
	3.44

Pipe 4-5

8" Sch 20

10x8 reducing elbow (model as 10x8 reducer (6' pipe equivilent and a long radius 90° elbow)

Pipe
6-0

Minor loss coefficient

1-Long radius 90° elbow = 0.20

Pipe 2-6

14" Sch 10

2-3

Tee 14x14x14 thru

Pipe
2-3

Minor loss coefficient

1-Tee 14x14x14 thru = 0.26

DUKE POWER COMPANY

Form 00184 (6-81)

Dev./Station Oconee Nuclear Station Unit 3 File No.

Subject Safety Pump NPSH Analysis in The Sump Mode By DNS

Sheet No. 22 of ___ Problem No. OSC-1977 Checked By SLN Date

Pipe 6-7

14" Sch 10

✓ Tee 14x14x14 branch

6-1

✓ Long radius 90° elbow

3-2

✓ Long radius 90° elbow

0-4

14" gate valve

✓ Long radius 90° elbow

2-2

✓ Long radius 90° elbow

Long radius 90° elbow

Pipe

1-3

19-0

Minor loss coefficients

1-Tee 14x14x14 branch		=	0.78
5-Long radius 90° elbows	5(0.19)	=	0.95
1-14" gate valve		=	0.11
			1.84

Pipe 7-8

12" Sch 20

0-6

Reducer 14x12 (6' equivilent)

Long radius 90° elbow

Pipe

6-6

Minor loss coefficient

1-Long radius 90° elbow = 0.19

Dev./Station Oconee Nuclear Station Unit 3 File No.
Subject Safety Pump NPSH Analysis in The Sump mode By DMS
Sheet No. 23 of ___ Problem No. OSC-1977 Checked By SLN

Pipe 6-9

14" Sch 10

Tee 14x14x14 thru
14" gate valve
0-5
Tee 14x14x14 thru

Pipe
6-5

Minor loss coefficients
2- Tees 14x14x14 thru (2)(0.26) = 0.52
1- 14" gate valve = 0.11
0.63

Pipe 9-10

14 Sch 10

Tee 14x14x14 branch
4-8
Long radius 90° elbow
9-3
Long radius 90° elbow
9-.6
Long radius 90° elbow
7-6
Long radius 90° elbow
Long radius 90° elbow
~3

Pipe
32-2
Minor loss coefficients
5- Long radius 90° elbows 5(0.19) = 0.95
1- Tee 14x14x14 branch = 0.78

Form 00184 (6-81)

DUKE POWER COMPANY

Dev./Station Oconee Nuclear Station Unit 3 File No.
Subject Safety Pump NPSH Analysis in The Sump Mode By DMS
Sheet No. 24 of ___ Problem No. OSC-1977 Checked By SZA

Pipe 10-11

12 Sch 20

Reducer 14x12 (6" equivilent)
0-6
Long radius 90° elbow

Pipe
6-6
Minor loss coefficient
1 - long radius 90° elbow = 0.19

Pipe 9-13

14" Sch 10

Tee 14x14x14 thru
14" gate valve

Pipe
0.1
Minor loss coefficient
1 - Tee 14x14x14 thru = 0.26
1 - 14" gate valve = 0.11
0.37

Pipe 0-12

18" Sch 20

Bell shaped reducer inlet
1-6
Short radius 90° elbow
25-7
48°-31' elbow cut from 90° long radius elbow (Assume 45° elbow)
3-1
41°-69' elbow cut from 90° long radius elbow (Assume 45° elbow)
16-4

Dev./Station Oconee Nuclear Station Unit 3 File No.
Subject Safety Pump NPSH Analysis in The S[...] Mode By DMB
Sheet No. 25 of ___ Problem No. OSC-1977 Checked By SLN

Pipe 0-12 (cont)

18" Sch 20

Long radius 90° elbow
6-10

Pipe
53-4

Minor loss coefficients

1-Long radius 90° elbow	= 0.17
1-Short radius 90° elbow	= 0.24
2-Long radius 45° elbow 2(0.20)	= 0.40
Entrance loss	= 0.10
	0.91

Pipe 12-13

14" Sch 10

Reducer 18x14 (15' pipe equivilent)
14" gate valve
9-9
Tee 14x14x14 branch

Pipe
24-9

Minor loss coefficient

1-Tee 14x14x14 branch	= 0.78
1-14 gate valve	= 0.11
	0.89

Dev./Station Oconee Nuclear Station Unit 3 File No.
Subject Safety Pumps NPSH Analysis in The Sump Mode By DMS
Sheet No. 26 of ___ Problem No. OSC-1977 Checked By SLN

Pipe 13-14

14" Sch 10

Tee 14x14x14 thru
3-11
Tee 14x14x14 thru
8-0
Long radius 90° elbow
9-1
Long radius 90° elbow
1-4
Long radius 90° elbow
9-1
Long radius 90° elbow

Pipe
31-9

Minor loss coefficients

2- Tee 14x14x14 thru	= 0.52
4- Long radius 90° elbow	= 0.72
	1.24

Pipe 14-15

10" Sch 20

✓ Tee 14x14x10 branch
10-5
✓ Long radius 90° elbow
✓ 10" Swing check valve
✓ 2-9 with 3" fabricated branch assume 10x10x3 tee thru
Long radius 90° elbow
– 10" gate valve
1-6
✓ Expansion joint

DUKE POWER COMPANY

Form 00184 (6-81)

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Attachment 19
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Dev./Station Oconee Nuclear Station Unit 3 File No.

Subject Safety Pump NPSH Analysis in The Sump Mode By DNS

Sheet No 21 of ____ Problem No. OSC-1977 Checked By SEN

Pipe 14-15 (cont)

10" Sch 20

Pipe

14-8

Minor piping losses

1- Tee 14x14x10 branch	= 0.84
1- Tee 10x10x3 thru	= 0.28
1- 10" gate valve	= 0.12
1- 10" swing check valve	= 0.70
1- Expansion joint	= 0.30
2- Long radius 90° elbow 2(0.20)	= 0.40
	2.64

Pipe 15-16

8" Sch 20

Reducing elbow 10"x8" (model as 10x8 reducer 6' pipe equivilent and a long radius 90° elbow)

Pipe

6-0

Minor loss coefficient

1- Long radius 90° elbow = 0.20

Pipe 14-17

14" Sch 10

Tee 14x14x14 thru

13-7

Long radius 90° elbow ✓

14" gate valve

8-4

Long radius 90° elbow ✓

1-3

Dev./Station Oconee Nuclear Station Unit 3 File No.
Subject Safety Pump NPSH Analysis in The Sump R... Mode By DMS
Sheet No 28 of ___ Problem No. OSC-1977 Checked By SLM Date

Pipe 14-17 (cont)

14" Sch 10

Pipe
23-6
Minor loss coefficients

1 - Tee 14x14x14 thru	= 0.26
2 - Long radius 90° elbows 2(0.19)	= 0.38
1 - 14" gate valve	= 0.11
	0.75

Pipe 17-18

12" Sch 20

Reducer 14 x 12 (6' equivalent)
Long radius 90° elbow

Pipe
6-0
Minor loss coefficients
1 - Long radius 90° elbow = 0.19

```
FAIRVIEW
LOGON
IKJ56700    NTER USERID -
DNS8374
ENTER CURRENT PASSWORD FOR DNS8374-
:BARK
:ICH70001I DNS8374  LAST ACCESS AT 09:50:45 ON WEDNESDAY, NOVEMBER 7, 198
4
DNS8374 LOGON IN PROGRESS AT 09:52:00 ON NOVEMBER 7, 1984
 ^-----------------------------------------------------------------^
 ^    W E L C O M E  T O   T H E   D U K E   P O W E R   ^
 ^         M V S / X A   3 0 8 1   S Y S T E M  "E"      ^
 ^-----------------------------------------------------------------^
READY
FREE F(FT05F001)
READY
ALLOC DA(DNS8374E.DATA) F(FT05F001)
READY
CALL 'SYS1.DUK2LOAD(RUN03445)'
 FLOWRATE IS EXPRESSED IN GPM AND PRESSURE IN PSIG
```

RUN 16
OSC-1977
DNS 11-6-84
Page 76

THE DARCY WEISBACH HEAD LOSS EQUATION IS USED, THE KINEMATIC VISCOSITY = 0.0000120

PIPE NUMBER	NODE NUMBERS		LENGTH (FEET)	DIAMETER (INCHES)	ROUGHNESS	MINOR LOSS K	FIXED GRADE
1	0	1	27.1	17.376	0.15	0.91	782.50
2	0	12	53.3	17.376	0.15	0.91	782.50

THE FLOW IN LINE NUMBER 2 IS RESTRICTED

PIPE NUMBER	NODE NUMBERS		LENGTH (FEET)	DIAMETER (INCHES)	ROUGHNESS	MINOR LOSS K	FIXED GRADE
3	1	2	24.0	13.500	0.15	0.89	
4	2	3	2.2	13.500	0.15	0.38	
5	3	4	7.1	10.250	0.15	3.44	
6	4	5	6.0	8.125	0.15	0.20	
7	2	6	2.3	13.500	0.15	0.26	
8	6	7	19.0	13.500	0.15	1.84	
9	7	8	6.5	12.250	0.15	0.19	
10	6	9	0.4	13.500	0.15	0.63	
11	9	10	32.2	13.500	0.15	1.73	
12	10	11	6.5	12.250	0.15	0.19	
13	9	13	0.1	13.500	0.15	0.37	
14	12	13	24.8	13.500	0.15	0.89	
15	13	14	31.8	13.500	0.15	1.24	
16	14	15	14.7	10.250	0.15	2.64	
17	15	16	6.0	8.125	0.15	0.20	
18	14	17	23.5	13.500	0.15	0.75	
19	17	18	6.0	12.250	0.15	0.19	

JUNCTION NUMBER	DEMAND	ELEVATION	CONNECTING PIPES		
1	0.0	0.0	-1		
2	0.0	0.0	-3	4	7
3	0.0	0.0	-4	5	
4	0.0	0.0	-5	6	
5	0.0	0.0	-6		
6	0.0	0.0	-7	8	10
7	0.0	0.0	-8	9	
8	0.0	0.0	-9		
9	0.0	0.0	-10	11	13
10	0.0	0.0	-11	12	
11	0.0	0.0	-12		
12	0.0	0.0	-2	14	
13	0.0	0.0	-13	-14	15
14	0.0	0.0	-15	16	18
15	0.0	0.0	-16	17	
16	1000.00	760.10	-17		
17	0.0	0.0	-18	19	
18	3000.00	761.10	-19		

