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TECHNICAL REPORT

FLUID FLOW ANALYSIS OF THE SSME HIGH PRESSURE FUEL AND OXIDIZER TURBINE COOLANT SYSTEMS

JULY 1989

Contract NAS8-36284

Prepared for

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
GEORGE C. MARSHALL SPACE FLIGHT CENTER
MARSHALL SPACE FLIGHT CENTER, AL 35812

Lockheed
Missiles & Space Company, Inc.
Huntsville Engineering Center
4800 Bradford Blvd., Huntsville, AL 35807

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by

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LOCKHEED MISSILES & SPACE COMPANY, INC.

HUNTSVILLE ENGINEERING CENTER

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FOREWORD

This document presents the results of work performed for NASA-Marshall Space Flight Center by the Computational Mechanics Section of the Lockheed Missiles & Space Company, Inc., Huntsville Engineering Center. This work was performed for NASA-MSFC under Contract NAS8-36284, with Dr. Helen McConnaughey serving as technical monitor.

CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

1. INTRODUCTION AND SUMMARY

1.1 OBJECTIVES

The objective of this study is to provide improved analysis capability for the Space Shuttle Main Engine (SSME) high pressure fuel and oxidizer turbine coolant systems. Each of the systems was analyzed to determine fluid flow rates and thermodynamic and transport properties at all key points in the systems.

1.2 SUMMARY

Existing computer codes developed by Lockheed for NASA-MSFC were used as a baseline for these analyses. These codes were modified to provide improved analysis capability. The major areas of improvement are listed below.

- A review of the drawings was performed, and pertinent geometry changes were included in the models.
- Improvements were made in the calculation of thermodynamic and transport properties for a mixture of hydrogen and steam.
- A one-dimensional turbine model for each system is included as a subroutine to each code. This provides a closed loop analysis with a minimum of required boundary conditions as input.
- An improved labyrinth seal model is included in the high pressure fuel turbine coolant model.

The modifications and the analysis results are presented in detail in the following sections.

2. GENERAL THEORY OF FLUID FLOW RELATIONS

The fluid flow model solves the steady state continuity, momentum, and energy equations to obtain thermodynamic and transport properties at various stations in the coolant systems. The models compute changes in fluid flow properties between stations using coolant system geometrical data, pressure loss factors, heat transfer rates, and bearing and labyrinth seal models discussed below.

2.1 FLOW EQUATIONS

The mass continuity, momentum, and energy conservation equations are cast in one-dimensional, incompressible form to describe the fluid flow from station to station. The continuity equation states that the fluid flow rate is con served from station to station. The momentum equation is cast in the form

$$P_{T2} = P_{T1} - \Delta P_{loss} + \Delta P_{cen}$$

where

P_{T2} is the total pressure at the downstream station

P_{T1} is the total pressure at the upstream station

ΔP_{loss} is the change in pressure due to friction or turbulence

and

ΔP_{cen} is the change in pressure due to centrifugal effects.

The term ΔP_{loss} depends on the type of flow passage involved and is evaluated using the relationship

$$\Delta P_{loss} = K \, (\rho V_F^2 / 2 \, g_c)$$

where

ρ is the fluid density

V_F is the fluid flow velocity (excluding centrifugal components)

g_c is the gravitational constant

and

K is a pressure loss factor that depends on the type of flow.

The values of K for several types of flow may be obtained from Ref. 1 and are presented in Table 2-1. The dynamic pressure term $\rho V_F^2/2\ g_c$ is evaluated at the station with the smaller flow area.

Table 2-1 PRESSURE LOSS FACTORS (K)

Type of Passage	Value of K (Ref. 1)	Remarks
Smooth Pipe (Darcy Weisbach)	$K = fL/D$	$f = 0.184/R^{0.2}$ L = length D = hydraulic diameter R = Reynolds number
Mitered Bend	$K = fL_e/D$	L_e = equivalent length (See page A-27 of Ref. 1)
Sudden Expansion	$K = [1 - (D_1/D_2)^2]^2$	D_1 = smaller hydraulic diameter D_2 = larger hydraulic diameter
Sudden Contraction		See page A-26 of Ref. 1
Entrance from Large Volume	K = 0.50 K = 0.23 K = 0.04	Sharp-edged entrance Rounded entrance Well-rounded entrance
Exit to Large Volume	K = 1.0	$V_F \simeq 0.0$ (small flow velocity)

The resultant pressure changes ΔP_{loss} may be modified by an expansion factor (Y) for compressible fluid flows. Expansion factors for several types of passages may be obtained from pages A-21 and A-22 of Ref. 1; the change in pressure becomes

$$\Delta P_{loss} = \Delta P_{loss}/Y^2$$

This expansion factor may be ignored for $\Delta P_{loss}/P_{T1}$ values of less than 10% and for up to 40% if the fluid density is replaced by the average density between stations 1 and 2 (Ref. 1)

The term ΔP_{loss} also includes the pressure losses that occur in bearings and labyrinth seals. These pressure losses will be discussed in subsequent paragraphs.

The term ΔP_{cen} accounts for pressure changes due to centrifugal effects of the spinning fluid and may be computed from the relationship

$$\Delta P_{cen} = K_c \rho (V_{T2}^2 - V_{T1}^2)/2 g_c$$

where V_{T1} and V_{T2} are the upstream and downstream tangential velocities. The term K_c is a frictional loss factor equal to unity for frictional dissipation.

For flow about spinning disks the pressure change is computed from the relationship

$$dP_s = \rho w_s^2 \eta^2 R \, dR/g_c$$

where

dP_s = differential static pressure

w_s = shaft angular velocity

η = ratio of fluid to shaft angular velocities

R = radial distance from spin axis.

Relationships for η may be obtained from Ref. 2 for inward and outward flows through smooth and bladed disk/housing configurations. The effect on total pressure ΔP_{cen} must be determined from dP_s and dynamic pressure.

These various contributions to pressure changes also affect the energy of the fluid through the energy equation

$$H_{T2} = H_{T1} + \frac{\dot{Q}_{1-2}}{\dot{m}} + \Delta H_{cen}$$

where

H_T = total enthalpy per pound of fluid
$\dot{Q}_{1-2}$ = heat transferred to the fluid
ΔH_{cen} = change in total enthalpy due to centrifugal effects.

Changes in pressure due to centrifugal effects result in a change in total enthalpy equal to

$$\Delta H_{cen} = \Delta P_{cen}/\rho$$

For spinning disks the heat generation term ΔH_{cen} becomes (Ref. 2):

$$\Delta H_{cen} = \left(\frac{2\pi N}{60}\right)^3 \left(\frac{1}{12}\right)^5 \frac{\rho\,(R_1^5 - R_2^5)}{4\,g_c\,J}\,C_m$$

where C_m is a coefficient depending on disk/housing configuration,

and $J = 778.2$ lbf-ft/Btu.

The above equations represent solutions to the general flow equations which will adequately describe the flow in the coolant systems.

2.2 BEARING MODEL

The bearing model computes the pressure drop in the fluid flowing through ball bearings. The pressure loss term ΔP_B is computed by solving the quadratic equation

$$\alpha(\Delta P_B)^2 - \dot{m}^2 (\Delta P_B) - \beta \dot{m}^2 = 0$$

where

$$\alpha = 288 \rho g_c A^2 C^2$$

$$\beta = \rho (RK)^2 \frac{(2\pi N/60)^2}{288 g_c}$$

N = shaft rpm

The coefficients A, C, R, and K are bearing constants supplied by NASA-MSFC.

2.3 LABYRINTH SEAL MODEL

The labyrinth seal model now used by the high pressure fuel turbine coolant model is an empirical leakage prediction program for straight-through labyrinth seals developed for NASA-MSFC by Texas A&M University (Ref. 3). This program is included as a subroutine in the fuel turbine coolant program.

2.4 THERMODYNAMIC AND TRANSPORT PROPERTIES

The high pressure fuel and oxidizer turbine coolant systems are complex flow systems comprising several flow paths in which the fluid is pure hydrogen and other flow paths containing a mixture of H_2 and H_2O. Thermodynamic and transport properties for hydrogen are computed from the GASP computer code (Ref. 4).

To evaluate real thermodynamic properties for H_2/H_2O gas mixtures the WASP computer code (Ref. 5) is used to calculate H_2O properties. The gas

components are assumed to occupy the entire volume at the mixture temperature and pressure, and the thermodynamic properties are mass fraction weighted to obtain mixture properties. The compressibility factor is assumed to obey the law of additive volumes and is computed accordingly.

To obtain thermodynamic properties for a mixture containing H_2O in the liquid phase, the following procedure is employed:

- P_M and H_M are the known thermodynamic properties (except at turbine inlet and discharge stations where P_M and T_M are known)
- Assume T_M and compute P_V
- Check if $P_{H_2O} > P_V$ (two-phase if true)
- Compute a gas phase mole fraction required to give $P_{H_2OG} = P_V$
- Compute XL and X_G
- $H_{TM} = X_H H_H + X_L H_L + X_G H_G$
- Iterate on T_M until $H_{TM} = H_M$.

This procedure is extended to include the solid region when P_M and H_M are known. However, in the solid region, the thermodynamic state cannot be defined by P_M and T_M alone.

In general, the properties routine evaluates thermodynamic properties of H_2O for four separate regions:

1. $T_M > T_{crit}$
   Composition is all gas, properties evaluated at P_M and T_M

2. $T_M < T_{crit}$, $P_V > P_M$
   Composition is all gas, properties evaluated at P_M and T_M

3. $P_V < P_M$, $P_V > P_{H_2O}$
   Composition is in vapor state.
   Enthalpy is evaluated by computing liquid enthalpy at P_M and T_M and adding the heat of vaporization. Transport properties are evaluated for saturated vapor only.

4. $P_V < P_M$, $P_V < P_{H_2O}$
   Composition is two phase

   - Liquid/vapor
   - Liquid
     Vapor phase is negligible
   - Solid/liquid
     Vapor phase is negligible
   - Solid
     Vapor and liquid phases negligible

   where

   T_M = mixture temperature
   P_M = mixture pressure
   T_{crit} = critical temperature of H_2O
   P_V = vapor pressure of H_2O at T_M
   P_{H_2O} = H_2O partial pressure based on total mixture mole fraction
   P_{H_2OG} = H_2O partial pressure based on gas phase mole fraction
   X_L = the mass fraction of liquid H_2O in the total mixture
   X_G = the mass fraction of H_2O vapor in the total mixture
   H_H = H_2 enthalpy at P_M and T_M
   H_L = H_2O liquid enthalpy at P_M and T_M
   H_G = H_2O vapor enthalpy at P_M and T_M
   H_M = mixture enthalpy
   H_{TM} = computed mixture enthalpy.

In the two-phase region, the mixture density computed by the program is the homogeneous two-phase density. The compressibility factor is computed for the gas phase only.

Transport properties are evaluated for a mixture of gases using the method of Wilke for computing viscosity and the method of Vanderslice for computing thermal conductivity (see Reference 6). Mixture transport properties are evaluated for the gas phase only.

3. HIGH PRESSURE FUEL TURBINE COOLANT ANALYSIS

3.1 TURBINE COOLANT SYSTEM

The existing high pressure fuel turbopump (HPFTP) turbine coolant system flow model developed by Lockheed for NASA-MSFC was used as a baseline for this analysis. This baseline model (shown in Figure 3-1) is documented in Reference 7. The turbine coolant system was modeled to evaluate the flow properties at each of the numbered stations shown in Figure 3-1 and to compute the flow rates along each of the flow paths in the system. Two additional flow paths have been added to compute flows through the turbine blade fir trees. These are the first stage blade fir trees (stations 95 through 98) and the second stage blade fir trees (stations 99 through 101). The model comprises 101 stations and 25 flow paths.

3.2 MODEL IMPROVEMENT

A review of current drawings was performed and pertinent geometry changes were included in the model. Operating clearances for the turbine blade platform seals, labyrinth seal, and the lift-off seal were supplied by NASA-MSFC.

A one-dimensional turbine model is included as a subroutine in the code. This provides a closed loop analysis with a minimum of required boundary conditions as input. Estimated platform seal leakage rates are input to the turbine model, and the turbine model is executed to provide pressures as boundary conditions for the coolant flow model (stations 35, 41, 64, and 72). The coolant model is then executed and new leakage flows are computed. An input option is provided for terminating the execution at this point or continuing with another pass through each model if greater accuracy is desired.

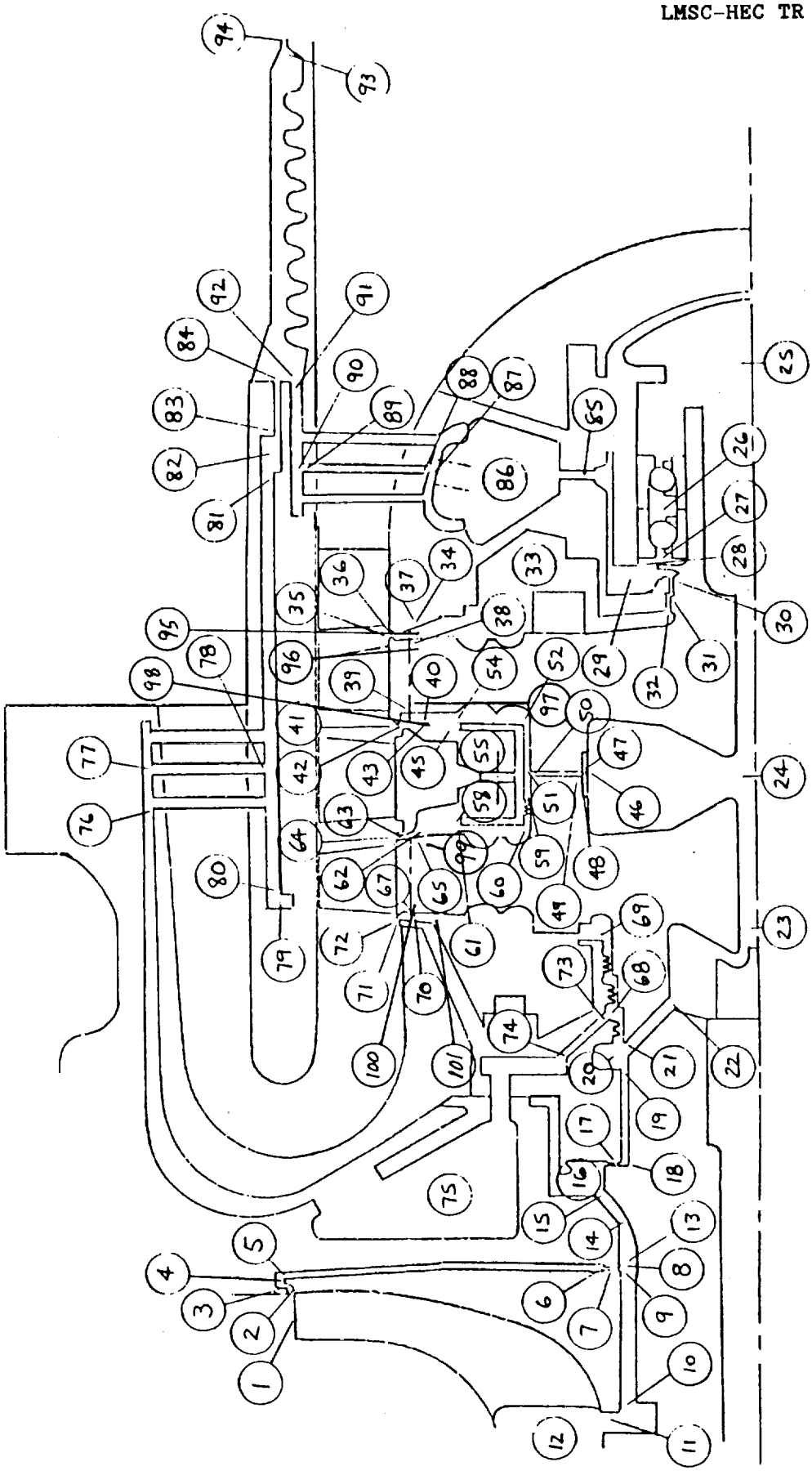


Figure 3-1 HPFTP Turbine Coolant System Schematic

An improved labyrinth seal leakage prediction program developed for NASA-MSFC by Texas A&M University (Ref. 3) is included as a subroutine in the turbine coolant program.