Run 1
OSC-12
DMS 1-6-84
Page 77

THIS SYSTEM HAS 19 PIPES WITH 18 JUNCTIONS , 0 LOOPS AND 2 FIXED GRADE NODES

THESE ARE THE RESULTS FOR THE ORIGINAL DATA

OCONEE UNIT 3 0000000
SUMP RECIRCULATION MODE 0000000
SAFETY PUMP NPSH CALCULATION 0000000

THE FOLLOWING RESULTS ARE OBTAINED AFTER 2 TRIALS

PIPE NO.	NODE NUMBERS		FLOWRATE	HEAD LOSS	PUMP HEAD	MINOR LOSS	VELOCITY	HL/1000
1	0	1	4000.000	0.119	0.0	0.414	5.412	4.411
THE FLOW IN LINE NUMBER 2 IS RESTRICTED								
3	1	2	4000.000	0.375	0.0	1.111	8.965	15.6
4	2	3	0.0	0.0	0.0	0.0	0.0	0.0
5	3	4	0.0	0.0	0.0	0.0	0.0	0.0
6	4	5	0.0	0.0	0.0	0.0	0.0	0.0
7	2	6	4000.000	0.035	0.0	0.324	8.965	15.6
8	6	7	0.0	0.0	0.0	0.0	0.0	0.0
9	7	8	0.0	0.0	0.0	0.0	0.0	0.0
10	6	9	4000.000	0.007	0.0	0.786	8.965	15.6
11	9	10	0.0	0.0	0.0	0.0	0.0	0.0
12	10	11	0.0	0.0	0.0	0.0	0.0	0.0
13	9	13	4000.000	0.002	0.0	0.462	8.965	15.6

1[illegible]	12	13	0.0	0.0	0.0	0.0	0.0	0.0
1[illegible]	13	14	4000.000	0.496	0.0	1.547	8.965	15.622
[illegible]	14	15	1000.000	0.065	.0	0.620	3.888	4.457
1[illegible]	15	16	1000.000	0.085	0.0	0.119	6.188	14.182
18	14	17	3000.000	0.212	0.0	0.526	6.724	9.013
19	17	18	3000.000	0.088	0.0	0.197	8.166	14.677

Run 16
OSC-1977
DNS 11-6-84
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JUNCTION NUMBER	DEMAND	GRADE LINE	ELEVATION	PRESSURE		
1	0.0	781.97				
2	0.0	780.48				
3	0.0	780.48				
4	0.0	780.48				
5	0.0	780.48				
6	0.0	780.12				
7	0.0	780.12				
8	0.0	780.12				
9	0.0	779.33				
10	0.0	779.33				
11	0.0	779.33				
12	0.0	778.87				
13	0.0	778.87				
14	0.0	776.82				
15	0.0	776.14				
16	1000.00	775.93	760.10	6.86 = 15.847	HL = 6.553	HL + 20% = 7.864
17	0.0	776.08				
18	3000.00	775.80	761.10	6.37 = 14.715	HL = 6.685	HL + 20% = 8.022

THE RELATIVE CHANGE IN FLOWRATE FROM THE PREVIOUS TRIAL = 0.00009

READY
LOGOFF
DNS8374 LOGGED OFF TSO AT 09:53:37 ON NOVEMBER 7, 1984
h

OSC-4467 Rev. 4
Attachment 19
Page 55 of 58

RUN OSC-19
DNS 11-84
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```
FAIRVIEW
LOGONB
IKJ56410   OGONB COMMAND NOT ACCEPTED DURING LOGON
IKJ56400  NTER LOGON OR LOGOFF-
LOGON
IKJ56700A ENTER USERID -
DNS8374
ENTER CURRENT PASSWORD FOR DNS8374-
:BARK
:ICH70001I DNS8374  LAST ACCESS AT 09:58:08 ON WEDNESDAY, NOVEMBER 7, 198
4
DNS8374 LOGON IN PROGRESS AT 09:59:24 ON NOVEMBER 7, 1984
 ^-----------------------------------------------------------^
 ^    W E L C O M E   T O   T H E   D U K E   P O W E R   ^
 ^         M V S / X A   3 0 8 1   S Y S T E M   "E"      ^
 ^-----------------------------------------------------------^
READY
FREE F(FT05F001)
READY
ALLOCV DA(DNS8374E.DATA) F(FT05F001:!
READY
ALLOC DA(DNS8374E.DATA) F(FT05F001)
READY
CALL 'ST:!
READY
CALL 'SYS1.DUK2LOAD(RUN03445)'
 FLOWRATE IS EXPRESSED IN GPM AND PRESSURE IN PSIG
```

THE DARCY WEISBACH HEAD LOSS EQUATION IS USED, THE KINEMATIC VISCOSITY = 0.0000120

PIPE NUMBER	NODE NUMBERS		LENGTH (FEET)	DIAMETER (INCHES)	ROUGHNESS	MINOR LOSS K	FIXED GRADE
1	0	1	27.1	17.376	0.15	0.91	782.50
2	0	12	53.3	17.376	0.15	0.91	782.50
THE FLOW IN LINE NUMBER 2 IS RESTRICTED							
3	1	2	24.0	13.500	0.15	0.89	
4	2	3	2.2	13.500	0.15	0.38	
5	3	4	7.1	10.250	0.15	3.44	
6	4	5	6.0	8.125	0.15	0.20	
7	2	6	2.3	13.500	0.15	0.26	
8	6	7	19.0	13.500	0.15	1.84	
9	7	8	6.5	12.250	0.15	0.19	
10	6	9	0.4	13.500	0.15	0.63	
11	9	10	32.2	13.500	0.15	1.73	
12	10	11	6.5	12.250	0.15	0.19	

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Attachment 19
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[illegible]	9	13	0.1	13.500	[illegible].15	0.37
[illegible]	12	13	24.8	13.500	[illegible].15	0.89
[illegible]	13	14	31.8	13.500	[illegible]15	1.24
[illegible]	14	15	14.7	10.250	[illegible].15	2.64
17	15	16	6.0	8.125	0.15	0.20
18	14	17	23.5	13.500	0.15	0.75
19	17	18	6.0	12.250	0.15	0.19

JUNCTION NUMBER	DEMAND	ELEVATION	CONNECTING PIPES		
1	0.0	0.0	-1	3	
2	0.0	0.0	-3	4	7
3	0.0	0.0	-4	5	
4	0.0	0.0	-5	6	
5	1000.00	760.10	-6		
6	0.0	0.0	-7	8	10
7	0.0	0.0	-8	9	
8	3000.00	761.10	-9		
9	0.0	0.0	-10	11	13
10	0.0	0.0	-11	12	
11	0.0	0.0	-12		
12	0.0	0.0	-2	14	
13	0.0	0.0	-13	-14	15
14	0.0	0.0	-15	16	18
15	0.0	0.0	-16	17	
16	0.0	0.0	-17		
17	0.0	0.0	-18	19	
18	0.0	0.0	-19		

THIS SYSTEM HAS 19 PIPES WITH 18 JUNCTIONS , 0 LOOPS AND 2 FIXED GRADE NODES

THESE ARE THE RESULTS FOR THE ORIGINAL DATA

0000000
0000000

OCONEE UNIT 3
SUMP RECIRCULATION MODE
SAFETY PUMP NPSH CALCULATION

THE FOLLOWING RESULTS ARE OBTAINED AFTER 2 TRIALS

PIPE NO.	NODE NUMBERS		FLOWRATE	HEAD LOSS	PUMP HEAD	MINOR LOSS	VELOCITY	HL/10
1	0	1	4000.000	0.119	0.0	0.414	5.412	4.4
THE FLOW IN LINE NUMBER 2 IS RESTRICTED								
3	1	2	4000.000	0.375	0.0	1.111	8.965	15.6
4	2	3	1000.000	0.002	0.0	0.030	2.241	1.1
5	3	4	1000.000	0.032	0.0	0.807	3.888	4.4
6	4	5	1000.000	0.085	0.0	0.119	6.188	14.1

	2	6	3000.000	0.020	0.0	0.183	6.724	9.013
	6	7	3000.000	0.171	0.0	1.292	6.724	9.013
	7	8	3000.000	0.095	.0	0.197	8.166	14.677
1[illegible]	6	9	0.0	0.0	0.0	0.0	0.0	0.0
11	9	10	0.0	0.0	0.0	0.0	0.0	0.0
12	10	11	0.0	0.0	0.0	0.0	0.0	0.0
13	9	13	0.0	0.0	0.0	0.0	0.0	0.0
14	12	13	0.0	0.0	0.0	0.0	0.0	0.0
15	13	14	0.0	0.0	0.0	0.0	0.0	0.0
16	14	15	0.0	0.0	0.0	0.0	0.0	0.0
17	15	16	0.0	0.0	0.0	0.0	0.0	0.0
18	14	17	0.0	0.0	0.0	0.0	0.0	0.0
19	17	18	0.0	0.0	0.0	0.0	0.0	0.0

RUN 18
OSC-1977
DMB 11-6-84
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JUNCTION NUMBER	DEMAND	GRADE LINE	ELEVATION	PRESSURE		
1	0.0	781.97				
2	0.0	780.48				
3	0.0	780.45				
4	0.0	779.61				
5	1000.00	779.41	760.10	8.37 = 19.355	HL = 3.065	HL + 20% = 3.678
6	0.0	780.28				
7	0.0	778.82				
8	3000.00	778.52	761.10	7.55 - 17.441	HL = 3.959	HL + 20% = 4.751
9	0.0	780.28				
10	0.0	780.28				
11	0.0	780.28				
12	0.0	780.28				
13	0.0	780.28				
14	0.0	780.28				
15	0.0	780.28				
16	0.0	780.28				
17	0.0	780.28				
18	0.0	780.28				

THE RELATIVE CHANGE IN FLOWRATE FROM THE PREVIOUS TRIAL = 0.00011

READY
LOGOFF
DNS8374 LOGGED OFF TSO AT 10:01:23 ON NOVEMBER 7, 1984
?

Vortexing can be prevented

F. M. Patterson
C. F. Braun & Co.
Alhambra, Calif.

Vortexing, which causes air or gas entrainment in a tank or process vessel, is undesirable for several reasons.

It causes poor pump performance and can be damaging to the pump. Process vapors can be entrained and lost from the vessel. Pressure drop increases, and flow rate is reduced. Vortexing can cause unsteady two-phase flow and result in harmful vibrations.

It is important, then, that vortexing be curtailed or eliminated in processing applications.

Vortexing is not a phenomenon which occurs solely during draining or net liquid outflow. A vortex can also occur above the outlet of a pressure

Paper presented at ASME meeting, Los Angeles.

Fig. 1

Development of a vortex

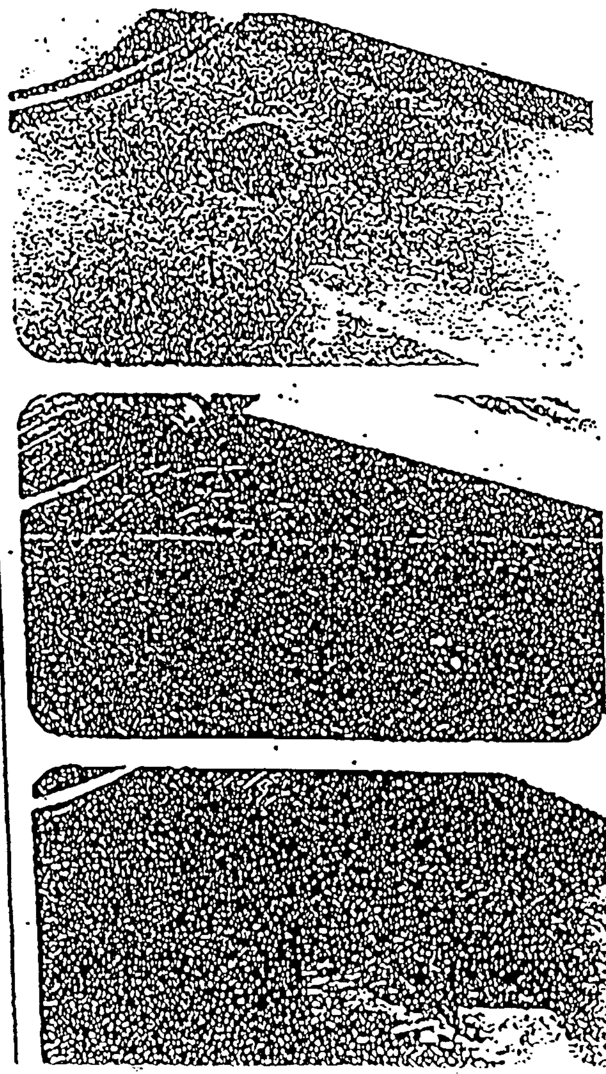