An improved properties subroutine for computing thermodynamic and transport properties for a mixture of H_2 and H_2O has been added to the program. See Section 2.4 for a detailed description of this calculation procedure.

3.3 RESULTS

The fuel turbine coolant system was analyzed at full power level (FPL), 104% and minimum power level (MPL), using Rocketdyne engine balance data obtained from Reference 8. The results of these analyses are presented in Tables 3-1 through 3-3. These results are for a balance piston high pressure orifice gap of 0.004 inch.

3.4 PROGRAM INPUT GUIDE

This section describes the input data file required for execution of the HPFTP turbine coolant program.

Column	Parameter	Description
Line number 1, Format (8E10.4)		
1-10	GAP	Balance piston high pressure orifice gap, in.
Line number 2, Format (8E10.4)		
1-10	RDEFO	Housing radial deflection at high pressure orifice, in.
11-20	RDEFI	Impeller radial deflection at high pressure orifice, in.
21-30	XDEF	Impeller axial deflection at high pressure orifice, positive toward turbine, in.

Table 3-1 HPFTP TURBINE COOLANT ANALYSIS (FPL)

STA	TOTAL PRESS (PSIA)	STATIC PRESS (PSIA)	TOTAL ENTHALPY (BTU/LBM)	TEMPER-ATURE (R)	DENSITY (LBM/FT3)	FLUID QUAL	VELO-CITY (FPS)	TANG VEL (FPS)	SONIC VEL (FPS)	FLOW RATE (LBM/SEC)	MASS FRACTIONS H2	MASS FRACTIONS H2O	ZFAC
1	7091.7	6262.6	228.1	92.3	5.028	1.00	256.2	1209.3	5904.5	6.608	1.000	0.000	2.5359
2	6712.6	6224.0	228.1	97.2	4.944	1.00	186.1	935.5	5836.9	6.608	1.000	0.000	2.4326
3	6063.8	4828.4	228.1	99.1	4.598	1.00	1388.9	714.7	5310.4	6.608	1.000	0.000	1.9919
4	5051.3	4837.4	228.1	112.4	4.366	1.00	68.1	668.8	5158.3	6.608	1.000	0.000	1.8528
5	5004.6	4837.7	228.1	113.0	4.355	1.00	32.7	593.9	5151.3	6.608	1.000	0.000	1.8471
6	4844.5	4837.7	287.9	133.9	4.002	1.00	125.1	0.0	4933.2	6.608	1.000	0.000	1.6968
7	4810.2	4696.5	288.5	133.5	3.963	1.00	480.3	185.6	4873.9	6.608	1.000	0.000	1.6684
8	4710.1	4688.6	288.5	134.8	3.938	1.00	136.7	178.4	4857.3	6.608	1.000	0.000	1.6594
9	4774.6	4627.2	293.5	134.9	3.917	1.00	258.5	529.8	4828.3	3.821	1.000	0.000	1.6457
10	4771.7	4624.3	293.5	134.9	3.915	1.00	258.6	529.8	4826.8	3.821	1.000	0.000	1.6449
11	4655.9	4611.2	293.5	136.4	3.886	1.00	55.6	321.2	4806.2	3.821	1.000	0.000	1.6343
12	4654.6	4611.2	293.5	136.4	3.886	1.00	7.5	321.2	4806.0	3.821	1.000	0.000	1.6342
13	4708.7	4693.7	288.5	134.9	3.939	1.00	57.7	178.4	4859.0	2.787	1.000	0.000	1.6602
14	4732.7	4693.6	289.7	134.9	3.939	1.00	57.7	297.4	4859.0	2.787	1.000	0.000	1.6601
15	4739.4	4692.1	290.0	134.9	3.939	1.00	80.0	323.6	4858.3	2.787	1.000	0.000	1.6599
16	4741.6	4691.6	290.2	134.9	3.938	1.00	34.4	341.0	4857.8	2.787	1.000	0.000	1.6596
17	4726.3	4686.3	290.2	135.1	3.933	1.00	96.3	291.5	4853.7	2.787	1.000	0.000	1.6575
18	4717.9	4675.8	290.2	135.1	3.929	1.00	157.6	272.8	4848.6	2.787	1.000	0.000	1.6551
19	4717.0	4674.9	290.2	135.1	3.929	1.00	157.6	272.8	4848.1	2.787	1.000	0.000	1.6548
20	4706.5	4674.7	290.2	135.2	3.926	1.00	22.7	272.8	4846.6	2.787	1.000	0.000	1.6540
21	4761.1	4636.2	294.4	135.4	3.911	1.00	104.7	533.0	4827.3	1.887	1.000	0.000	1.6448
22	4624.8	4569.2	294.4	136.8	3.866	1.00	105.9	349.0	4783.3	1.887	1.000	0.000	1.6236
23	4524.3	4467.3	294.4	137.4	3.821	1.00	362.9	79.3	4730.0	1.887	1.000	0.000	1.5992
24	4522.7	4465.7	294.4	137.4	3.821	1.00	362.9	79.3	4729.2	1.887	1.000	0.000	1.5988
25	4502.3	4501.3	294.4	138.0	3.823	1.00	28.6	39.7	4740.4	1.102	1.000	0.000	1.6036
26	4500.4	4494.6	294.4	137.9	3.821	1.00	40.5	111.4	4737.5	1.102	1.000	0.000	1.6023
27	4498.1	4488.6	294.4	137.9	3.819	1.00	28.3	148.5	4734.9	1.102	1.000	0.000	1.6011
28	4505.2	4489.0	294.8	137.9	3.820	1.00	7.2	198.3	4735.0	1.102	1.000	0.000	1.6012
29	4489.0	4488.9	294.8	138.1	3.816	1.00	7.2	0.0	4732.8	1.102	1.000	0.000	1.6001
30	4439.6	4326.9	295.0	137.5	3.769	1.00	515.4	102.6	4661.2	0.639	1.000	0.000	1.5687
31	4331.1	4325.3	295.0	139.0	3.743	1.00	62.3	102.6	4645.9	0.639	1.000	0.000	1.5617
32	4287.9	4195.4	295.0	138.5	3.704	1.00	468.2	107.4	4587.1	0.639	1.000	0.000	1.5367

Table 3-1 HPFTP TURBINE COOLANT ANALYSIS (FPL) (Continued)

STA	TOTAL PRESS (PSIA)	STATIC PRESS (PSIA)	TOTAL ENTHALPY (BTU/LBM)	TEMPER-ATURE (R)	DENSITY (LBM/FT3)	FLUID QUAL	VELO-CITY (FPS)	TANG VEL (FPS)	SONIC VEL (FPS)	FLOW RATE (LBM/SEC)	MASS FRACTIONS H2	MASS FRACTIONS H20	ZFAC
33	4200.0	4195.3	295.0	139.8	3.682	1.00	19.0	107.4	4575.2	0.639	1.000	0.000	1.5315
34	4248.4	4224.4	3135.1	1524.6	0.851	1.00	297.0	415.6	5408.2	3.862	0.528	0.472	1.0529
35	5504.8	4709.5	3549.0	1817.0	0.889	1.00	1151.4	2547.0	5578.8	3.370	0.459	0.541	1.0539
36	4600.5	4232.0	3549.0	1852.3	0.788	1.00	1954.7	716.7	5637.1	3.370	0.459	0.541	1.0486
37	4248.4	4224.5	3134.7	1524.4	0.851	1.00	296.9	415.6	5407.9	3.862	0.528	0.472	1.0529
38	4399.1	4219.9	3169.5	1524.9	0.850	1.00	181.7	1385.4	5408.9	3.862	0.528	0.472	1.0528
39	4398.8	4219.7	3169.5	1524.9	0.850	1.00	181.7	1385.4	5408.9	3.862	0.528	0.472	1.0528
40	4235.1	4216.2	3237.9	1620.1	0.828	1.00	195.9	415.6	5485.6	5.632	0.506	0.494	1.0518
41	4498.1	4363.2	3381.1	1796.8	0.836	1.00	1161.9	358.8	5550.4	1.770	0.459	0.541	1.0502
42	4326.9	4219.5	3381.1	1799.8	0.808	1.00	1050.7	356.5	5556.5	1.770	0.459	0.541	1.0487
43	4235.1	4216.2	3237.9	1620.1	0.828	1.00	195.9	415.6	5485.6	5.632	0.506	0.494	1.0518
44	4233.2	4203.3	3237.9	1618.9	0.826	1.00	403.0	415.6	5483.8	5.779	0.506	0.494	1.0516
45	4215.2	4202.2	2959.2	1398.8	0.888	1.00	111.4	351.2	5260.5	6.391	0.554	0.446	1.0524
46	4507.9	4506.0	294.4	137.9	3.825	1.00	1.6	66.6	4743.0	0.786	1.000	0.000	1.6047
47	4678.3	4113.1	312.0	137.1	3.696	1.00	974.8	666.2	4558.8	0.786	1.000	0.000	1.5249
48	4310.6	4054.0	312.8	141.9	3.592	1.00	437.5	682.1	4484.4	0.786	1.000	0.000	1.4941
49	4236.2	4052.1	312.8	143.0	3.573	1.00	97.1	682.1	4474.1	0.786	1.000	0.000	1.4899
50	4505.3	4183.0	326.9	144.4	3.601	1.00	60.4	904.1	4527.9	0.786	1.000	0.000	1.5114
51	4218.4	4189.2	326.9	148.6	3.536	1.00	17.6	276.0	4495.5	0.786	1.000	0.000	1.4979
52	4218.3	4189.2	326.9	148.6	3.536	1.00	13.7	276.0	4495.5	0.612	1.000	0.000	1.4979
53	4222.3	4191.0	327.1	148.6	3.536	1.00	18.9	285.5	4496.3	0.612	1.000	0.000	1.4982
54	4215.2	4202.2	2959.2	1398.9	0.888	1.00	111.4	351.2	5260.6	6.391	0.554	0.446	1.0524
55	4202.2	4201.8	2959.2	1400.0	0.888	1.00	68.4	0.0	5263.1	6.391	0.554	0.446	1.0525
56	4201.6	4200.2	2959.2	1399.9	0.887	1.00	119.2	0.0	5262.9	6.391	0.554	0.446	1.0524
57	4200.2	4199.7	2959.2	1399.9	0.887	1.00	68.5	0.0	5263.1	6.391	0.554	0.446	1.0524
58	4214.4	4198.3	2892.5	1349.8	0.905	1.00	139.3	380.7	5192.7	6.565	0.565	0.435	1.0516
59	4218.4	4189.3	326.9	148.6	3.536	1.00	3.9	276.0	4495.6	0.174	1.000	0.000	1.4979
60	4208.5	4179.5	326.9	148.7	3.531	1.00	1.9	276.0	4490.3	0.174	1.000	0.000	1.4959
61	4214.4	4198.3	2892.5	1349.8	0.905	1.00	139.3	380.7	5192.7	6.565	0.565	0.435	1.0516
62	4215.8	4185.1	2893.0	1348.8	0.903	1.00	382.1	410.9	5190.5	6.468	0.565	0.435	1.0514
63	4099.7	3843.3	2893.2	1327.2	0.846	1.00	1620.8	424.5	5150.8	3.390	0.565	0.435	1.0468
64	3860.4	3843.2	2893.4	1348.1	0.832	1.00	24.4	437.2	5203.6	3.390	0.565	0.435	1.0478

Table 3-1 HPFTP TURBINE COOLANT ANALYSIS (FPL) (Concluded)