Fig. 2

Positions in which vortex forms

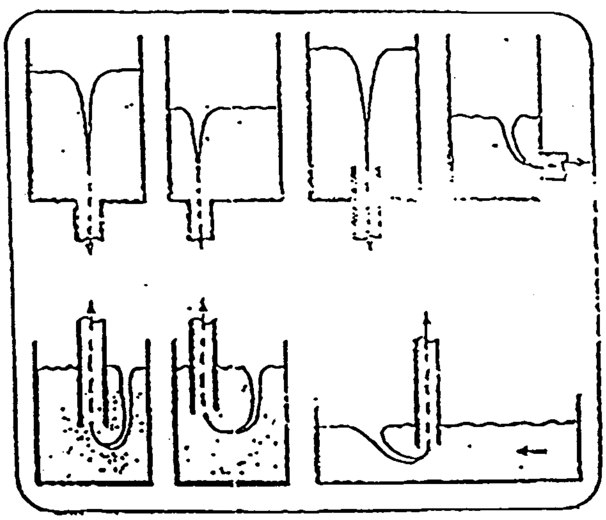
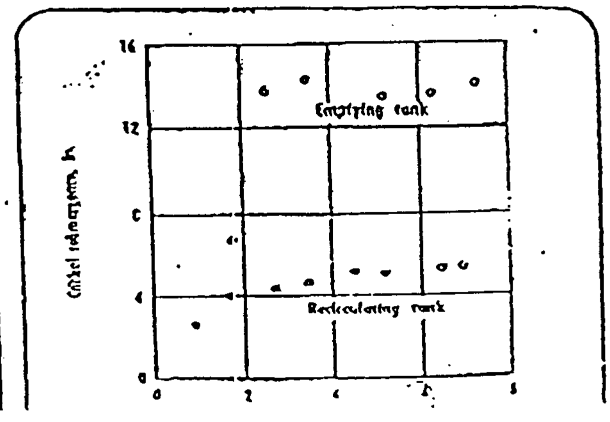


Fig. 3

Vortex critical submergence



in process vessels and tanks

vessel under steady-flow conditions where inflow equals outflow.

Vortexing can occur with any type of flow, whether it is caused by pressure, pumping, or gravity.

So an understanding of vortexing, how it occurs, what conditions cause or favor it, and what can be done to remedy or prevent it, are important to the process man.

Nature of the vortex. Due to conservation of angular momentum, any tangential components of velocity are increased when a fluid converges toward an outlet. The velocity must increase as the radius from the outlet decreases.

Under unfavorable liquid-level conditions, this intensified swirling motion results in vortexing over the discharge opening.

The development of a discharge vortex starts with a dimple on the free-liquid surface. A swirling three-dimensional flow exists below such a dimple to the outlet.

As the dimple deepens, a surface vortex develops with a cone-like projection of the gas or vapor core into the liquid. In a fully developed vortex the core funnel extends to the outlet and entrainment occurs.

Stages in the development of a vortex are shown in Fig. 1.

Vortex positions. Discharge vortexes can occur above vessel outlets which are in positions other than at the bottom centerline of the vessel. The outlet may be off-center on the bottom, vertical as with side outlets, or horizontal upwards as with sump-pump suction bells.

Some positions in which vortexes can occur are shown in Fig. 2. Of these positions, an outlet on the vessel sidewall allows operation at lower liquid levels above the nozzle without vortexing then it will if centered at the bottom.

Critical submergence. Sufficient height of liquid above the lip of the suction bell of a vertical pump or above the outlet nozzle of a vessel will suppress vortexing.

The highest liquid level at which a vortex will form is called critical submergence. Liquid levels above the critical submergence are safe from vortexing.

Critical submergence is principally affected by these variables: (a) tangential velocity components in bulk liquid, (b) outlet nozzle size and position, and (c) draining vs. steady flow at constant liquid level, and (d) outlet nozzle velocity. Liquid viscosity also has an effect.

Tangential velocity. Tangential nozzles or geometric situations producing tangential velocities must be avoided if vortexing is to be prevented.

Gas levels blowing primarily in one direction should be avoided even if they are above the liquid level because they can generate circulation of the liquid. If necessary, gas distributors should be installed.

Since causes of swirl are so important to the vortex problem, one might logically question the effect of prerotation of the fluid by upstream effects from the impeller rotation of the pump.

Several investigators have considered this in vortex studies of vertical wet-pit pumps and concluded that such an effect is minor.[1] And it can be expected to be even less significant for vessels.

Outlet nozzle size and position. Because of the capture effect of the outlet opening, vortex breaker dimensioning is related to the nozzle size. With vertical suction pipes, the closer the pipe to the vessel wall, the lower the liquid level may be without vortexing.

The bottom clearance below such vertical pipes should be 0.5d to 1d, where d is the pipe opening diameter. Clearance greater than 1d will permit excessive vortexing under low submergence conditions.

With vertical vessels, the location of the outlet off-center allows operation at lower liquid levels without vortexing than if the nozzle is bottom centered. Location of the outlet at the side of the vessel is even less conducive to vortexing but is impractical except for flat-bottom tanks.

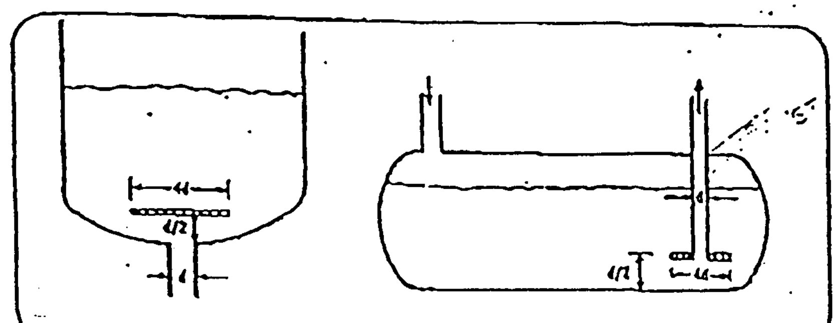
Experiments with wet-pit pumps for vertical pumps show that the suction bell should be symmetrically located with respect to the side walls of the sump in order to avoid swirls caused by velocity differences.

The flow situation for a horizontal vessel is somewhat analogous to that of a rectangular sump with uniform inflow. Hence, the outlet nozzle should be located directly below the horizontal centerline of the vessel and not inclined from the vertical.

Draining vs. no net outflow. Vortexing occurs more readily and at

Fig. 4

Typical vortex breaker dimensions



conditions than under steady flow with inflow equaling outflow.

Fig. 3 shows a comparison of critical-submergence data for water obtained in a 3-ft diameter tank with a 1½-in. centered bottom outlet.

Vortexing occurred at a maximum level of about 14 in. for draining, compared to only 5 in. under recirculating-flow conditions. This is almost a 3/1 difference.

Although most process vessels are on liquid-level control, any conditions of falling liquid level could more closely resemble the vortex condition for draining and thus require more vortex protection than might be expected.

Another interesting feature of these tank data is that with the tank draining the critical submergence essentially reached its maximum at only 2.6 fps outlet velocity and changed very little with velocity increase above this.

Vortex suppression. When vortexing occurs during operation, best temporary means of solving the problem is to raise the operating liquid level as high as possible. But it is more difficult to break a vortex once formed than it is to prevent its forming by proper design for liquid level or velocity. Vortex breakers should be installed over most process vessel outlet nozzles.

Vortex-breaker design. A surface dimple, the embryo of a vortex, has a swirling column of liquid extending below it down to the drain. Vortex breakers introduce shear in the vicinity of the outlet. This reduces the swirl and suppresses vortex development from the dimple.

While vortexes start at the liquid surface, varying locations of the liquid level, however, make surface-type vortex breakers impractical for process apparatus.

While flat plates and simple crosses help in vortex prevention, radial vanes or a grating configuration most effectively prevent vortexing. Multiple radial vanes avoid the eddy problem of the simple cross by breaking up the quadrants. As the number of sectors is increased, the interference with swirling fluid flow is increased.

The radial-vane baffle offers an advantage over the plate-type baffle in that it provides protection down to lower liquid levels and is less susceptible to secondary vortexes.

Grating. Closely spaced parallel bars are an effective antivortex configuration. They operate on the same principle as the multiple radial vanes in providing swirl suppressing shear to the liquid.

Commercially available floor grating with parallel 1-in. deep bars spaced 1-in. apart is practical for vessel use. Such grating is available in carbon steel, stainless steel, and in plastic.

Tests on a 1-ft-sq grating made from 1-in. vertical and parallel 1 by ⅛-in. bars served as an effective vortex breaker in a 36-in. diameter vertical tank under severe swirling conditions created by tangential supply nozzles.

This vortex breaker was able to prevent vortexing and air entrainment for liquid levels from 48-in. down to just above the vortex breaker under induced swirl conditions that without the grating present created a 7-in. diameter cavity at the 48-in. liquid level with a 1-in. diameter filament extending into the bottom centered outlet.

There are no published studies on optimization of the vortex-breaker size. Cross and flat-plate baffles have frequently been used with a width of two times the nozzle diameter. This size certainly reduces the occurrence of vortexing but has not always been effective. Closeness of vessel walls aids in deterring vortexing. This explains in part why some small baffles are effective and others are not.

For a high degree of effectiveness the vortex breaker width should be four times the nozzle diameter with a maximum size of one-third the vessel diameter. The height of the breaker above the outlet should be about half the nozzel diameter but for practical reasons with a minimum bottom clearance of several inches.

Fig. 4 shows typical application dimensions.

References

1. Iversen, H. W., "Studies of submergence requirements of high specific speed pumps," Trans. ASME, Vol. 75, No. 4, 1953, pp. 635-638.
2. Springer, E. K. and Patterson, F. M., "Experimental investigation of critical submergence for vortexing in a vertical cylindrical tank." ASME paper 69-FE-49 (1969).

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Anwar, H. O., "Flow in a free vortex," Water Power, 17, 4, April 1965, pp. 153-161.
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Kamel, M. Y. M., "The effect of swirl on the flow of liquids through bottom outlets." ASME paper 64-WA/FE-37, 1964.

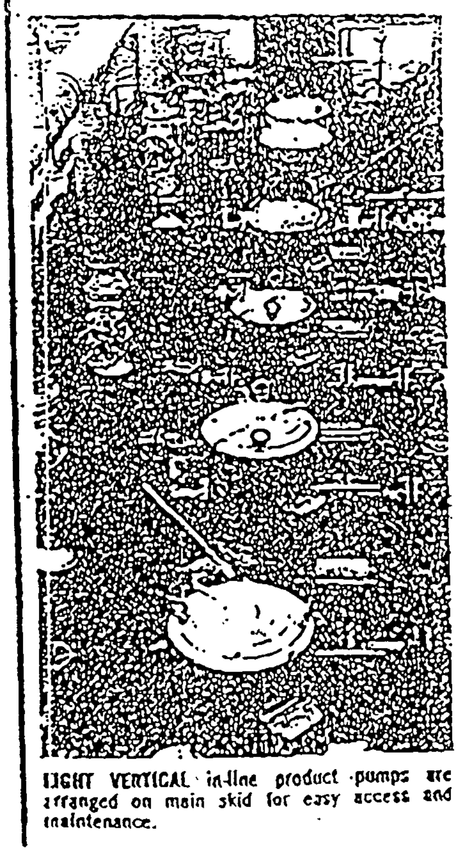
Orito's oil

Robert C. Ewing
Gulf Coast Refining Editor

COLOMBIA'S sprawling Orito oil-field operation is largely self-sufficient as a result of a small refinery installed there. A completely self-contained 1,300-b/d topping unit charges lease crude to produce diesel fuel and kerosine for drilling rigs and field equipment.

Texaco Inc., and Gulf Oil Corp., through subsidiaries, each hold a 50% interest in these facilities. But Texaco operates the Orito plant which lies in the Napo-Putumayo Basin—a part of the broad foreland belt between the Andean ranges and the Brazilian shield.

Early development of this area involved hacking out roads and right-of-ways since the site was otherwise inaccessible except for helicopters. Consequently, the initial design concept of this plant was based on packaging the unit in parcels. Should roads under construction not be ready on time, the parcels would be delivered