STA	TOTAL PRESS (PSIA)	STATIC PRESS (PSIA)	TOTAL ENTHALPY (BTU/LBM)	TEMPER-ATURE (R)	DENSITY (LBM/FT3)	FLUID QUAL	VELO-CITY (FPS)	TANG VEL (FPS)	SONIC VEL (FPS)	FLOW RATE (LBM/SEC)	MASS FRACTIONS H2	MASS FRACTIONS H2O	ZFAC
65	4366.8	4182.7	2927.1	1349.8	0.902	1.00	126.8	1369.5	5193.2	3.078	0.565	0.435	1.0515
66	4366.7	4182.6	2927.1	1349.8	0.902	1.00	126.8	1369.5	5193.2	3.078	0.565	0.435	1.0515
67	4200.7	4181.3	2594.8	1213.5	0.982	1.00	119.7	410.9	4678.2	3.510	0.591	0.409	1.0344
68	4300.5	4288.2	290.2	137.8	3.750	1.00	27.5	172.7	4639.8	0.899	1.000	0.000	1.5594
69	4146.9	4133.5	290.2	138.6	3.679	1.00	10.2	183.5	4555.2	0.336	1.000	0.000	1.5233
70	4200.9	4181.5	2594.8	1213.5	0.982	1.00	119.6	410.9	4678.5	3.510	0.591	0.409	1.0344
71	4006.3	3581.2	2595.0	1164.7	0.888	1.00	2063.2	424.3	4287.0	3.510	0.591	0.409	1.0213
72	3598.6	3581.0	2595.3	1198.6	0.854	1.00	21.4	437.2	4731.8	3.510	0.591	0.409	1.0317
73	3986.0	3670.4	290.2	136.4	3.529	1.00	905.5	0.0	4331.7	0.564	1.000	0.000	1.4327
74	3956.2	3639.1	290.2	136.5	3.514	1.00	909.4	0.0	4313.4	0.564	1.000	0.000	1.4257
75	3638.8	3638.8	290.2	141.2	3.431	1.00	0.8	0.0	4270.6	0.564	1.000	0.000	1.4112
76	3638.8	3638.8	808.2	272.6	2.012	1.00	5.7	0.0	4044.7	0.564	1.000	0.000	1.2467
77	3637.6	3635.4	808.2	272.5	2.011	1.00	99.1	0.0	4043.4	0.564	1.000	0.000	1.2464
78	3635.0	3631.4	985.6	315.2	1.771	1.00	137.6	0.0	4178.2	0.564	1.000	0.000	1.2220
79	3631.0	3629.9	985.6	315.3	1.771	1.00	78.0	0.0	4177.9	0.564	1.000	0.000	1.2218
80	3630.4	3630.2	985.6	315.3	1.771	1.00	31.0	0.0	4178.1	0.564	1.000	0.000	1.2218
81	3630.3	3630.1	985.6	315.3	1.771	1.00	30.6	0.0	4178.1	0.564	1.000	0.000	1.2218
82	3630.1	3630.1	985.6	315.3	1.771	1.00	3.8	0.0	4178.1	0.564	1.000	0.000	1.2218
83	3624.4	3612.9	985.6	315.1	1.765	1.00	245.4	0.0	4171.7	0.564	1.000	0.000	1.2206
84	3612.9	3612.9	985.6	315.4	1.764	1.00	1.7	0.0	4172.7	0.564	1.000	0.000	1.2204
85	4470.4	4433.1	294.8	137.9	3.800	1.00	301.5	0.0	4708.3	0.462	1.000	0.000	1.5893
86	4433.1	4433.1	294.8	138.5	3.791	1.00	0.7	0.0	4703.3	0.462	1.000	0.000	1.5868
87	4431.9	4429.5	294.8	138.5	3.790	1.00	75.8	0.0	4701.7	0.462	1.000	0.000	1.5862
88	4429.3	4428.7	294.8	138.5	3.789	1.00	36.7	0.0	4701.0	0.462	1.000	0.000	1.5858
89	4429.1	4428.4	511.1	197.5	2.971	1.00	46.8	0.0	4339.9	0.462	1.000	0.000	1.4185
90	4428.4	4425.3	511.1	197.4	2.970	1.00	98.2	0.0	4338.7	0.462	1.000	0.000	1.4181
91	4168.4	3607.0	511.1	190.9	2.703	1.00	1367.8	0.0	3988.6	0.462	1.000	0.000	1.3136
92	3611.8	3611.8	511.1	200.4	2.599	1.00	0.9	0.0	3971.6	0.462	1.000	0.000	1.3033
93	3608.0	3599.5	771.9	263.7	2.054	1.00	196.3	0.0	4006.2	1.026	1.000	0.000	1.2487
94	3599.5	3599.5	771.9	263.9	2.053	1.00	1.8	0.0	4006.7	1.026	1.000	0.000	1.2486
95	4282.0	4224.5	301.4	140.7	3.678	1.00	11.4	380.7	4581.1	0.639	1.000	0.000	1.5338
96	4862.4	4221.4	330.7	140.7	3.677	1.00	71.6	1269.0	4579.7	0.147	1.000	0.000	1.5332
97	4856.7	4216.2	330.7	140.7	3.674	1.00	71.6	1269.0	4576.8	0.147	1.000	0.000	1.5320
98	4271.5	4216.2	330.7	149.2	3.538	1.00	2.4	380.7	4504.3	0.147	1.000	0.000	1.5012
99	4353.6	4193.0	2921.8	1349.7	0.904	1.00	190.6	1269.0	5192.5	0.096	0.565	0.435	1.0516
100	4341.5	4181.3	2921.8	1349.6	0.901	1.00	191.1	1269.0	5192.9	0.096	0.565	0.435	1.0514
101	4195.2	4181.3	2921.8	1361.7	0.893	1.00	3.6	380.7	5223.1	0.096	0.565	0.435	1.0520

F1,F2,F3,F4,F5=-0.16430E+05-0.26986E+06 0.17750E+06-0.17033E+06 0.23082E+06

FROT1,FROT2,FNET=-0.95813E+04-0.84818E+04-0.66364E+05

Table 3-2 HPFTP TURBINE COOLANT ANALYSIS (104%)

STA	TOTAL PRESS (PSIA)	STATIC PRESS (PSIA)	TOTAL ENTHALPY (BTU/LBM)	TEMPER-ATURE (R)	DENSITY (LBM/FT3)	FLUID QUAL	VELO-CITY (FPS)	TANG VEL (FPS)	SONIC VEL (FPS)	FLOW RATE (LBM/SEC)	MASS FRACTIONS H2	MASS FRACTIONS H2O	ZFAC
1	6604.1	5834.6	208.4	89.8	4.982	1.00	246.8	1170.6	5794.5	6.336	1.000	0.000	2.4495
2	6249.9	5796.1	208.4	94.5	4.899	1.00	178.6	904.0	5725.4	6.336	1.000	0.000	2.3519
3	5649.8	4518.2	208.4	96.3	4.566	1.00	1328.2	690.7	5216.4	6.336	1.000	0.000	1.9315
4	4715.8	4516.5	208.4	108.5	4.342	1.00	65.2	646.4	5062.4	6.336	1.000	0.000	1.8011
5	4672.4	4517.2	208.4	109.1	4.331	1.00	31.4	574.0	5055.7	6.336	1.000	0.000	1.7960
6	4523.4	4517.2	264.4	128.8	3.983	1.00	119.9	0.0	4838.1	6.336	1.000	0.000	1.6547
7	4492.1	4388.3	265.0	128.4	3.946	1.00	458.3	179.3	4781.1	6.336	1.000	0.000	1.6273
8	4400.0	4380.1	265.0	129.6	3.922	1.00	130.9	172.4	4764.5	6.336	1.000	0.000	1.6188
9	4459.6	4321.2	269.7	129.7	3.900	1.00	254.0	512.0	4735.3	3.760	1.000	0.000	1.6050
10	4456.7	4318.5	269.7	129.7	3.899	1.00	255.5	512.0	4733.8	3.760	1.000	0.000	1.6043
11	4347.1	4305.5	269.7	131.2	3.869	1.00	54.6	310.4	4712.8	3.760	1.000	0.000	1.5940
12	4345.9	4305.6	269.7	131.2	3.869	1.00	7.4	310.4	4712.7	3.760	1.000	0.000	1.5939
13	4398.8	4385.0	265.0	129.7	3.922	1.00	53.5	172.4	4766.2	2.576	1.000	0.000	1.6196
14	4421.1	4384.9	266.1	129.7	3.922	1.00	53.5	287.4	4766.2	2.576	1.000	0.000	1.6195
15	4427.3	4383.6	266.4	129.7	3.922	1.00	74.2	312.7	4765.6	2.576	1.000	0.000	1.6193
16	4429.6	4383.1	266.6	129.7	3.921	1.00	31.9	329.6	4765.1	2.576	1.000	0.000	1.6190
17	4415.5	4378.5	266.6	129.9	3.917	1.00	89.3	281.7	4761.3	2.576	1.000	0.000	1.6171
18	4408.0	4369.5	266.6	129.9	3.913	1.00	146.2	263.7	4756.6	2.576	1.000	0.000	1.6149
19	4407.2	4368.8	266.6	129.9	3.913	1.00	146.3	263.7	4756.2	2.576	1.000	0.000	1.6147
20	4398.2	4368.6	266.6	130.0	3.911	1.00	21.1	263.7	4754.8	2.576	1.000	0.000	1.6140
21	4449.3	4333.3	270.5	130.2	3.896	1.00	96.3	515.1	4736.1	1.736	1.000	0.000	1.6052
22	4322.1	4270.7	270.5	131.5	3.851	1.00	97.2	337.2	4692.6	1.736	1.000	0.000	1.5846
23	4228.8	4180.6	270.5	132.0	3.809	1.00	333.0	76.6	4642.2	1.736	1.000	0.000	1.5618
24	4227.4	4178.9	270.5	132.0	3.808	1.00	334.9	76.6	4641.4	1.736	1.000	0.000	1.5614
25	4210.3	4209.4	270.5	132.6	3.810	1.00	26.1	38.3	4651.5	1.002	1.000	0.000	1.5658
26	4208.9	4203.6	270.5	132.5	3.809	1.00	36.9	107.6	4648.9	1.002	1.000	0.000	1.5646
27	4207.2	4198.4	270.5	132.5	3.807	1.00	25.8	143.5	4646.5	1.002	1.000	0.000	1.5636
28	4213.8	4198.7	270.9	132.5	3.807	1.00	6.5	191.6	4646.6	1.002	1.000	0.000	1.5636
29	4198.7	4198.7	270.9	132.7	3.804	1.00	6.5	0.0	4644.4	1.002	1.000	0.000	1.5626
30	4159.3	4068.3	271.0	132.2	3.764	1.00	461.5	99.1	4583.9	0.575	1.000	0.000	1.5360
31	4071.4	4066.2	271.0	133.5	3.741	1.00	55.7	99.1	4570.3	0.575	1.000	0.000	1.5301
32	4036.7	3962.5	271.1	133.0	3.709	1.00	416.6	103.7	4521.1	0.575	1.000	0.000	1.5090

Table 3-2 HPFTP TURBINE COOLANT ANALYSIS (104%) (Continued)

STA	TOTAL PRESS (PSIA)	STATIC PRESS (PSIA)	TOTAL ENTHALPY (BTU/LBM)	TEMPER-ATURE (R)	DENSITY (LBM/FT3)	FLUID QUAL	VELO-CITY (FPS)	TANG VEL (FPS)	SONIC VEL (FPS)	FLOW RATE (LBM/SEC)	MASS FRACTIONS H2	MASS FRACTIONS H2O	ZFAC
33	3965.6	3961.2	271.1	134.0	3.691	1.00	16.9	103.7	4510.3	0.575	1.000	0.000	1.5045
34	4010.6	3989.1	3096.1	1495.3	0.814	1.00	285.9	401.6	5383.4	3.582	0.534	0.466	1.0503
35	5168.3	4431.1	3486.0	1759.3	0.850	1.00	1134.5	2508.6	5543.5	3.147	0.470	0.530	1.0517
36	4332.2	4000.2	3486.0	1794.9	0.756	1.00	1885.2	692.6	5604.1	3.147	0.470	0.530	1.0469
37	4009.3	3987.9	3095.7	1495.2	0.814	1.00	290.7	401.6	5383.0	3.582	0.534	0.466	1.0503
38	4144.8	3983.8	3128.3	1495.6	0.813	1.00	175.1	1338.8	5384.0	3.582	0.534	0.466	1.0502
39	4143.5	3983.6	3128.3	1495.6	0.813	1.00	176.3	1338.8	5384.0	3.582	0.534	0.466	1.0502
40	3997.4	3980.4	3192.6	1583.4	0.792	1.00	189.7	401.6	5457.3	5.252	0.514	0.486	1.0494
41	4245.1	4118.4	3325.3	1740.8	0.801	1.00	1142.4	379.7	5517.0	1.669	0.470	0.530	1.0483
42	4084.6	3986.0	3325.3	1743.8	0.775	1.00	1024.7	344.5	5523.1	1.669	0.470	0.530	1.0469
43	3998.2	3981.4	3192.7	1583.4	0.792	1.00	191.9	401.6	5457.3	5.252	0.514	0.486	1.0494
44	3996.7	3969.7	3192.7	1582.4	0.791	1.00	391.9	401.6	5455.5	5.391	0.514	0.486	1.0493
45	3980.2	3968.7	2917.0	1369.3	0.851	1.00	109.3	339.4	5227.5	5.959	0.560	0.440	1.0495
46	4214.4	4212.7	270.5	132.5	3.812	1.00	1.5	64.4	4653.4	0.734	1.000	0.000	1.5667
47	4386.0	3885.8	286.9	131.9	3.698	1.00	903.1	643.8	4491.5	0.734	1.000	0.000	1.4963
48	4067.8	3832.6	287.7	136.1	3.602	1.00	404.9	659.1	4422.1	0.734	1.000	0.000	1.4685
49	4003.2	3830.6	287.7	137.1	3.585	1.00	90.0	659.1	4412.4	0.734	1.000	0.000	1.4648
50	4254.6	3954.0	300.9	138.4	3.613	1.00	56.7	873.7	4465.3	0.734	1.000	0.000	1.4863
51	3984.7	3957.2	300.9	142.4	3.546	1.00	16.2	266.7	4431.0	0.734	1.000	0.000	1.4729
52	3984.5	3957.2	300.9	142.4	3.546	1.00	12.7	266.7	4431.0	0.568	1.000	0.000	1.4729
53	3988.2	3958.9	301.1	142.4	3.547	1.00	17.5	275.9	4431.7	0.568	1.000	0.000	1.4732
54	3981.2	3969.5	2917.1	1369.4	0.852	1.00	107.7	339.4	5227.6	5.959	0.560	0.440	1.0495
55	3968.7	3968.3	2917.1	1370.4	0.851	1.00	66.5	0.0	5230.0	5.959	0.560	0.440	1.0495
56	3968.1	3966.8	2917.1	1370.3	0.850	1.00	115.9	0.0	5229.8	5.959	0.560	0.440	1.0495
57	3966.8	3966.4	2917.1	1370.4	0.850	1.00	66.6	0.0	5230.0	5.959	0.560	0.440	1.0495
58	3979.5	3965.1	2848.9	1320.9	0.868	1.00	136.2	367.9	5154.8	6.125	0.572	0.428	1.0484
59	3984.5	3957.3	300.9	142.4	3.546	1.00	3.7	266.7	4431.0	0.166	1.000	0.000	1.4729
60	3975.5	3948.3	300.9	142.4	3.542	1.00	1.8	266.7	4425.9	0.166	1.000	0.000	1.4709
61	3980.4	3966.0	2848.9	1320.9	0.868	1.00	134.7	367.9	5154.8	6.125	0.572	0.428	1.0484
62	3980.8	3953.1	2849.4	1319.9	0.866	1.00	371.0	397.0	5152.6	6.036	0.572	0.428	1.0482
63	3875.8	3645.0	2849.6	1299.9	0.814	1.00	1560.7	410.2	5115.2	3.168	0.572	0.428	1.0439
64	3656.8	3641.2	2849.8	1319.1	0.801	1.00	23.5	422.5	5166.8	3.168	0.572	0.428	1.0450

Table 3-2 HPFTP TURBINE COOLANT ANALYSIS (104%) (Concluded)