EIGHT VERTICAL in-line product pumps are arranged on main skid for easy access and maintenance.

NPSH REQUIREMENTS FOR RBS & LPI OPERATION AT ELEVATED SUMP TEMPERATURES

SUMP TEMP (F)	NPSHr (Ref. 8.9,8.53) RBS (FT)	NPSHr Corrected RBS (FT)	NPSH AVAILABLE RBS (FT)	NPSHr (Ref. 8.15) LPI (FT)	NPSHr Corrected LPI (FT)	NPSH AVAILABLE LPI (FT)	NPSH REDUCTION FACTOR (FT)
195	17	16.50	25.98	13	12.50	24.70	0.50
200	17	16.40	24.21	13	12.40	22.93	0.60
205	17	16.30	22.35	13	12.30	21.08	0.70
210	17	16.25	20.46	13	12.25	19.20	0.75
215	17	16.15	19.93	13	12.15	18.67	0.85
220	17	16.10	19.83	13	12.10	18.57	0.90
225	17	16.00	21.35	13	12.00	20.09	1.00
229.6	17	15.90	25.80	13	11.90	24.54	1.10

BUILDING PRESSURE REQUIREMENTS FOR RBS & LPI OPERATION AT ELEVATED SUMP TEMPERATURES

SUMP TEMP (F)	BUILDING PRESSURE REQUIRED RBS (PSIG)	AVAILABLE RBS (PSIG)	REQUIRED LPI (PSIG)	AVAILABLE LPI (PSIG)	Psat (Gauge)
195	-3.46	0.50	-4.61	0.50	-4.31
200	-2.37	0.90	-3.51	0.90	-3.17
205	-1.17	1.35	-2.31	1.35	-1.93
210	0.15	1.90	-0.98	1.90	-0.58
215	1.58	3.15	0.45	3.15	0.89
220	3.16	4.70	2.03	4.70	2.49
225	4.84	7.05	3.71	7.05	4.21
229.6	6.52	10.60	5.40	10.60	5.94

Note: Minimum available pressure is found in Ref. 8.22 (shown as Pb on page 2 of this attachment).

Required building pressure is found by computing NPSHa without credit for building pressure, subtracting NPSHa from NPSHr, then converting the result to psi. See page 3 for values.

NPSHr is taken from Ref. 8.9 as modified by Ref. 8.53. Attachment 23 shows that the Unit 3 analysis is bounded by the Unit 1&2 analysis.

DETERMINATION OF NPSHa

NPSHa = Pb x C + Pa x C + Hs - hf - Psat x C

Sump Temperature	Pb	C	Pa	Hs	hf	Psat	**NPSHa** (with Pb)	**NPSHavp** (w/o Pb)
			RBS @ 1150 GPM:					
195	0.50	2.39	14.70	21.05	6.57	10.39	25.98	24.78
200	0.90	2.39	14.70	21.05	6.57	11.53	24.21	22.06
205	1.35	2.40	14.70	21.05	6.57	12.77	22.35	19.11
210	1.90	2.41	14.70	21.05	6.57	14.12	20.46	15.88
215	3.15	2.41	14.70	21.05	6.57	15.59	19.93	12.34
220	4.70	2.42	14.70	21.05	6.57	17.19	19.83	8.45
225	7.05	2.42	14.70	21.05	6.57	18.91	21.35	4.29
229.6	10.60	2.43	14.70	21.05	6.57	20.64	25.80	0.05
			LPI @ 3291 GPM:					
195	0.50	2.39	14.70	20.05	6.84	10.39	24.70	23.51
200	0.90	2.39	14.70	20.05	6.84	11.53	22.93	20.78
205	1.35	2.40	14.70	20.05	6.84	12.77	21.08	17.84
210	1.90	2.41	14.70	20.05	6.83	14.12	19.20	14.62
215	3.15	2.41	14.70	20.05	6.83	15.59	18.67	11.08
220	4.70	2.42	14.70	20.05	6.83	17.19	18.57	7.19
225	7.05	2.42	14.70	20.05	6.83	18.91	20.09	3.03
229.6	10.60	2.43	14.70	20.05	6.83	20.64	24.54	-1.21

Assumptions:

Pa assumed 14.7 psia for consistency with OSC-6521 bounding assumptions.
Initial RB pressure taken as -1.0 psig (at accident time zero).
Pb taken from bounding analyses documented in OSC-6521.
RB temp taken as 160 F due to Aux Coolers being valved out for Units 1&2.
Cooling assumptions varied from 160 million BTU/hr to 60 million BTU/hr.
Single failures were varied to give bounding RB pressures at all sump temperatures.
BWST temperature assumed to be 100F.
Lake temperature assumed to be 85F.

DETERMINATION OF RB PRESSURE REQUIRED

Pr = (NPSHr - NPSHavp) / C

RBS @ 1150 GPM:

Sump Temperature	C	NPSHr	NPSHa (with Pb)	NPSHavp (w/o Pb)	Pr
195	2.39	16.50	25.98	24.78	-3.46
200	2.39	16.40	24.21	22.06	-2.37
205	2.40	16.30	22.35	19.11	-1.17
210	2.41	16.25	20.46	15.88	0.15
215	2.41	16.15	19.93	12.34	1.58
220	2.42	16.10	19.83	8.45	3.16
225	2.42	16.00	21.35	4.29	4.84
229.6	2.43	15.90	25.80	0.05	6.52

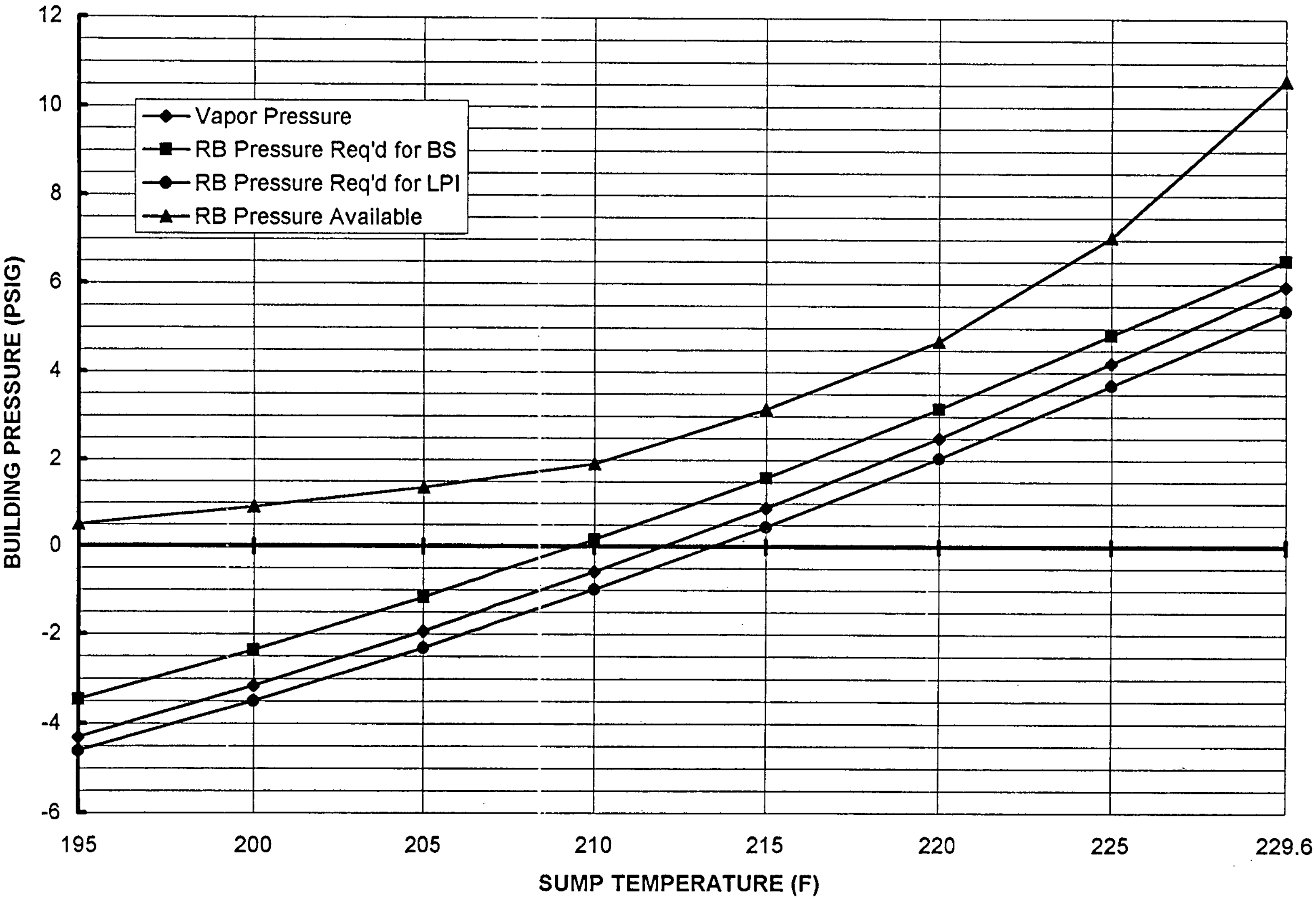
LPI @ 3291 GPM:

195	2.39	12.50	24.70	23.51	-4.61
200	2.39	12.40	22.93	20.78	-3.51
205	2.40	12.30	21.08	17.84	-2.31
210	2.41	12.25	19.20	14.62	-0.98
215	2.41	12.15	18.67	11.08	0.45
220	2.42	12.10	18.57	7.19	2.03
225	2.42	12.00	20.09	3.03	3.71
229.6	2.43	11.90	24.54	-1.21	5.40

Assumptions:

Pb taken from bounding analyses documented in OSC-6521. (See Attachment 23, Figure C-4.)
NPSHr taken from curves for Unit 1as modified by Ingersoll-Dresser letter of 9/24/98 and adjusted for high temperature.

RB PRESSURE REQ'D/AVAILABLE VS SUMP TEMP W/HIGH FLOW IN BS & LPI



(ASSUMES 3291 GPM LPI AND 1150 GPM RBS)

INPUT FROM OSC-6521 IN RESPONSE TO PIP 0-O98-3976

The curves on the pages that follow are taken from Safety Analysis Calculation OSC-6521, Appendix C (Ref. 8.22). These curves were generated specifically to respond to concerns raised in PIP 0-O98-3976. The considerations included in this analysis are as follows:

1. Reactor building initial pressure assumed to be -0.2 psig was not conservative with respect to Tech. Spec. allowable minimum pressure of -2.45 psig.
2. Reactor building initial temperature in Units 1&2 is higher than previously documented in OSC-6521 due to RB Aux Coolers being out of service for these two units.

The analysis was revised to remove conservatism in order to accommodate the above conditions. Various runs of the FATHOMS computer code were performed using the following assumptions/design inputs to produce the curves on the following pages:

All Figures:

1. All runs assume a large hot leg break as the initiating event. Small breaks typically do not produce temperatures high enough to reach the range of NPSH concern (above 200 F). Cold leg breaks are less limiting than hot leg breaks because the cold leg break produces more steaming, which tends to increase building pressure.

2. All runs assume flow rates of 3291 gpm for LPI pumps based upon EOP throttling guidance (3000 gpm)and instrument uncertainty of 291 gpm as documented in reference 8.8. Lower flow rates were shown in previous revisions of this calculation (OSC-4467, Attachment 4) to be less limiting for NPSH margin.

3. All runs assume flow rates of 1160 gpm for BS pumps based upon EOP throttling guidance (1000 gpm) and instrument uncertainty of 160 gpm as documented in reference 8.7.

4. All runs assume a lake temperature of 85 F, based upon seasonal peaks that do not exceed 83 F and an instrument uncertainty of 2 degrees F.

5. All runs assume a BWST temperature of 100 F. This is based upon a review of OAC data for the past 5 years which shows the maximum seasonal peak in BWST temperature to be slightly less than 90 F, excluding periods when the BWST was intentionally heated for testing of the LPI coolers. An uncertainty of 9.44 F was applied to this peak to arrive at the final input.

Figures C-1, C-2, C-3, and C-3A:

These figures are time histories of reactor building pressure, vapor temperature, and emergency sump temperature with the following assumptions:

1. Reactor building initial pressure is -1.0 psig. This value is based upon an instrument uncertainty of 0.5 psi and a manageable operating band of 0 to -0.5 psig.

2. Minimum RBCU cooling capacity of 60 x 10^6 Btu/hr is assumed for Units 1 & 2 (as shown in Figures C-1 through C-3) and 52 x 10^6 Btu/hr is assumed for Unit 3 (Figure C-3A). This is based upon failure of one RBCU and worst case fouling of the remaining two RBCU's.

3. Initial RB temperature was assumed to be 160 F for Units 1 & 2, which is based upon known temperatures in the Unit 1 & 2 reactor buildings and the guidance provided in reference 8.48. Results for Units 1&2 are reflected in Figures C-1 through C-3. Initial temperature was assumed to be 125 F for Unit 3, based upon current temperatures with RB Aux Coolers in service. Unit 3 results are reflected in Figure C-3A.

4. A 30 minute LPSW delay is assumed after the swap is made from the BWST to the RBES.

Figure C-4:

These curves show the effects of varying cooling of the RB atmosphere by assuming various RBCU heat removal capacity. The curves for high fouling result in higher peak sump temperatures, and are shown for completeness. As cooling capacity increases (or fouling decreases) the curves shift downward and to the left. This means that the fouling of coolers is shown to be non-limiting for the lower sump temperature range, due to the lower static pressure in the building associated with higher cooler capacity.

Figure C-5:

This figure assumes an initial RB pressure of -2.45 psig with a corresponding temperature of 80 F. These values are substantiated by the bases for Tech Spec 3.6.4. This curve demonstrates that the Tech Spec lower limit on RB pressure is not the limiting RB pressure for NPSH evaluation as compared to the results shown on the curves in Figure C-4. The decrease in RB pressure is more than offset by the corresponding low temperature required to produce it.

Figure C-6:

This figure is included to show the effects of restoring the Reactor building auxiliary coolers to service. The results shown here would be applicable to Unit 3, which currently has its auxiliary coolers in service, and has a maximum average temperature of approximately 125F. This graph, when compared to those in Figure C-4, clearly shows that the response for Units 1 & 2 is conservative with respect to NPSH availability. Although the Unit 3 BS pumps have a NPSH requirement one foot greater than the other two units' pumps, the additional pressure present in the building (due to lower initial temperature in the Unit 3 reactor building) is more than adequate to offset this difference.

Figure C-7:

This figure shows the effect of delaying LPSW flow to the LPI coolers at the time of swapover from the BWST to the RBES. The 30 minute case is shown to produce higher sump temperatures, and lower reactor building static pressures, both of which are conservative with respect to pump NPSH availability. This further supports the use of the data from Figure C-4 as limiting conditions.

Figure C-8:

This figure shows that the assumption of 13.7 psia and 160F initial conditions in the reactor building is more conservative than an assumption of 13.0 psia and 125F initial conditions. (125F was used in the analysis because it is more limiting than 116F, provides conservatism, and is useful for comparison with other "normal" building conditions where all auxiliary coolers are in service.)