STA	TOTAL PRESS (PSIA)	STATIC PRESS (PSIA)	TOTAL ENTHALPY (BTU/LBM)	TEMPER-ATURE (R)	DENSITY (LBM/FT3)	FLUID QUAL	VELO-CITY (FPS)	TANG VEL (FPS)	SONIC VEL (FPS)	FLOW RATE (LBM/SEC)	MASS FRACTIONS H2	MASS FRACTIONS H2O	ZFAC
65	4116.1	3951.0	2881.2	1320.8	0.865	1.00	123.0	1323.5	5155.4	2.868	0.572	0.428	1.0482
66	4115.8	3950.9	2881.2	1320.8	0.865	1.00	123.2	1323.5	5155.4	2.868	0.572	0.428	1.0482
67	3967.0	3949.7	2553.6	1196.1	0.940	1.00	117.0	397.0	4618.3	3.268	0.597	0.403	1.0273
68	4040.5	4029.0	266.6	132.3	3.748	1.00	25.7	166.9	4563.2	0.840	1.000	0.000	1.5270
69	3917.7	3905.2	266.6	132.9	3.688	1.00	9.4	177.3	4492.1	0.311	1.000	0.000	1.4967
70	3967.6	3950.1	2553.7	1196.2	0.940	1.00	115.7	397.0	4618.3	3.268	0.597	0.403	1.0273
71	3791.5	3408.1	2553.9	1140.0	0.847	1.00	1998.4	410.0	4564.2	3.268	0.597	0.403	1.0329
72	3418.1	3402.1	2554.1	1180.5	0.822	1.00	20.6	422.5	4588.3	3.268	0.597	0.403	1.0259
73	3764.4	3491.3	266.6	131.1	3.548	1.00	839.0	0.0	4282.4	0.529	1.000	0.000	1.4108
74	3737.9	3462.2	266.6	131.1	3.533	1.00	845.4	0.0	4264.9	0.529	1.000	0.000	1.4040
75	3460.9	3460.9	266.6	135.3	3.456	1.00	0.8	0.0	4224.1	0.529	1.000	0.000	1.3910
76	3460.9	3460.9	798.2	270.7	1.951	1.00	5.5	0.0	3975.0	0.529	1.000	0.000	1.2314
77	3459.8	3457.9	798.2	270.7	1.950	1.00	95.9	0.0	3973.8	0.529	1.000	0.000	1.2311
78	3457.5	3454.2	980.3	314.5	1.708	1.00	132.8	0.0	4118.3	0.529	1.000	0.000	1.2084
79	3453.8	3452.8	980.3	314.5	1.707	1.00	75.9	0.0	4118.0	0.529	1.000	0.000	1.2083
80	3453.3	3453.1	980.3	314.6	1.707	1.00	30.2	0.0	4118.2	0.529	1.000	0.000	1.2083
81	3453.2	3453.0	980.3	314.6	1.707	1.00	29.8	0.0	4118.2	0.529	1.000	0.000	1.2083
82	3453.0	3453.0	980.3	314.6	1.707	1.00	3.7	0.0	4118.2	0.529	1.000	0.000	1.2083
83	3447.8	3437.4	980.3	314.3	1.702	1.00	238.1	0.0	4112.3	0.529	1.000	0.000	1.2072
84	3437.3	3437.3	980.3	314.6	1.701	1.00	1.6	0.0	4113.3	0.529	1.000	0.000	1.2070
85	4182.8	4151.0	270.9	132.5	3.789	1.00	278.4	0.0	4622.4	0.427	1.000	0.000	1.5529
86	4150.8	4150.8	270.9	133.0	3.781	1.00	0.7	0.0	4617.8	0.427	1.000	0.000	1.5508
87	4149.8	4147.8	270.9	133.0	3.780	1.00	70.3	0.0	4616.4	0.427	1.000	0.000	1.5502
88	4147.6	4147.1	270.9	133.0	3.780	1.00	34.0	0.0	4615.8	0.427	1.000	0.000	1.5499
89	4147.5	4146.8	496.3	194.8	2.891	1.00	44.0	0.0	4225.1	0.427	1.000	0.000	1.3839
90	4146.8	4144.1	496.3	194.7	2.890	1.00	93.3	0.0	4224.0	0.427	1.000	0.000	1.3835
91	3920.0	3436.6	496.3	188.7	2.648	1.00	1281.5	0.0	3912.5	0.427	1.000	0.000	1.2921
92	3437.4	3437.4	496.3	197.1	2.553	1.00	0.9	0.0	3896.6	0.427	1.000	0.000	1.2835
93	3434.1	3426.5	764.0	262.3	1.990	1.00	187.2	0.0	3938.9	0.956	1.000	0.000	1.2330
94	3426.4	3426.4	764.0	262.5	1.989	1.00	1.7	0.0	3939.3	0.956	1.000	0.000	1.2329
95	4017.1	3987.9	277.1	134.9	3.685	1.00	18.9	367.9	4515.5	0.575	1.000	0.000	1.5068
96	4585.1	3985.2	304.4	134.9	3.685	1.00	67.7	1226.3	4514.2	0.140	1.000	0.000	1.5062
97	4580.3	3980.4	304.4	134.9	3.682	1.00	67.8	1226.3	4511.5	0.140	1.000	0.000	1.5051
98	4032.7	3980.4	304.4	142.9	3.547	1.00	2.2	367.9	4438.3	0.140	1.000	0.000	1.4758
99	4104.4	3960.3	2876.3	1320.7	0.867	1.00	184.6	1226.3	5154.6	0.090	0.572	0.428	1.0483
100	4093.5	3949.6	2876.3	1320.6	0.865	1.00	184.8	1226.3	5155.0	0.090	0.572	0.428	1.0482
101	3962.3	3949.6	2876.3	1331.7	0.857	1.00	3.5	367.9	5184.6	0.090	0.572	0.428	1.0488

F1,F2,F3,F4,F5=-0.15384E+05-0.25485E+06 0.16758E+06-0.16089E+06 0.21805E+06

FROT1,FROT2,FNET=-0.86645E+04-0.76779E+04-0.61823E+05

Table 3-3 HPFTP TURBINE COOLANT ANALYSIS (MPL)

STA	TOTAL PRESS (PSIA)	STATIC PRESS (PSIA)	TOTAL ENTHALPY (BTU/LBM)	TEMPER-ATURE (R)	DENSITY (LBM/FT3)	FLUID QUAL	VELO-CITY (FPS)	TANG VEL (FPS)	SONIC VEL (FPS)	FLOW RATE (LBM/SEC)	MASS FRACTIONS H2	MASS FRACTIONS H2O	ZFAC
1	4042.5	3552.2	94.6	73.3	4.750	1.00	162.6	964.4	5168.7	4.760	1.000	0.000	1.9182
2	3784.3	3530.1	94.6	77.0	4.668	1.00	140.8	693.0	5079.0	4.760	1.000	0.000	1.8464
3	3435.4	2780.1	94.6	77.7	4.412	1.00	1034.7	529.4	4660.2	4.760	1.000	0.000	1.5234
4	2892.2	2778.3	94.6	85.3	4.231	1.00	50.3	495.4	4497.1	4.760	1.000	0.000	1.4469
5	2867.4	2778.6	94.6	85.6	4.223	1.00	24.2	440.0	4490.2	4.760	1.000	0.000	1.4439
6	2782.1	2778.6	127.6	97.4	3.939	1.00	90.8	0.0	4274.2	4.760	1.000	0.000	1.3609
7	2764.4	2705.0	128.0	97.1	3.911	1.00	348.1	137.5	4228.5	4.760	1.000	0.000	1.3380
8	2711.9	2700.4	128.0	97.8	3.892	1.00	99.2	132.2	4213.1	4.760	1.000	0.000	1.3327
9	2749.2	2672.0	130.7	97.9	3.877	1.00	172.0	392.4	4192.7	2.526	1.000	0.000	1.3231
10	2747.8	2670.7	130.7	97.9	3.876	1.00	172.6	392.4	4191.7	2.526	1.000	0.000	1.3227
11	2689.0	2664.8	130.7	98.7	3.854	1.00	36.9	237.9	4174.0	2.526	1.000	0.000	1.3167
12	2688.4	2664.8	130.7	98.7	3.853	1.00	5.0	237.9	4173.9	2.526	1.000	0.000	1.3167
13	2711.0	2702.8	128.0	97.9	3.892	1.00	46.8	132.2	4214.2	2.234	1.000	0.000	1.3333
14	2724.0	2702.7	128.6	97.9	3.892	1.00	46.8	220.3	4214.2	2.234	1.000	0.000	1.3333
15	2727.6	2701.7	128.8	97.9	3.891	1.00	64.9	239.7	4213.6	2.234	1.000	0.000	1.3330
16	2728.5	2701.4	128.9	97.9	3.891	1.00	27.9	252.6	4213.0	2.234	1.000	0.000	1.3327
17	2720.0	2697.9	128.9	98.0	3.887	1.00	78.1	215.9	4209.0	2.234	1.000	0.000	1.3311
18	2715.0	2691.1	128.9	98.0	3.883	1.00	127.7	202.1	4204.0	2.234	1.000	0.000	1.3288
19	2714.5	2690.5	128.9	98.0	3.883	1.00	127.8	202.1	4203.6	2.234	1.000	0.000	1.3286
20	2707.6	2690.4	128.9	98.1	3.880	1.00	18.4	202.1	4201.8	2.234	1.000	0.000	1.3280
21	2737.0	2668.6	131.2	98.2	3.868	1.00	85.9	394.8	4185.3	1.537	1.000	0.000	1.3205
22	2662.6	2631.7	131.2	98.9	3.832	1.00	86.2	258.5	4146.8	1.537	1.000	0.000	1.3048
23	2607.0	2569.8	131.2	99.1	3.794	1.00	294.7	58.7	4098.4	1.537	1.000	0.000	1.2837
24	2606.0	2568.3	131.2	99.1	3.794	1.00	297.5	58.7	4097.3	1.537	1.000	0.000	1.2832
25	2592.6	2592.0	131.2	99.6	3.795	1.00	23.5	29.4	4107.4	0.897	1.000	0.000	1.2890
26	2591.1	2587.8	131.2	99.5	3.794	1.00	33.2	82.5	4104.7	0.897	1.000	0.000	1.2877
27	2589.3	2584.2	131.2	99.5	3.792	1.00	23.2	110.0	4102.2	0.897	1.000	0.000	1.2865
28	2593.2	2584.4	131.4	99.5	3.792	1.00	5.9	146.9	4102.3	0.897	1.000	0.000	1.2866
29	2584.4	2584.3	131.4	99.7	3.789	1.00	5.9	0.0	4100.1	0.897	1.000	0.000	1.2860
30	2542.7	2452.1	131.5	99.0	3.735	1.00	466.2	76.0	4013.1	0.577	1.000	0.000	1.2459
31	2453.2	2449.6	131.5	100.3	3.701	1.00	56.4	76.0	3989.4	0.577	1.000	0.000	1.2401
32	2417.5	2343.1	131.5	99.7	3.655	1.00	425.7	79.5	3916.6	0.577	1.000	0.000	1.2080

Table 3-3 HPFTP TURBINE COOLANT ANALYSIS (MPL) (Continued)

STA	TOTAL PRESS (PSIA)	STATIC PRESS (PSIA)	TOTAL ENTHALPY (BTU/LBM)	TEMPER-ATURE (R)	DENSITY (LBM/FT3)	FLUID QUAL	VELO-CITY (FPS)	TANG VEL (FPS)	SONIC VEL (FPS)	FLOW RATE (LBM/SEC)	MASS FRACTIONS H2	MASS FRACTIONS H20	ZFAC
33	2344.7	2342.1	131.5	100.8	3.627	1.00	17.3	79.5	3897.8	0.577	1.000	0.000	1.2042
34	2367.4	2358.1	2486.6	1065.4	0.595	1.00	220.5	307.9	4801.8	2.027	0.636	0.364	1.0326
35	2893.9	2527.1	3234.1	1531.7	0.523	1.00	1026.9	2262.8	5413.7	1.539	0.520	0.480	1.0326
36	2488.7	2363.4	3234.1	1567.3	0.479	1.00	1458.2	530.9	5479.3	1.539	0.520	0.480	1.0307
37	2368.6	2359.3	2486.8	1065.2	0.596	1.00	224.1	307.9	4801.7	2.027	0.636	0.364	1.0326
38	2426.7	2357.5	2505.9	1065.5	0.595	1.00	135.5	1026.2	4801.9	2.027	0.636	0.364	1.0325
39	2426.2	2357.4	2505.9	1065.5	0.595	1.00	136.3	1026.2	4801.9	2.027	0.636	0.364	1.0325
40	2363.1	2356.1	2676.0	1191.1	0.558	1.00	143.5	307.9	5022.5	2.802	0.604	0.396	1.0286
41	2474.2	2402.7	3117.7	1522.7	0.501	1.00	1014.8	526.7	5399.5	0.775	0.520	0.480	1.0311
42	2391.4	2357.4	3117.7	1528.5	0.490	1.00	754.4	264.1	5410.5	0.775	0.520	0.480	1.0306
43	2362.9	2355.9	2676.0	1191.1	0.557	1.00	145.9	307.9	5022.5	2.802	0.604	0.396	1.0286
44	2362.2	2351.2	2676.0	1190.5	0.557	1.00	298.7	307.9	5021.2	2.891	0.604	0.396	1.0285
45	2355.9	2350.7	2290.1	931.5	0.642	1.00	82.9	260.1	4684.0	3.412	0.664	0.336	1.0516
46	2596.1	2595.1	131.2	99.5	3.798	1.00	1.3	49.3	4110.1	0.640	1.000	0.000	1.2901
47	2667.4	2316.0	140.9	98.5	3.870	1.00	792.3	493.5	3915.2	0.640	1.000	0.000	1.2032
48	2420.6	2272.2	141.3	101.7	3.560	1.00	356.6	505.2	3826.0	0.640	1.000	0.000	1.1793
49	2371.0	2270.3	141.3	102.4	3.540	1.00	79.4	505.2	3812.9	0.640	1.000	0.000	1.1769
50	2516.2	2342.1	149.0	103.3	3.562	1.00	50.0	869.7	3856.7	0.640	1.000	0.000	1.1966
51	2359.6	2343.6	149.0	105.6	3.502	1.00	14.3	204.4	3821.3	0.640	1.000	0.000	1.1908
52	2359.5	2343.7	149.0	105.6	3.502	1.00	11.8	204.4	3821.3	0.521	1.000	0.000	1.1908
53	2361.6	2344.6	149.2	105.6	3.502	1.00	16.2	211.5	3821.9	0.521	1.000	0.000	1.1911
54	2356.0	2350.8	2290.2	931.5	0.642	1.00	81.5	260.1	4684.0	3.412	0.664	0.336	1.0516
55	2350.8	2350.6	2290.2	932.1	0.642	1.00	50.5	0.0	4685.4	3.412	0.664	0.336	1.0515
56	2350.5	2349.9	2290.2	932.1	0.642	1.00	88.0	0.0	4685.3	3.412	0.664	0.336	1.0515
57	2349.9	2349.8	2290.2	932.1	0.642	1.00	50.5	0.0	4685.4	3.412	0.664	0.336	1.0515
58	2355.5	2349.2	2219.8	899.5	0.653	1.00	104.7	282.0	4645.4	3.531	0.675	0.325	1.0553
59	2359.5	2343.7	149.0	105.6	3.502	1.00	2.7	204.4	3821.4	0.119	1.000	0.000	1.1908
60	2354.7	2338.9	149.0	105.6	3.498	1.00	1.3	204.4	3817.3	0.119	1.000	0.000	1.1894
61	2355.6	2349.2	2219.8	899.6	0.653	1.00	102.9	282.0	4645.5	3.531	0.675	0.325	1.0553
62	2356.1	2343.9	2220.0	899.9	0.651	1.00	284.2	304.3	4646.2	3.480	0.675	0.325	1.0552
63	2300.9	2181.0	2220.2	888.9	0.615	1.00	1300.9	314.4	4617.8	1.995	0.675	0.325	1.0521
64	2186.1	2179.1	2220.3	894.7	0.611	1.00	19.5	323.9	4632.9	1.995	0.675	0.325	1.0515

Table 3-3 HPFTP TURBINE COOLANT ANALYSIS (MPL) (Concluded)

STA	TOTAL PRESS (PSIA)	STATIC PRESS (PSIA)	TOTAL ENTHALPY (BTU/LBM)	TEMPER-ATURE (R)	DENSITY (LBM/FT3)	FLUID QUAL	VELO-CITY (FPS)	TANG VEL (FPS)	SONIC VEL (FPS)	FLOW RATE (LBM/SEC)	MASS FRACTIONS H2	MASS FRACTIONS H20	ZFAC
65	2416.0	2343.1	2238.7	899.6	0.651	1.00	84.6	1014.5	4645.6	1.485	0.675	0.325	1.0552
66	2416.0	2343.1	2238.7	899.6	0.651	1.00	84.6	1014.5	4645.6	1.485	0.675	0.325	1.0552
67	2349.1	2342.4	1839.1	756.9	0.602	0.89	101.1	304.3	5471.8	1.828	0.709	0.291	1.0711
68	2464.8	2458.1	128.9	99.4	3.728	1.00	21.5	128.0	4010.4	0.697	1.000	0.000	1.2462
69	2323.0	2315.7	128.9	100.0	3.631	1.00	9.0	135.9	3889.1	0.292	1.000	0.000	1.1981
70	2347.6	2340.9	1839.1	756.9	0.602	0.89	100.7	304.3	5471.8	1.828	0.709	0.291	1.0711
71	2265.0	2085.4	1839.3	743.1	0.561	0.87	1686.4	314.3	5415.3	1.828	0.709	0.291	1.0647
72	2088.5	2082.4	1839.4	753.8	0.533	0.90	17.7	323.9	5470.8	1.828	0.709	0.291	1.0633
73	2303.0	2144.0	128.9	98.4	3.568	1.00	639.4	0.0	3775.3	0.405	1.000	0.000	1.1471
74	2286.9	2126.8	128.9	98.4	3.556	1.00	643.2	0.0	3760.0	0.405	1.000	0.000	1.1414
75	2126.4	2126.4	128.9	100.8	3.490	1.00	0.6	0.0	3718.4	0.405	1.000	0.000	1.1356
76	2126.4	2126.3	605.9	226.6	1.572	1.00	5.2	0.0	3347.8	0.405	1.000	0.000	1.1219
77	2125.6	2124.2	605.9	226.5	1.571	1.00	91.1	0.0	3346.9	0.405	1.000	0.000	1.1217
78	2123.8	2121.4	769.3	266.1	1.339	1.00	130.0	0.0	3490.4	0.405	1.000	0.000	1.1185
79	2121.1	2120.3	769.3	266.2	1.338	1.00	74.0	0.0	3490.3	0.405	1.000	0.000	1.1184
80	2120.7	2120.6	769.3	266.2	1.338	1.00	29.5	0.0	3490.4	0.405	1.000	0.000	1.1184
81	2120.6	2120.5	769.3	266.2	1.338	1.00	29.1	0.0	3490.4	0.405	1.000	0.000	1.1184
82	2120.5	2120.5	769.3	266.2	1.338	1.00	3.6	0.0	3490.4	0.405	1.000	0.000	1.1184
83	2116.6	2108.8	769.3	266.0	1.333	1.00	232.5	0.0	3485.5	0.405	1.000	0.000	1.1175
84	2108.8	2108.8	769.3	266.2	1.332	1.00	1.6	0.0	3486.7	0.405	1.000	0.000	1.1175
85	2575.4	2557.6	131.4	99.5	3.778	1.00	209.0	0.0	4082.8	0.319	1.000	0.000	1.2779
86	2557.5	2557.5	131.4	99.8	3.772	1.00	0.5	0.0	4078.3	0.319	1.000	0.000	1.2768
87	2557.0	2555.8	131.4	99.8	3.771	1.00	52.7	0.0	4077.2	0.319	1.000	0.000	1.2763
88	2555.7	2555.4	131.4	99.8	3.770	1.00	25.5	0.0	4076.7	0.319	1.000	0.000	1.2761
89	2555.6	2555.2	338.4	157.6	2.574	1.00	37.1	0.0	3532.7	0.319	1.000	0.000	1.1834
90	2555.2	2553.5	338.4	157.6	2.574	1.00	78.3	0.0	3531.7	0.319	1.000	0.000	1.1831
91	2412.6	2108.4	338.4	151.5	2.352	1.00	1078.6	0.0	3274.9	0.319	1.000	0.000	1.1119
92	2107.5	2107.5	338.4	157.7	2.255	1.00	0.7	0.0	3261.8	0.319	1.000	0.000	1.1133
93	2105.2	2099.8	579.2	219.8	1.603	1.00	176.5	0.0	3318.2	0.724	1.000	0.000	1.1196
94	2099.8	2099.8	579.2	220.0	1.602	1.00	1.6	0.0	3318.6	0.724	1.000	0.000	1.1196
95	2373.2	2359.3	135.1	101.3	3.623	1.00	23.6	282.0	3902.5	0.577	1.000	0.000	1.2079
96	2704.4	2358.2	151.1	101.3	3.623	1.00	43.8	940.0	3901.6	0.089	1.000	0.000	1.2078
97	2702.3	2356.1	151.1	101.3	3.621	1.00	43.8	940.0	3899.8	0.089	1.000	0.000	1.2069
98	2386.4	2356.1	151.1	105.9	3.501	1.00	1.4	282.0	3826.1	0.089	1.000	0.000	1.1936
99	2410.8	2347.1	2235.8	899.5	0.653	1.00	139.5	940.0	4645.2	0.051	0.675	0.325	1.0553
100	2406.0	2342.4	2235.8	899.5	0.651	1.00	139.6	940.0	4645.3	0.051	0.675	0.325	1.0552
101	2347.9	2342.3	2235.8	903.4	0.649	1.00	2.6	282.0	4657.5	0.051	0.675	0.325	1.0548

F1,F2,F3,F4,F5=-0.94608E+04-0.15067E+06 0.99192E+05-0.95397E+05 0.12922E+06

FROT1,FROT2,FNET=-0.34914E+04-0.31668E+04-0.33781E+05

Column	Parameter	Description
Line numbers 3 through 103, Format (I5,5X, 6E10.4)		
1-5	IP	Flow type
11-20	A	Passage flow area, in^2
21-30	D	Passage hydraulic diameter, in.
31-40	XL	Passage effective length for frictional losses, in.
41-50	XR	Radial location, in.
51-60	XK	Flow loss coefficient
61-70	EFF	Ratio of fluid to shaft rotational speed.
Line number 104, Format (8E10.4)		
1-10	BAREA	Bearing area, in^2
11-20	BRAD	Bearing pitch radius, in.
21-30	BC	Empirical constant
31-40	BK	Empirical constant.
Line number 105, Format (2I5, 7F10.5) Data for interstage labyrinth seal		
1-5	N	Final tooth number, enter 4
6-10	J	Parameter not used; enter 0
11-20	CL	Radial clearance from drawings, in.
21-30	PL	Tooth pitch, in.
31-40	HL	Tooth height, in.
41-50	WL	Tooth width, in.
51-60	DSHF	Shaft diameter, in.
61-70	DCASE	Case diameter, in. = DSHF+2(CL+HL)
71-80	DCL	Change in diametral clearance at operating conditions, in.

Column	Parameter	Description
Line number 106, Format (2I5, 7F10.5) Data for first two teeth of turbine seal		
1-5	N	Final tooth number, enter 6
6-80	Same parameters as above.	
Line number 107, Format (2I5, 7F10.5) Data for next three teeth of turbine seal		
1-5	N	Final tooth number, enter 9
6-80	Same parameters as above.	
Line number 108, Format (2I5, 7F10.5) Data for final three teeth of turbine seal		
1-5	N	Final tooth number, enter 12
6-80	Same parameters as above.	
Line number 109, blank card image.		
Line number 110, Format (8I5)		
1-5	IOPT	= 1 Fixed blade coefficient and iterates to determine flow rate = 2 Fixed flow rate and iterates to determine blade coefficient
6-10	IOPTX1	= 1 Enter total pressures in pump input data = 2 Enter static pressures in pump input data
11-15	ITURB	= 1 Uses programmed turbine leakage flows and makes one pass through turbine and coolant flow models = 2 Uses computed leakage flows from first pass and makes an additional pass through each model
16-20	KPUMP	= 1 Reads input impeller inlet and discharge conditions and bypasses pump head rise model = 2 Computes impeller inlet and discharge conditions using pump head rise model.

Column	Parameter	Description
Line number 111, Format (8E10.4)		
1-10	WPIO	Pump inlet flow rate, lbm/s
11-20	PIOF	Pump inlet pressure, psia Total pressure if IOPTX1 = 1 Static pressure if IOPTX1 = 2
21-30	TIOF	Pump inlet temperature, °R
31-40	POOF	Pump discharge pressure, psia Total pressure if IOPTX1 = 1 Static pressure if IOPTX1 = 2
41-50	TOOF	Pump discharge temperature, °R
51-60	ETAP	Pump efficiency
61-70	RPM	Pump speed, rpm
71-80	XPL	Power level ratio.
Line number 112, Format (8E10.4)		
1-10	PKNOWN(1)	Impeller discharge total pressure, psia
11-20	TKNOWN(1)	Impeller discharge temperature, °R
21-30	RKNOWN(1)	Impeller discharge density, lbm/ft^3
31-40	VTKNON(1)	Impeller discharge fluid tangential velocity, ft/s.
Line number 113, Format (8E10.4)		
1-10	PKNOWN(2)	Impeller inlet total pressure, psia
11-20	TKNOWN(2)	Impeller inlet temperature, °R
21-30	PKNOWN(2)	Impeller inlet density, lbm/ft^3
31-40	VTKNON(2)	Impeller inlet fluid tangential velocity, ft/s.

Column	Parameter	Description
Line number 114, Format (8E10.4)		
1-10	WDPB	Turbine inlet flow rate, lbm/s
11-20	PPB	Turbine inlet total pressure, psia
21-30	TPB	Turbine inlet total temperature, °R
31-40	HPA	Turbine horsepower, hp
41-50	TFTD	Turbine discharge total temperature, °R
51-60	PFTD	Turbine turnaround duct discharge total pressure, psia
61-70	ETANZ	Nozzle efficiency, K_n^2
71-80	XKB	Blade coefficient, K_b.
Line number 115, Format (8E10.4)		
1-10	OF	Preburner mixture ratio.
Line number 116, Format (8E10.4)		
1-80	WDLEG	Legs 1 through 8 estimated flow rate at FPL, lbm/s.
Line number 117, Format (8E10.4)		
1-80	WDLEG	Legs 9 through 16 estimated flow rate at FPL, lbm/s.
Line number 118, Format (8E10.4)		
1-80	WDLEG	Legs 17 through 24 estimated flow rate at FPL, lbm/s.
Line number 119, Format (8E10.4)		
1-10	WDLEG	Leg 25 estimated flow rate at FPL, lbm/s.

4. HIGH PRESSURE OXIDIZER TURBINE COOLANT ANALYSIS

4.1 TURBINE COOLANT SYSTEM

The existing high pressure oxidizer turbopump (HPOTP) turbine coolant system flow model developed by Lockheed for NASA-MSFC was used as a baseline for this analysis. This baseline model (shown in Figures 4-1 and 4-2) is documented in Reference 9. The turbine coolant system was modeled to evaluate the flow properties at each of the numbered stations and to compute the flow rates along each of the flow paths in the system. Four additional stations have been included in the model for computational purposes. These are at the first stage blade exit (station 159), second stage nozzle exit (station 160), second stage blade exit (station 161), and primary turbine seal inlet (station 162). The model comprises 162 stations and 27 flow paths.

4.2 MODEL IMPROVEMENT

A review of current drawings was performed, and pertinent geometry changes were included in the model. Operating clearances for the interstage seal and turbine seal were supplied by NASA-MSFC. The flow path supplying coolant hydrogen to the turbine seal region at station 131 (see Figure 4-2a) has been modified and now supplies mixed coolant from the mixing chamber. The cold hydrogen supply has been blanked off, and mixed coolant is now introduced at old station location 122 shown in Figure 4-1m. This flow path now consists of stations 120 through 131.

A one-dimensional turbine model is included as a subroutine in the code. This provides a closed loop analysis with a minimum of required boundary conditions as input. Estimated leakage rates into the primary turbine flow path are input to the turbine model, and the turbine model is executed to provide pressures as boundary conditions for the coolant flow model (stations 29, 159, 160, and 161). The coolant model is then executed and new leakage