ONS Hot Leg Break Analysis
Building Pressure

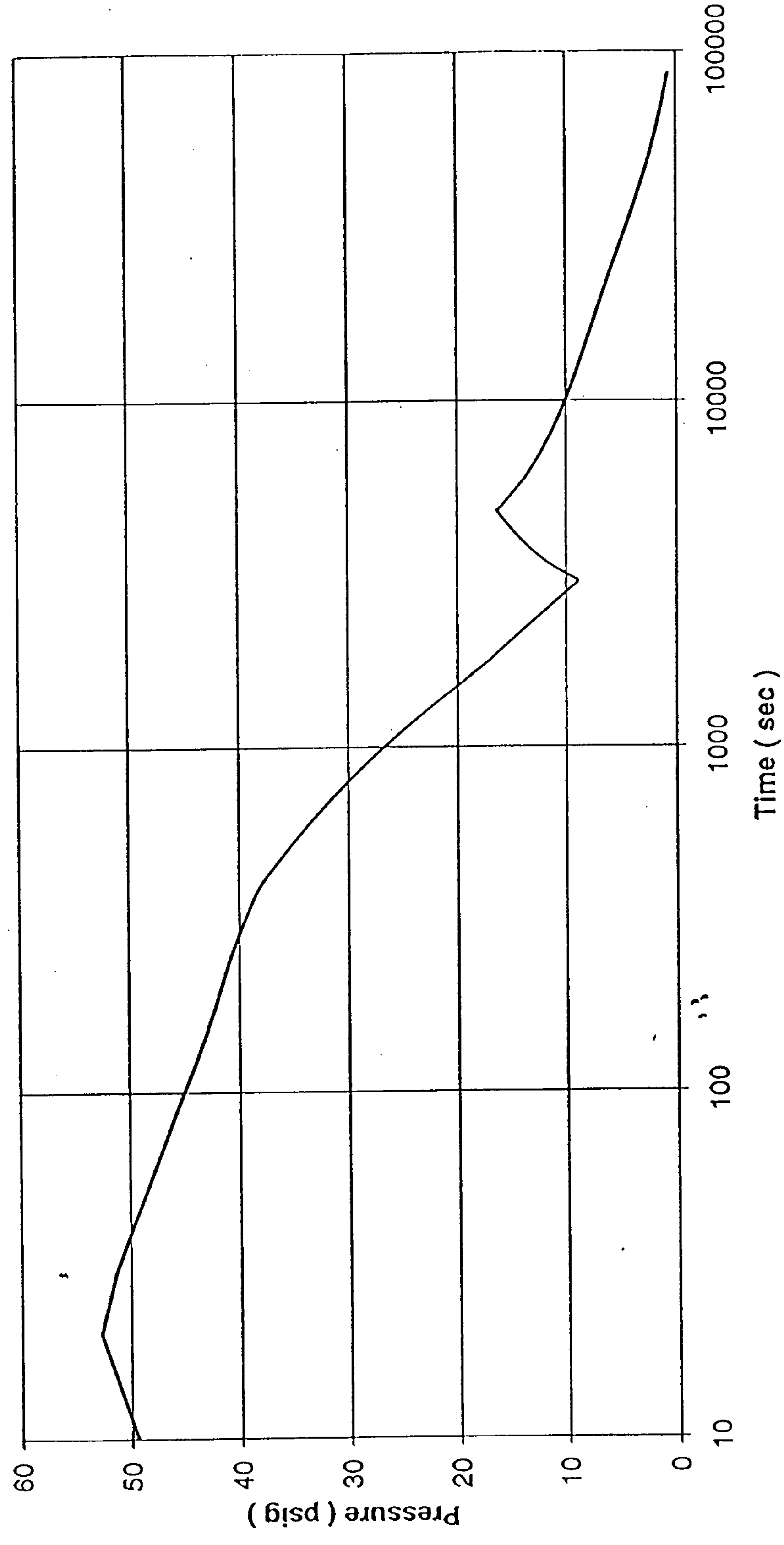


FIGURE C-1

ONS Hot Leg Break Analysis
Vapor Temperature

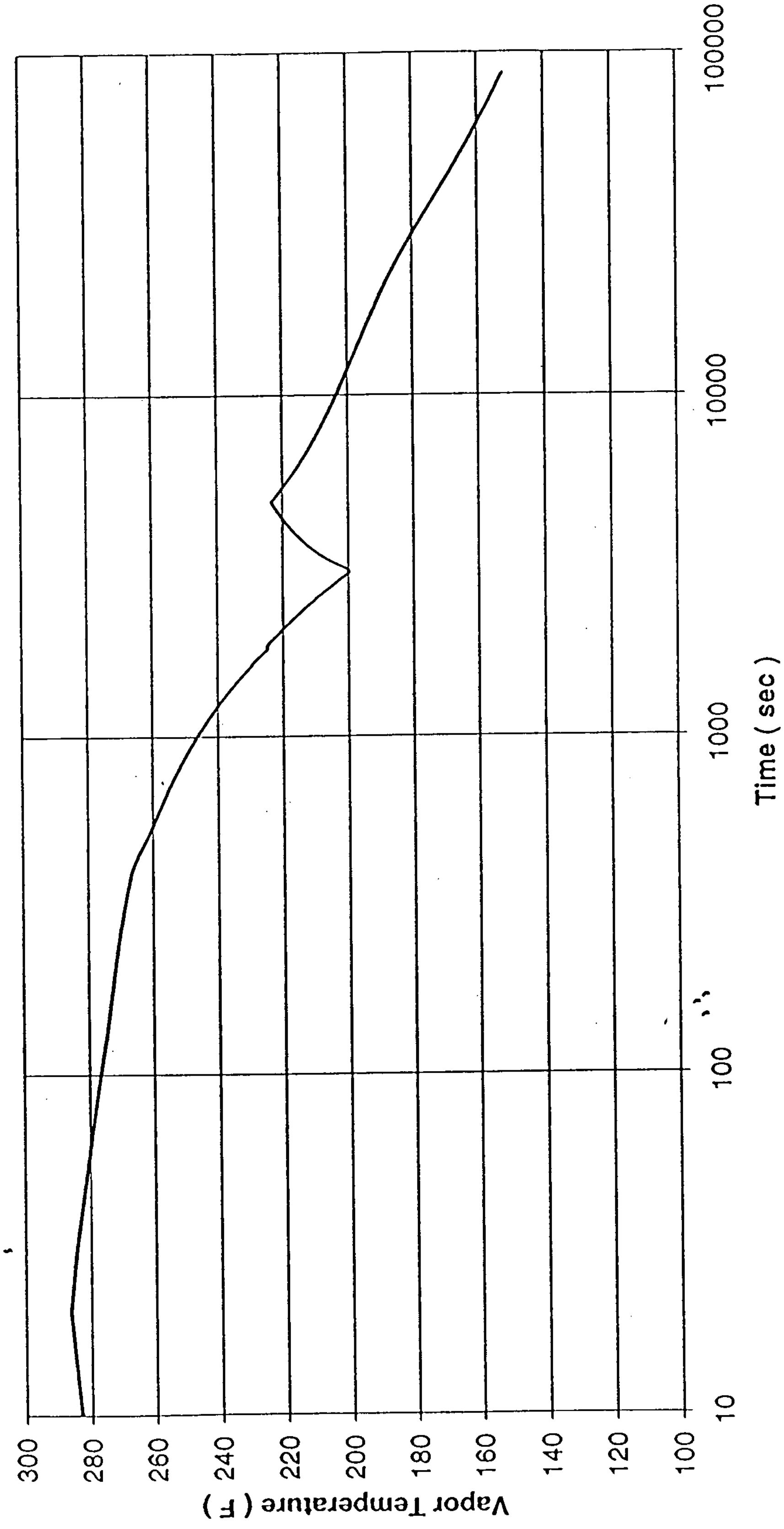


FIGURE C-2

ONS Hot Leg Break Analysis
Sump Temperature

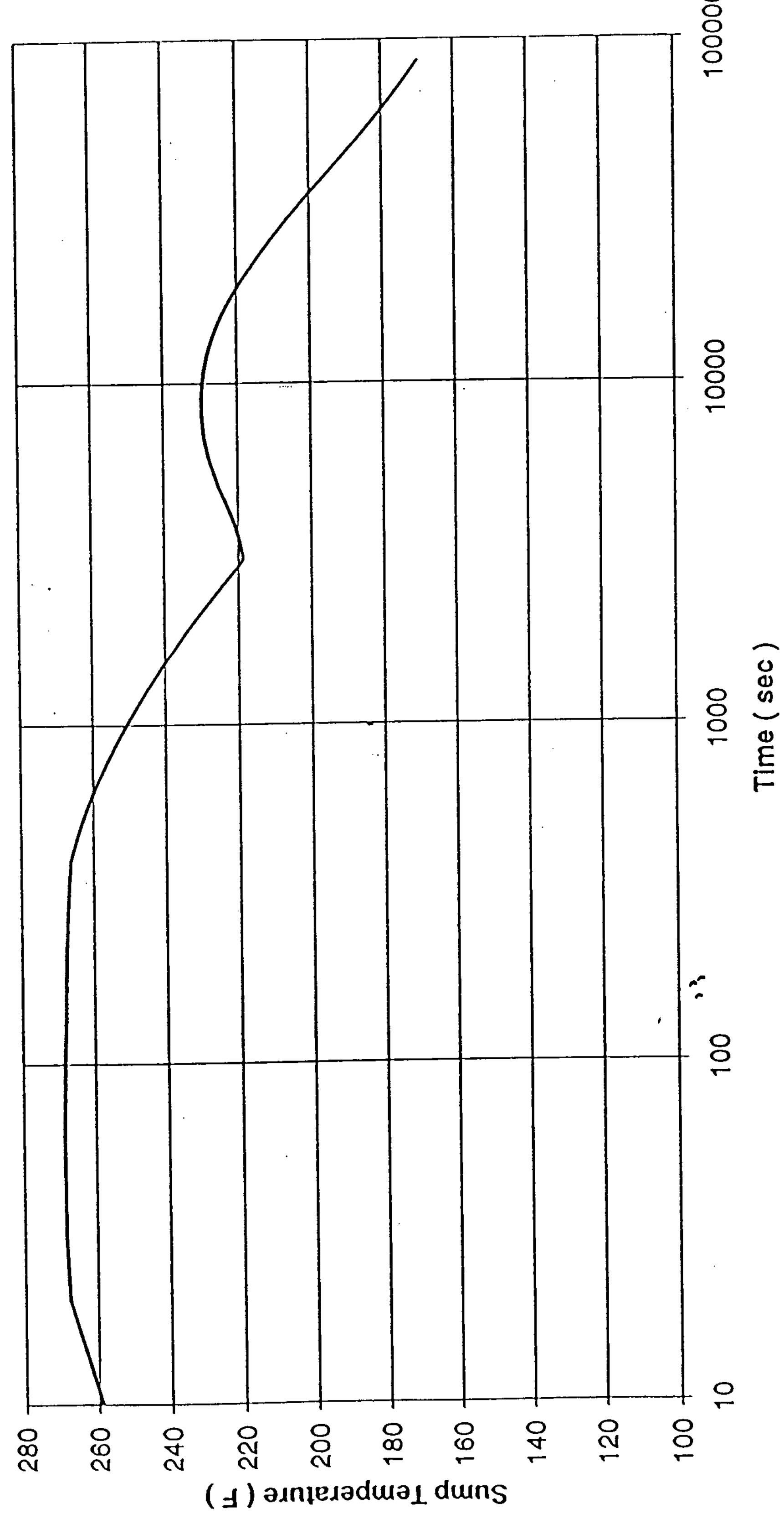


FIGURE C-3

ONS Hot Leg Break Analysis
Sump Temperature

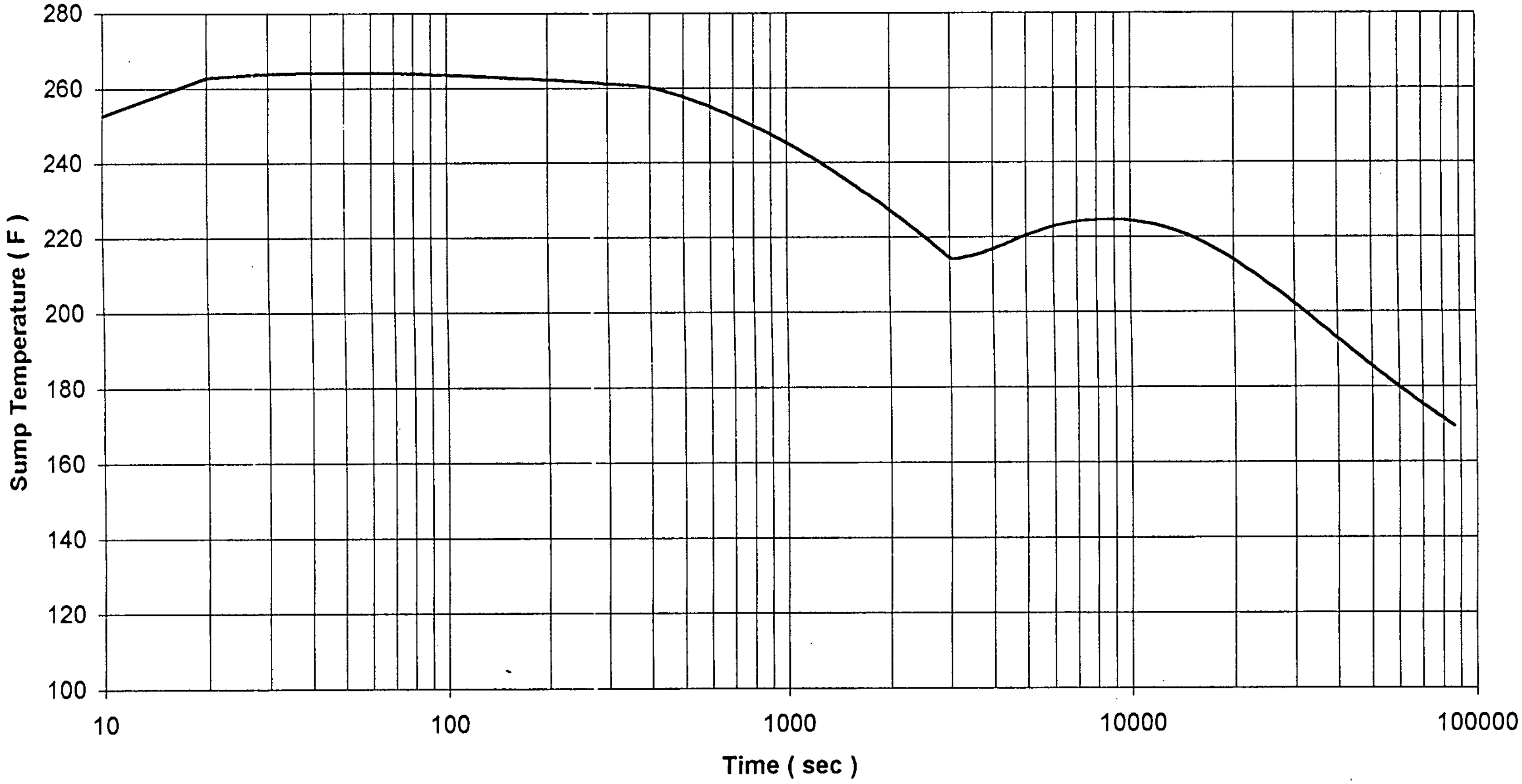


FIGURE C-3A

(UNIT 3 ONLY)

OSC - 4467, Rev. C
Attachment 23
Page-5A of 10

ONS Hot Leg Break Analysis

Building Pressure Vs. Sump Temperature for Building NPSH
30 Minute Delay in LPSW Flow to LPI Cooler

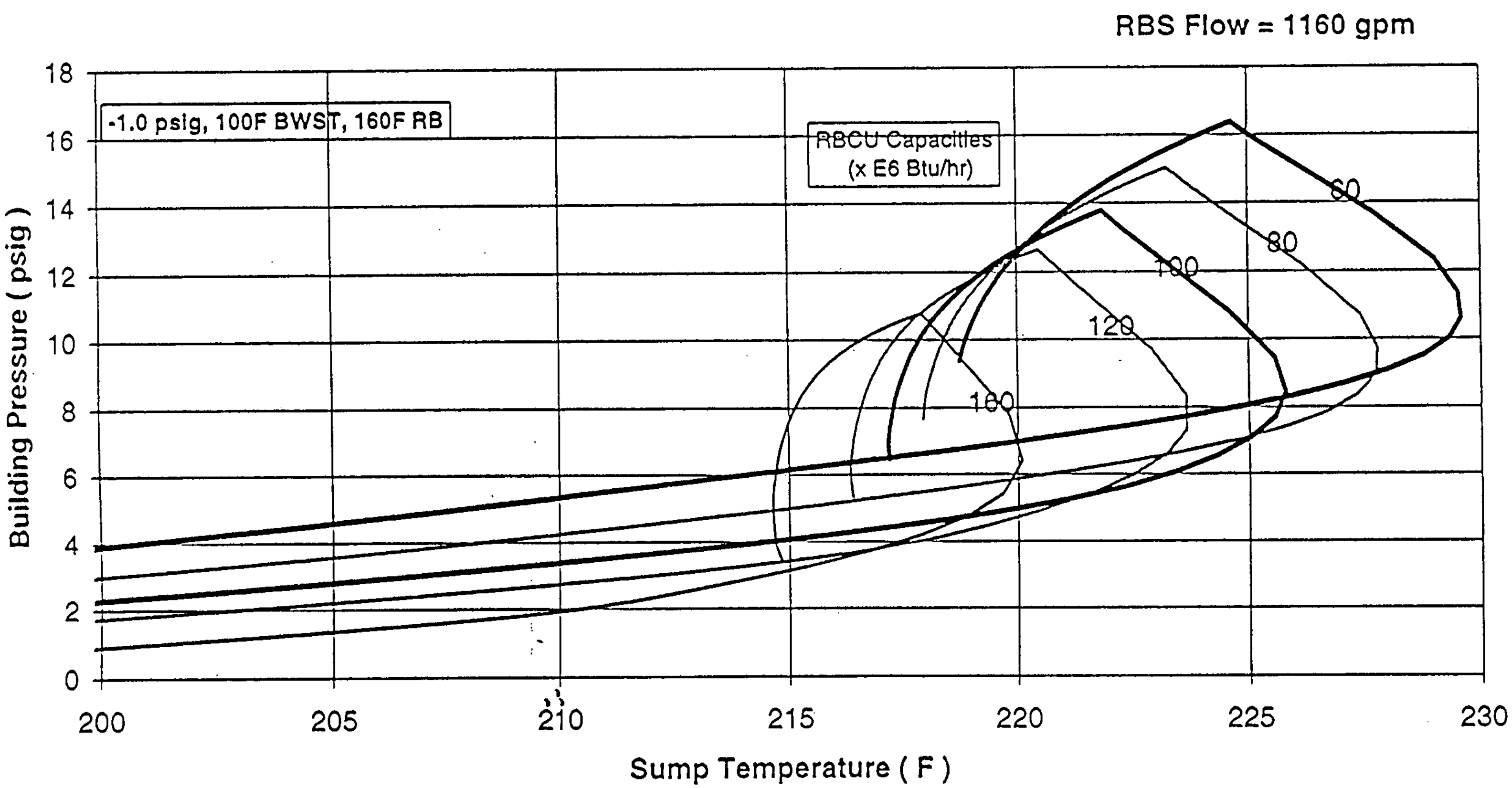


FIGURE C-4

ONS Hot Leg Break Analysis

Building Pressure Vs. Sump Temperature for Building NPSH
30 Minute Delay in LPSW Flow to LPI Cooler

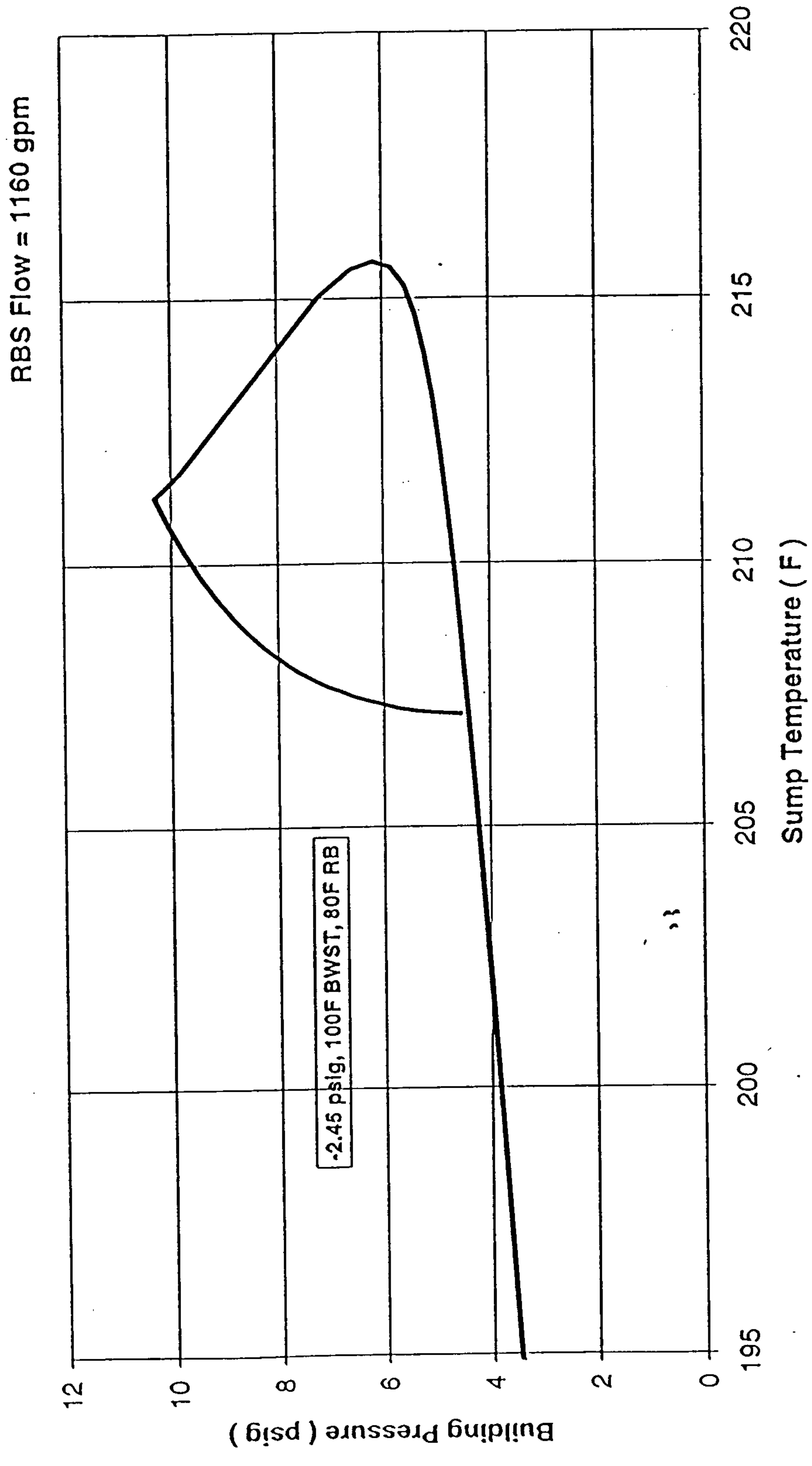


FIGURE C-5

ONS Hot Leg Break Analysis

Building Pressure Vs. Sump Temperature for Building NPSH
30 Minute Delay in LPSW Flow to LPI Cooler

RBS Flow = 1160 gpm

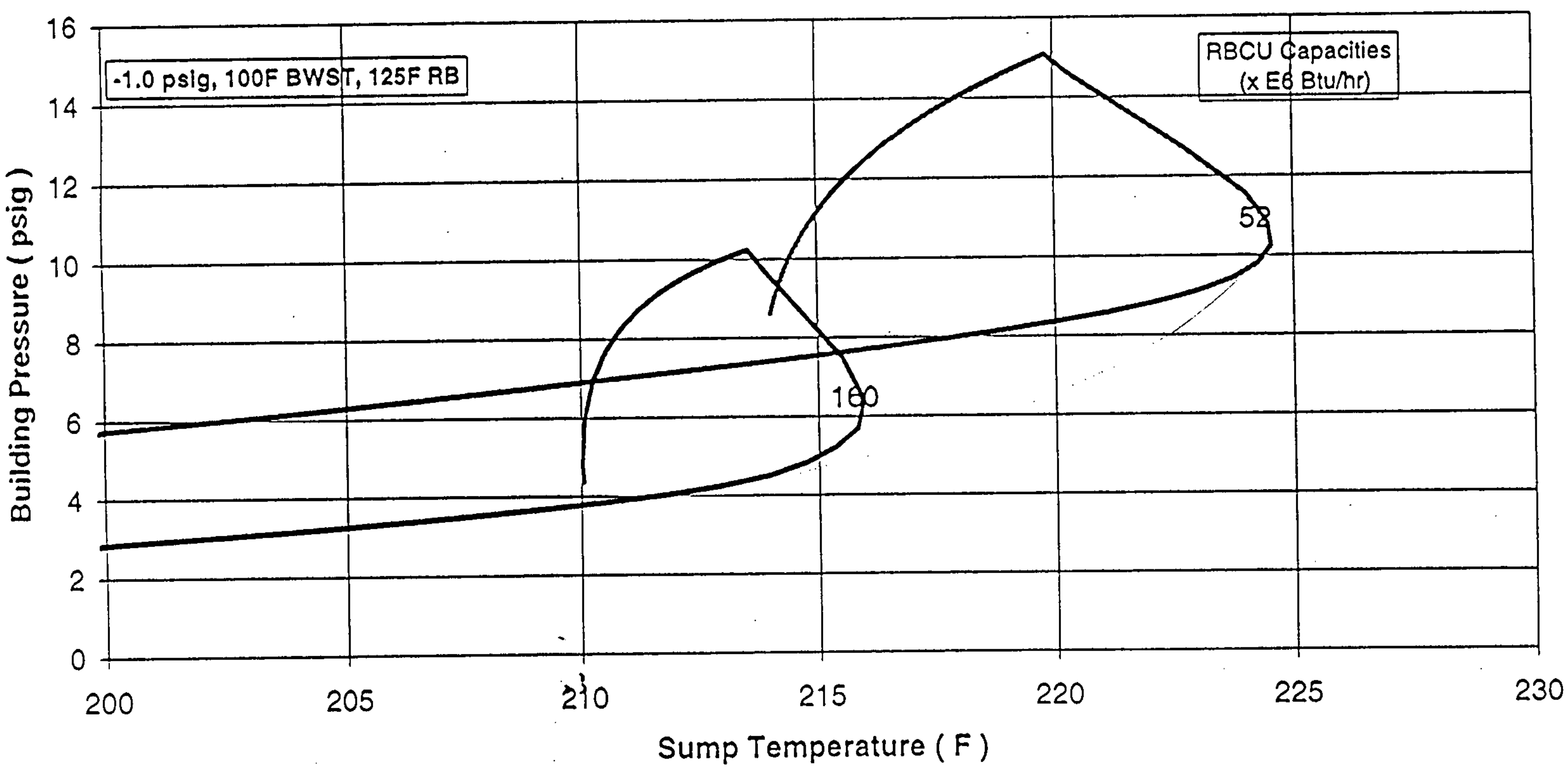


FIGURE C-6

ONS Hot Leg Break Analysis

Building Pressure Vs. Sump Temperature for Building NPSH
Effect of Delay in LPSW Flow to LPI Cooler

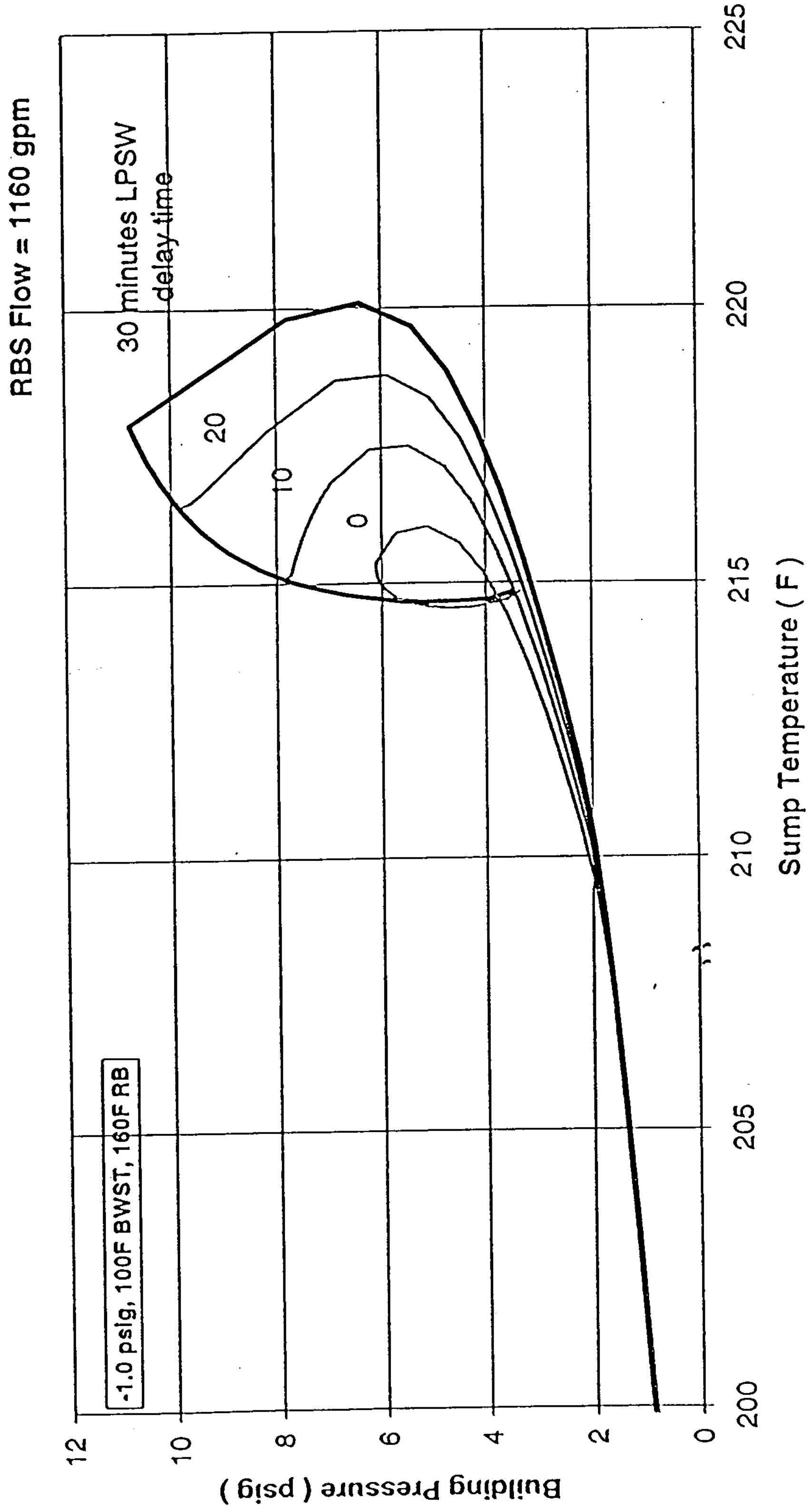


FIGURE C-7

ONS Hot Leg Break Analysis

Building Pressure Vs. Sump Temperature for Building NPSH
30 Minute Delay in LPSW Flow to LPI Cooler

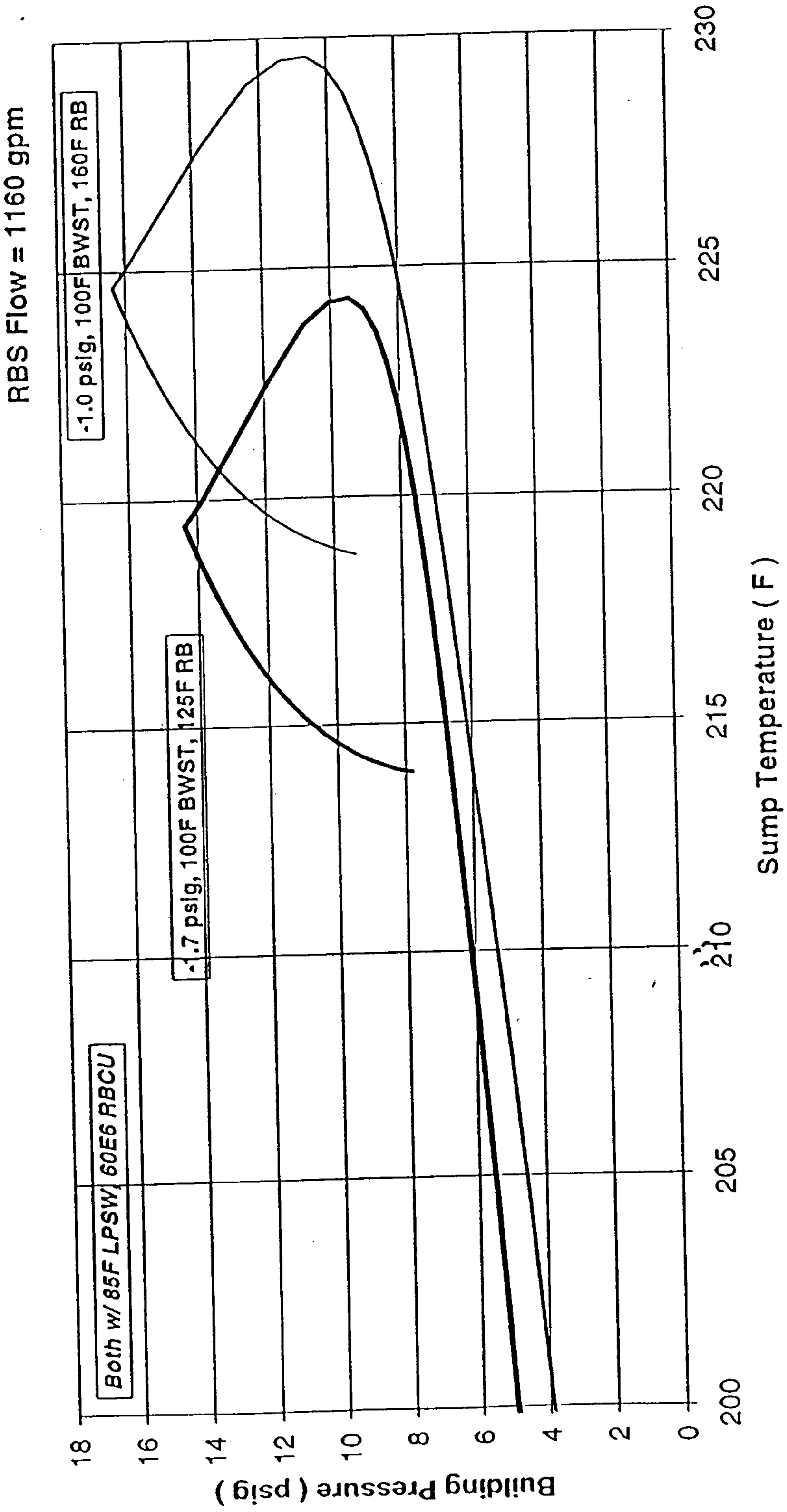


FIGURE C-8

July 23, 1987

MBOE-87-360

MEMO TO FILE

Re: Oconee Nuclear Station
Atmospheric Pressure for Design Calculations
File: OS-3C

During a review of NPSH calculations, a concern arose over the proper value of "standard" atmospheric pressure. Consequently, the Civil Division provided a frequency distribution of observed atmospheric pressures at Oconee. Results showed that 90% of the time the atmospheric pressure is 29.00" Hg or below (14.2 psia or 32.9 ft H_2O). Therefore, the standard practice of using 14.7 psia or 34 ft H_2O is not a conservative or even a realistic assumption.

The atmospheric pressure is less than 28.76" Hg less than 1% of the time. Therefore, it is recommended that a conservative atmospheric pressure of 14.0 psia or approximately 32.0 ft H_2O be used, particularly for NPSH calculations.

If there are any questions, please call S. L. Nader at extension 3-2506.

S. L. Nader

S. L. Nader
Design Engineer I

SLN/tdw

cc: J. F. Norris
E. M. Weaver
R. A. Harris
Central Records

December 10, 1986

T. F. Wyke
Attn: R. A. Harris → SLN ✓

Re: Oconee Nuclear Station
Barometric Pressures - Additional Information
MA #531.10
File Nos: OS-161, OS-3-C

Attached is a cumulative frequency distribution of barometric pressure for Oconee NPS. Observations at the Greenville-Spartanburg Airport are extrapolated to Oconee NPS based on standard atmospheric conditions.

S. B. Hager, Chief Engineer
Civil/Environmental Division

By: S. T. Apple
Scientist II

STA/mdc

Attachment

cc w/att: Central Records
D. W. Anderson
M. A. Casper

Barometric Pressure

*Oconee NPS

Frequency of Observations Equal To or Less Than Specified Value

Barometric Pressure ("Hg)

	14.13	14.16	14.18	14.19	14.10	14.21	14.22	14.23	[illegible]	14.24
	28.76	28.82	28.87	28.90	28.92	28.94	28.96	28.98	28.99	29.00
Cumulative Frequency (%)	1	2	3	4	5	6	7	8	9	10

* Taken from 224,067 hourly observations at the Greenville-Spartanburg Airport adjusted [illegible] 972' MSL to 800' MSL at an assumed pressure increase of 0.22" Hg.

Ingersoll-Dresser Pump Company

ID

September 24, 1998

Russ Oakley
Duke Power Company
Oconee Nuclear Station
P.O. Box 1439 – Mail Code 0N03MS
Seneca, SC 29672

Re: Reactor Building Spray Pump Performance
IDP Pump Model 4X11A
S/N 016964, 016965, 0369141, 0369142, 037039, 037040

Dear Russ:

Per our discussion of the requirement for your pumps to run a short time duration (less than one hour) with limited NPSHA (approx. 27 feet) against minimum system resistance of 300 feet; these pumps will run to a maximum flow of 1700 gpm. At that point they will become NPSH limited, cavitation will occur if the system resistance of 400 feet is not provided. At lesser resistance the pump head will drop off to meet the lower value. Short periods of operation (less than one hour) with approx. 20 – 25% head drop will not adversely affect the integrity of the pump. If a drop off of more than 100 feet occurs, a service inspection should be performed once the pump has been stopped in order to assess survivability of the pump and determine the pump ready for future operation.

I have also reviewed our test files for this model pump and conclude the following NPSHR points to be typical, provided your requirement is still in the as new condition.

GPM	NPSHR
700	12.5
1100	16.0
1400	20.0
1675	27.0

I hope this helps.

Sincerely,

Paul J. Kasztejna

Paul J. Kasztejna
Supervising Design Engineer

PJK:kg

cc: Charlie Sandt
Mike Dozier