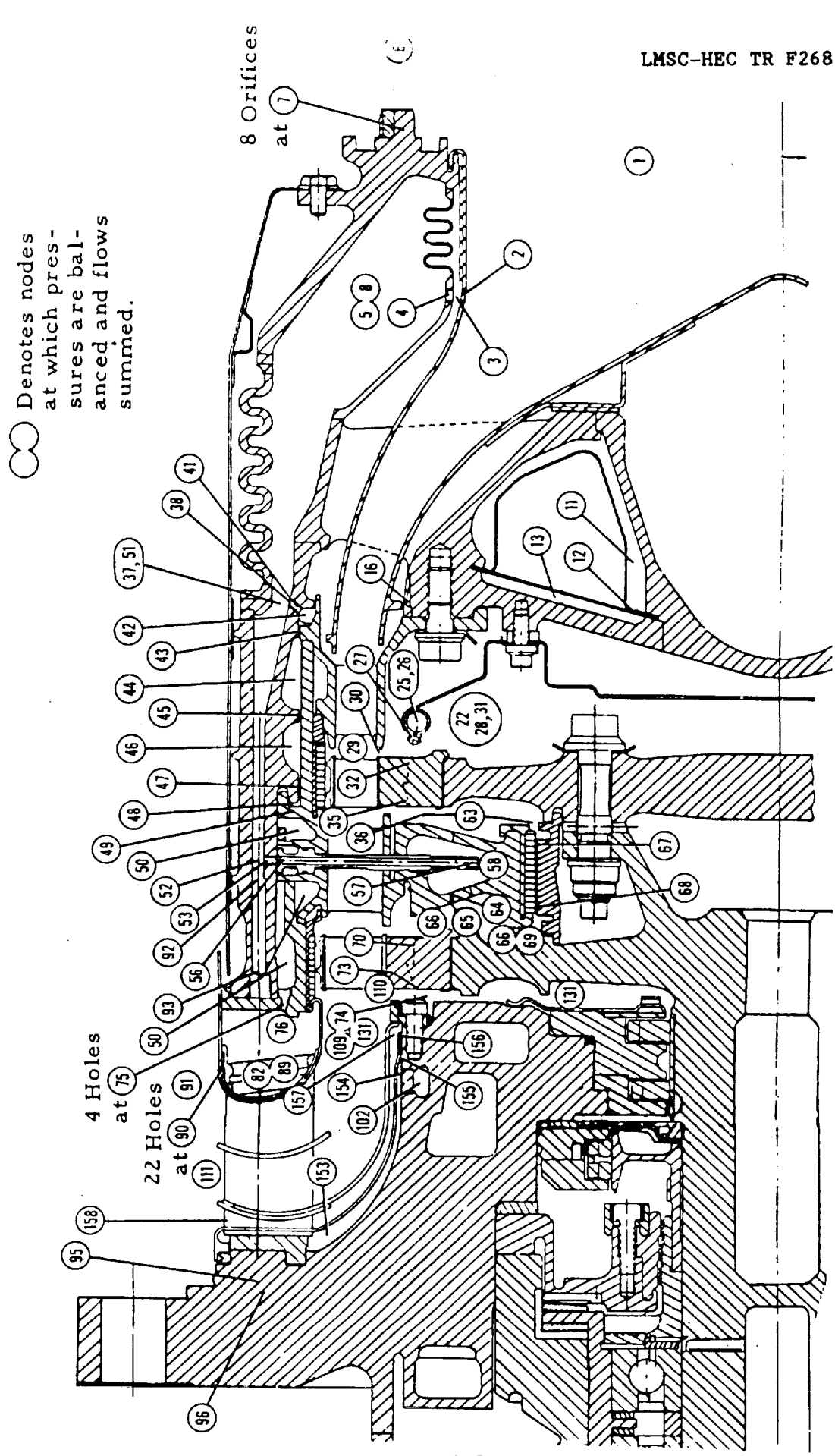


Figure 4-1 HPOTP Turbine Coolant System Schematic Diagram

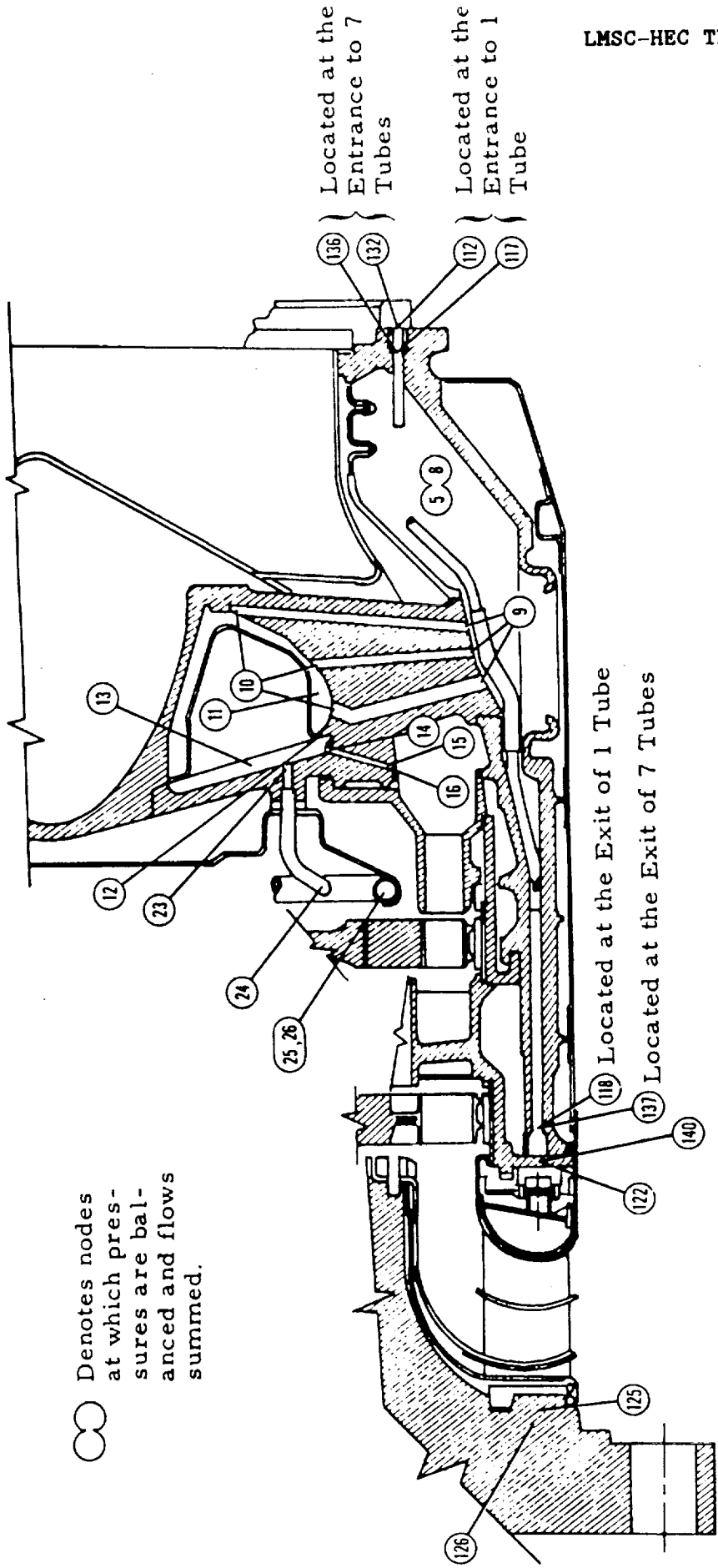

Located at the Entrance to 7 Tubes
Located at the Entrance to 1 Tube
136
132
112
117
8
5
9
10
11
13
14
15
16
12
23
24
25,26
118
Located at the Exit of 1 Tube
137
Located at the Exit of 7 Tubes
140
122
125
126
Denotes nodes at which pressures are balanced and flows summed.

Figure 4-1a

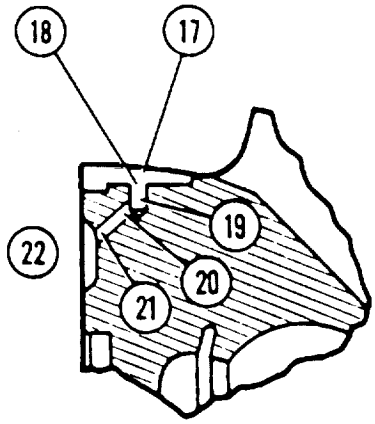


Figure 4-1b

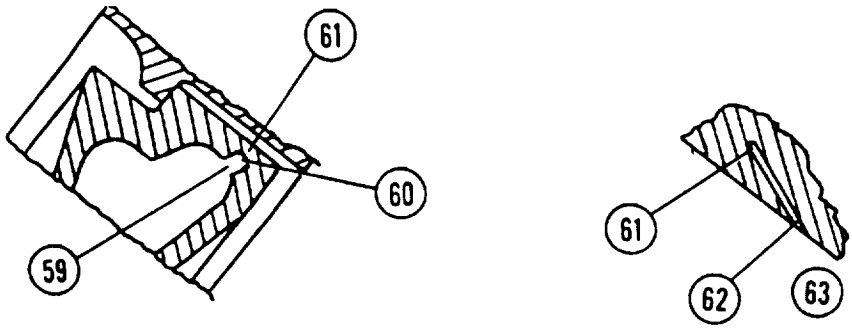


Figure 4-1c

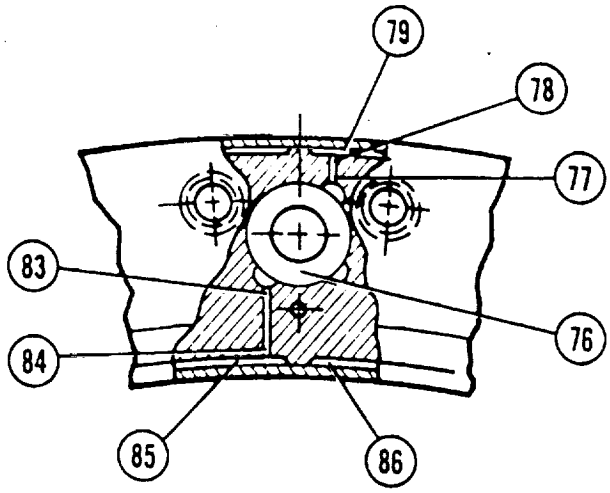
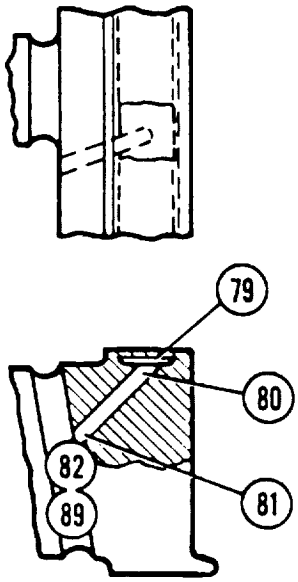


Figure 4-1d



Denotes nodes at which pressures are balanced and flows summed.

Figure 4-1e

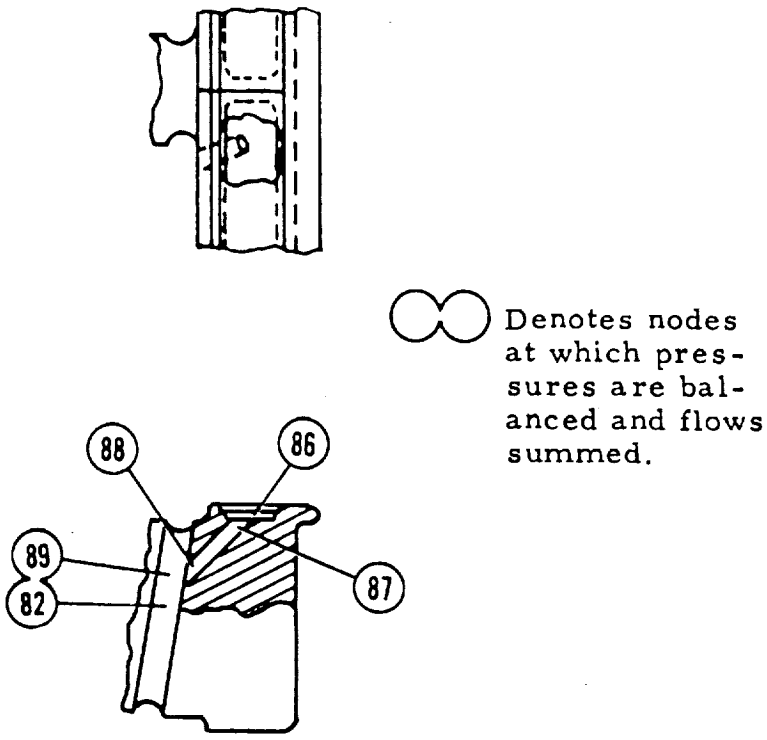


Figure 4-1f

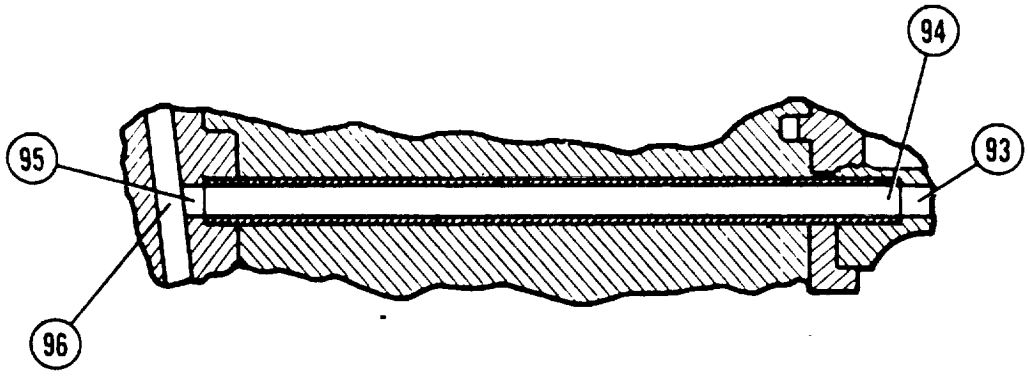


Figure 4-1g

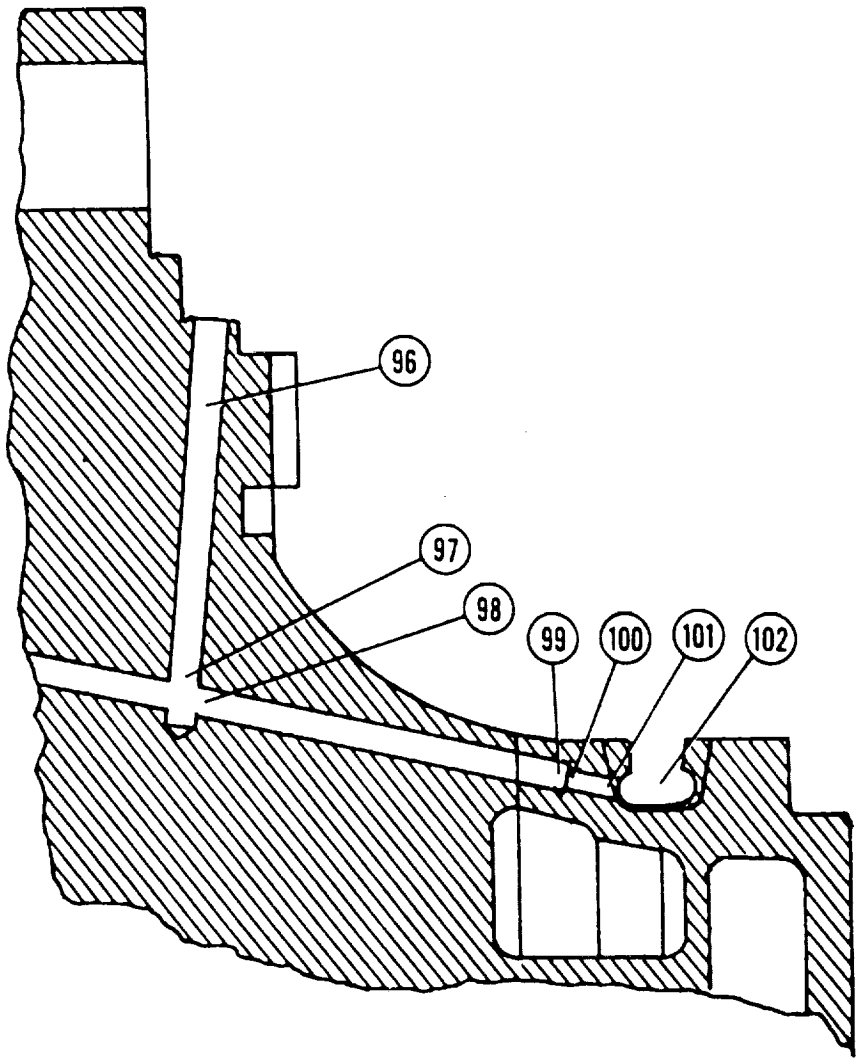


Figure 4-1h

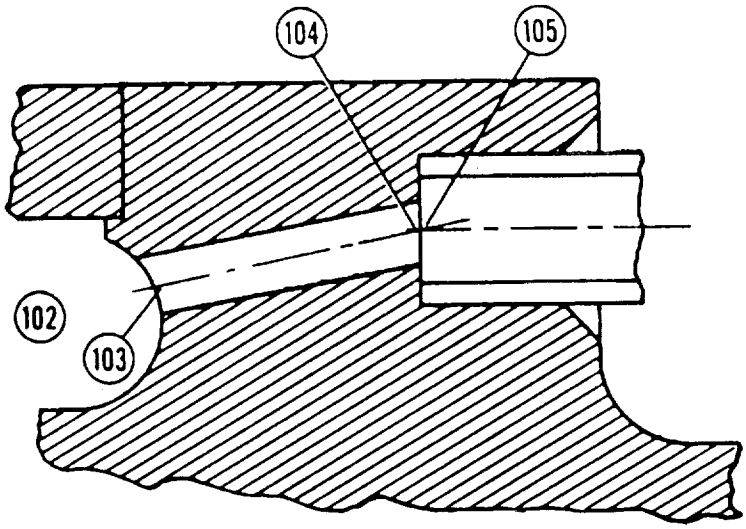


Figure 4-1i

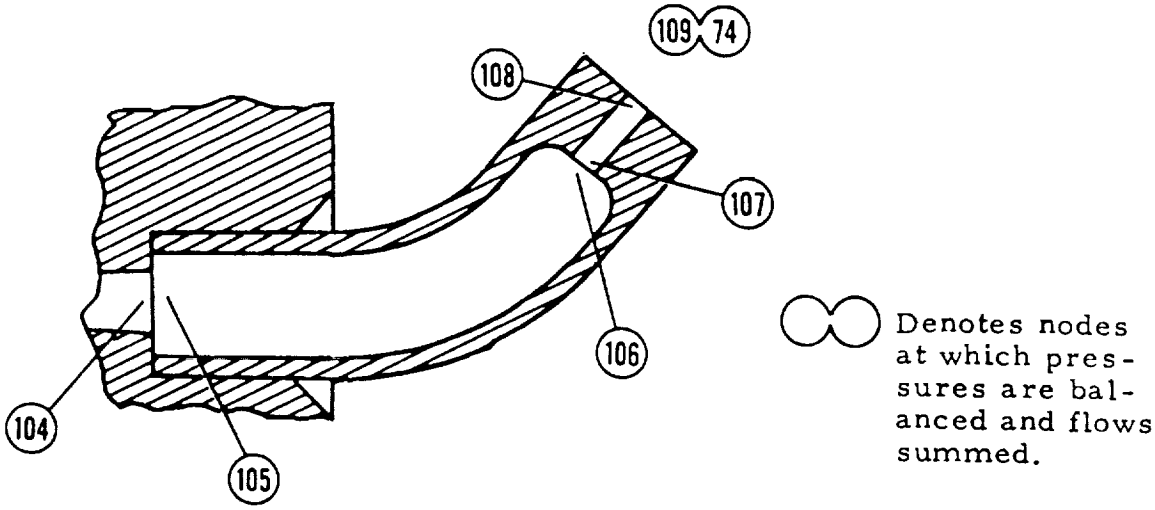


Figure 4-1j

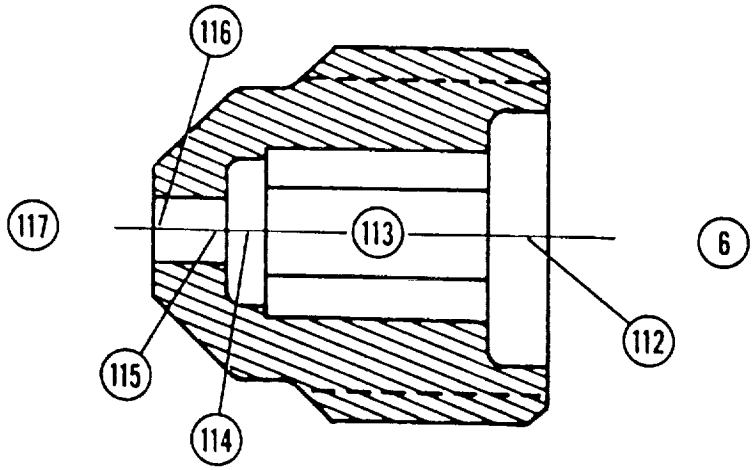


Figure 4-1k

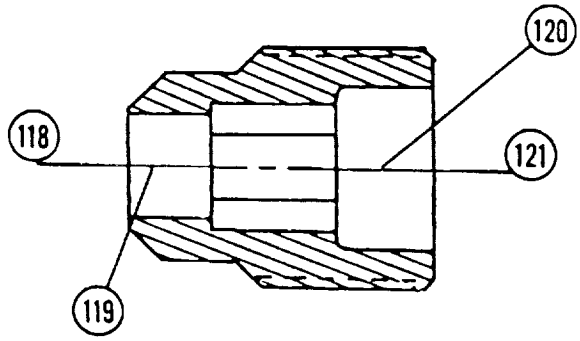


Figure 4-1ℓ

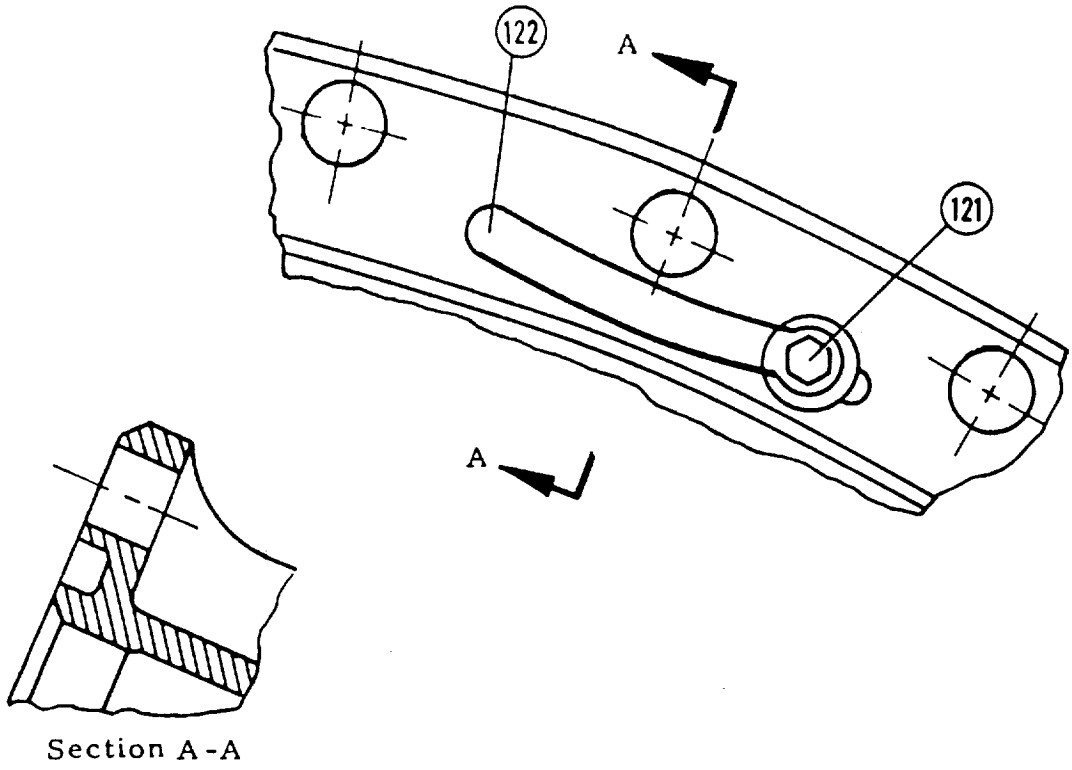


Figure 4-1m

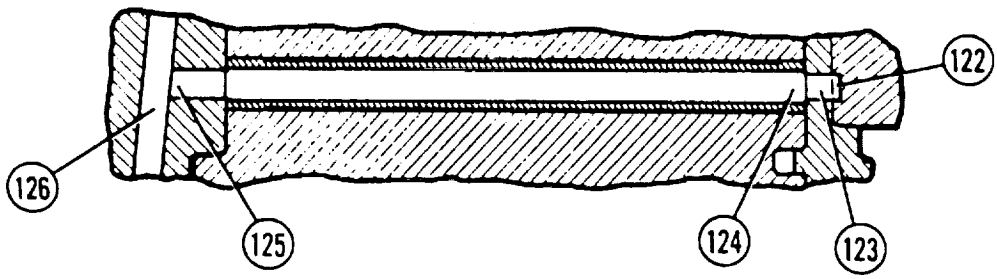


Figure 4-1n

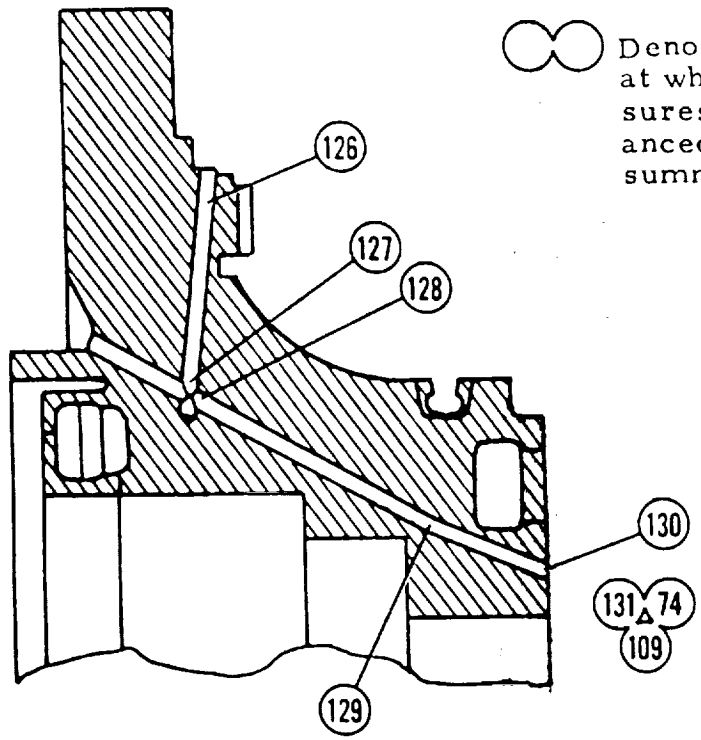


Figure 4-1o

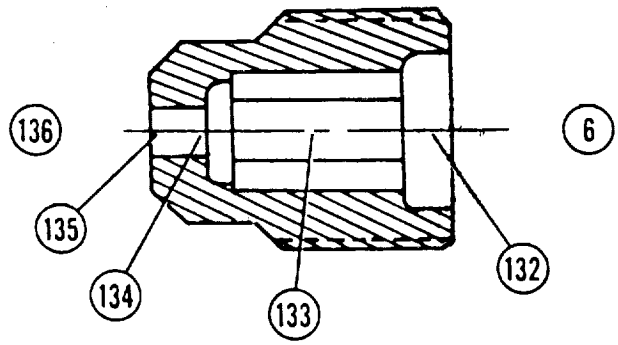


Figure 4-1p

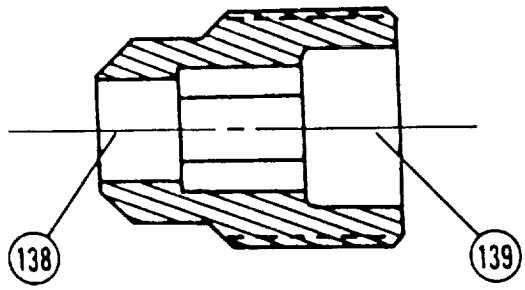


Figure 4-1q

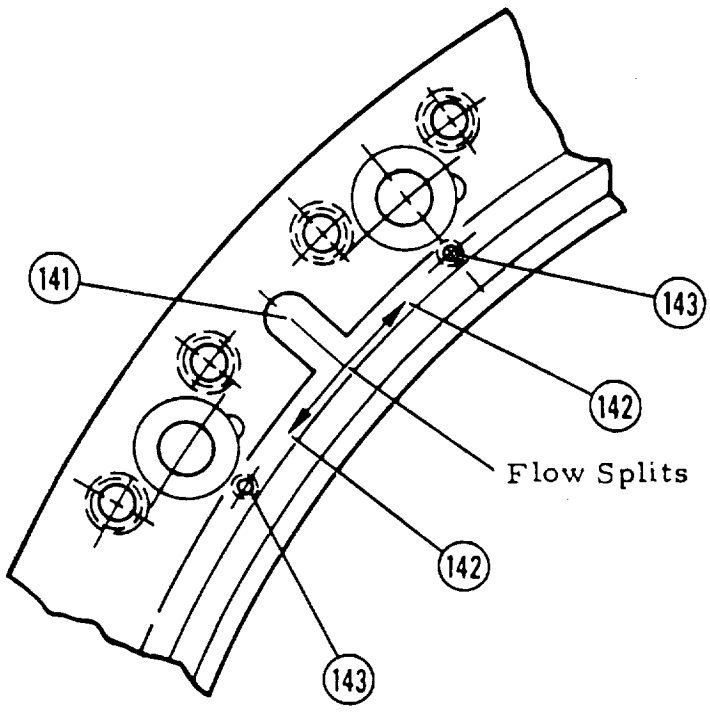


Figure 4-1r

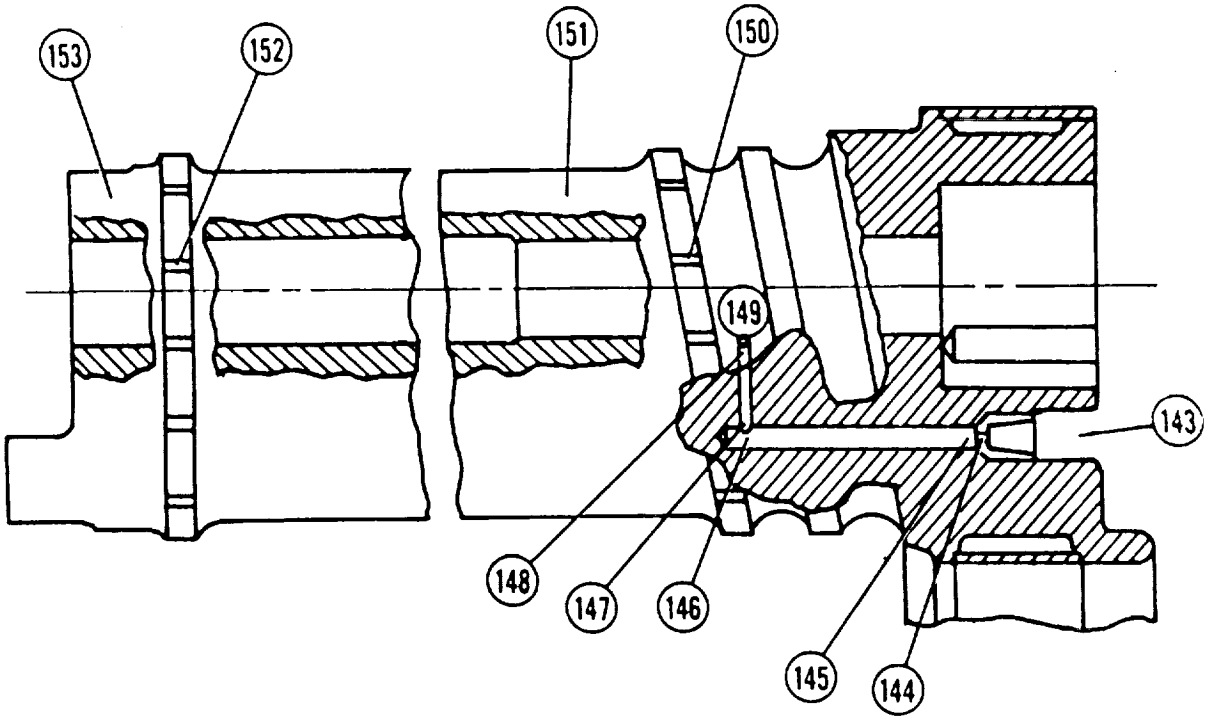


Figure 4-1s

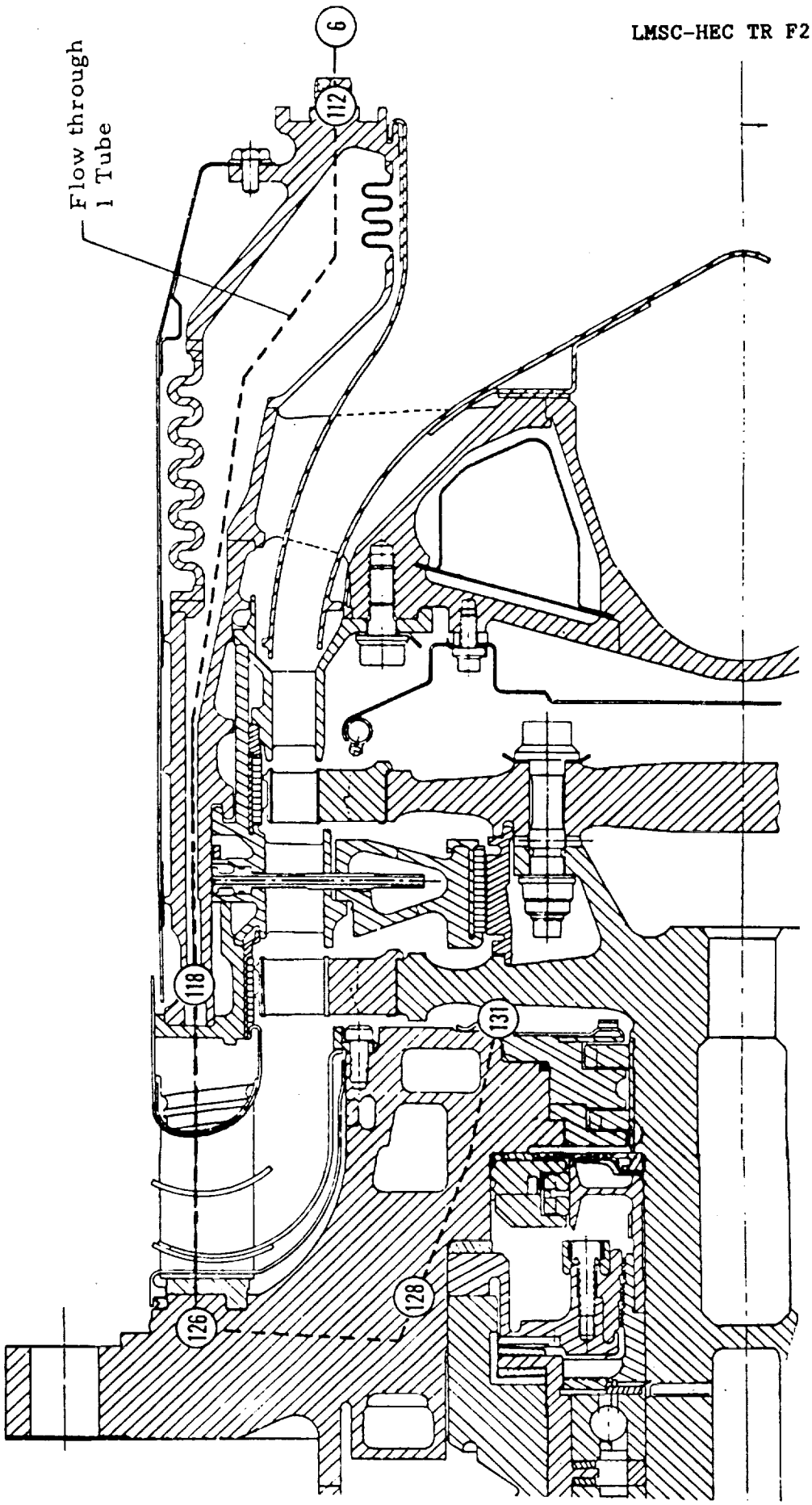


Figure 4-2a Flow Passage of Hydrogen from the Coolant Manifold at Station 6 to the Turbine Seal Region at Station 131

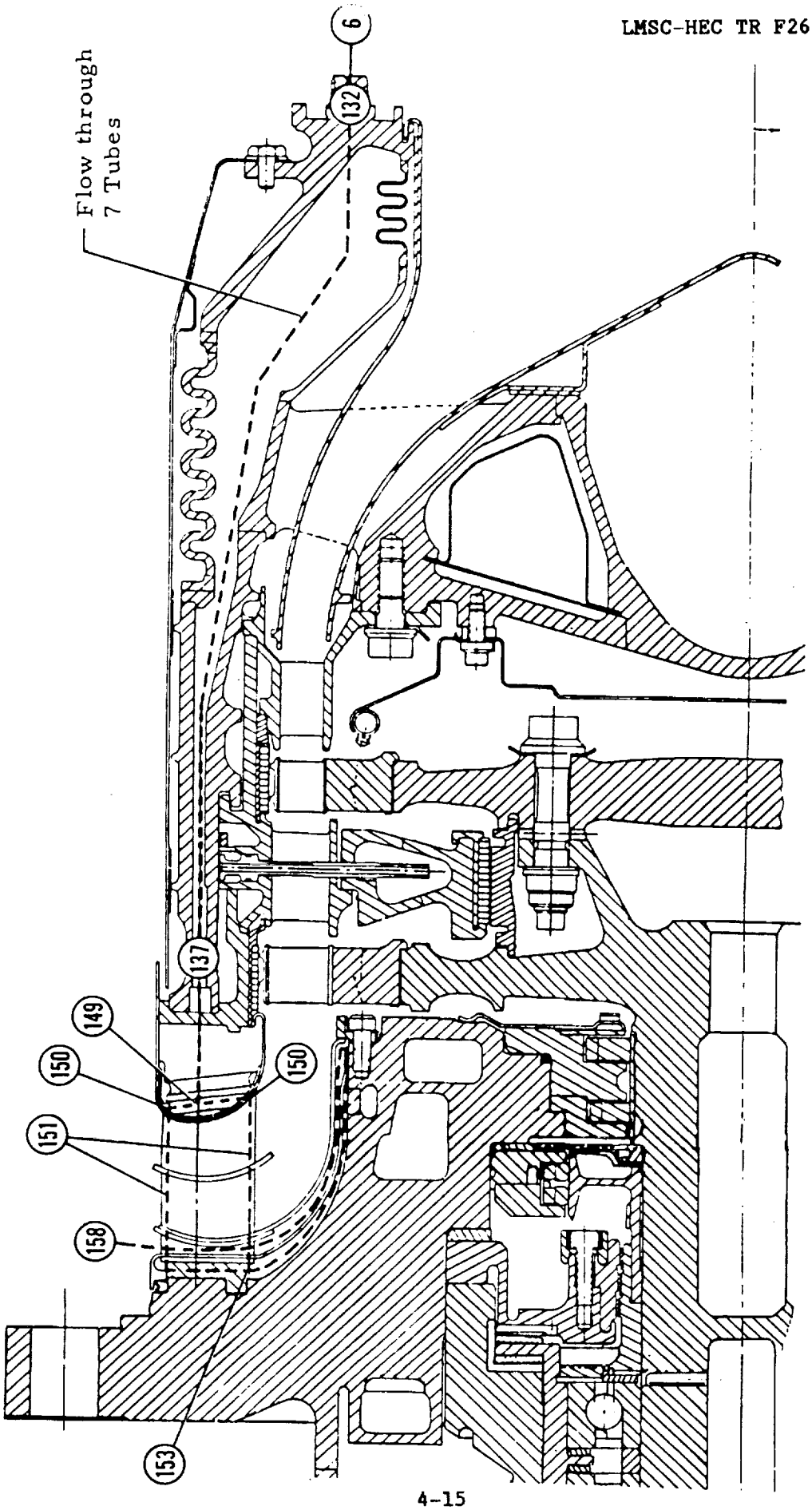


Figure 4-2b Flow Passage of Hydrogen from the Coolant Manifold at Station 6 to the Struts at Stations 149 through 153

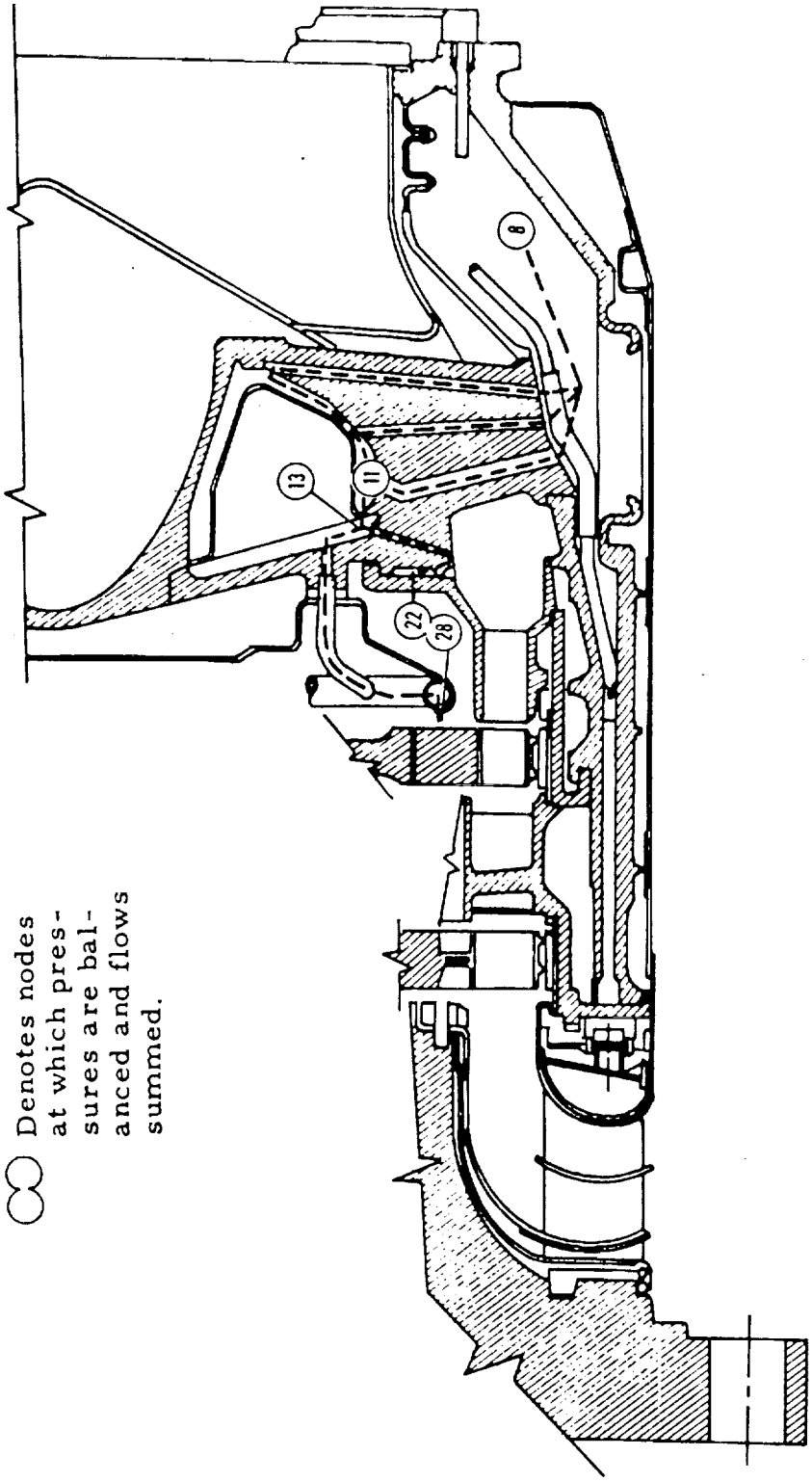


Figure 4-2c Flow Passage of Mixed Coolant from the Mixing Chamber at Station 8 to the First Stage Rotor at Stations 22 and 28

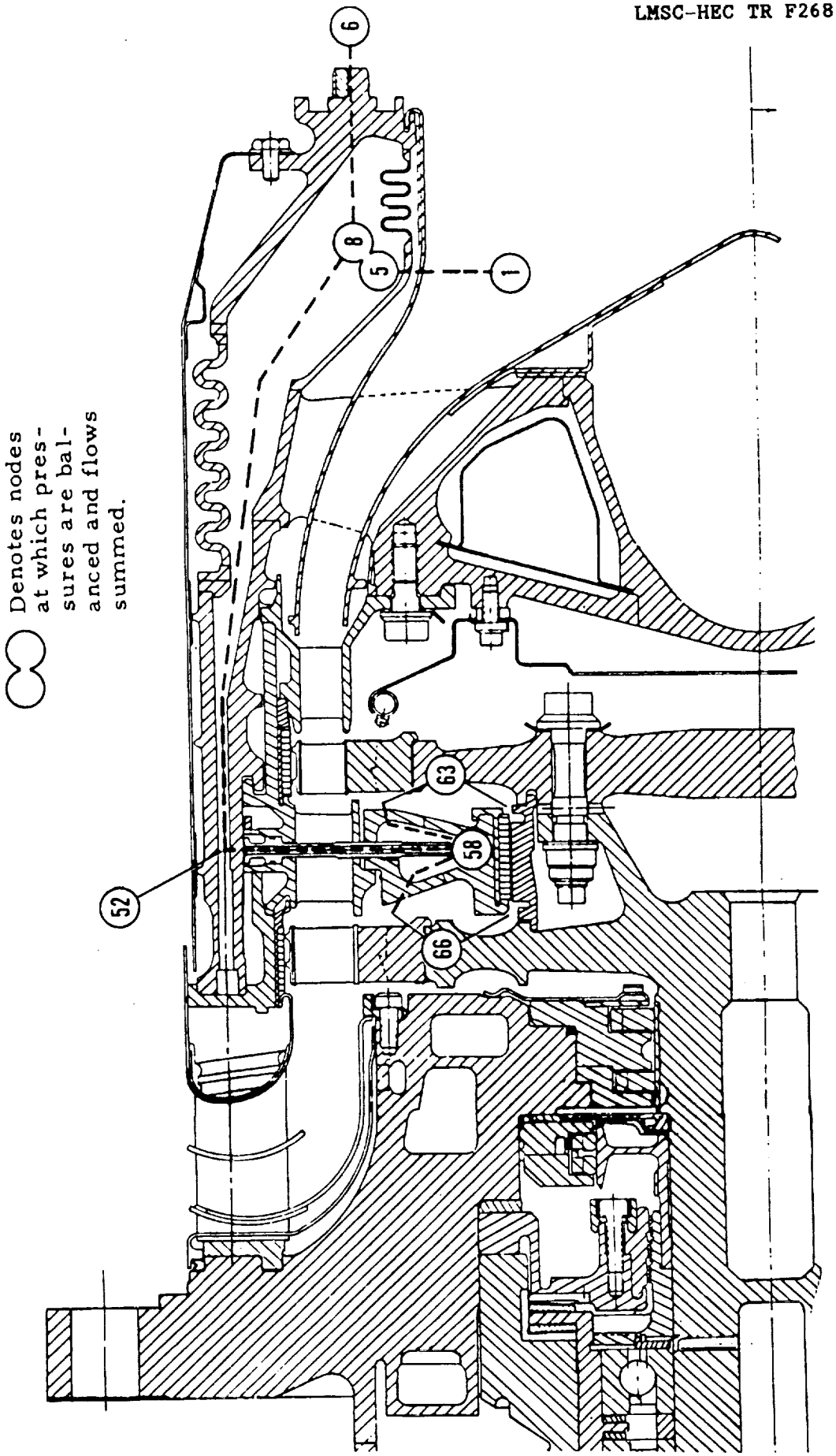


Figure 4-2d Flow Passage of Mixed Coolant from the Mixing Chamber at Station 8 to the Turbine Stator Region at Stations 63 and 66

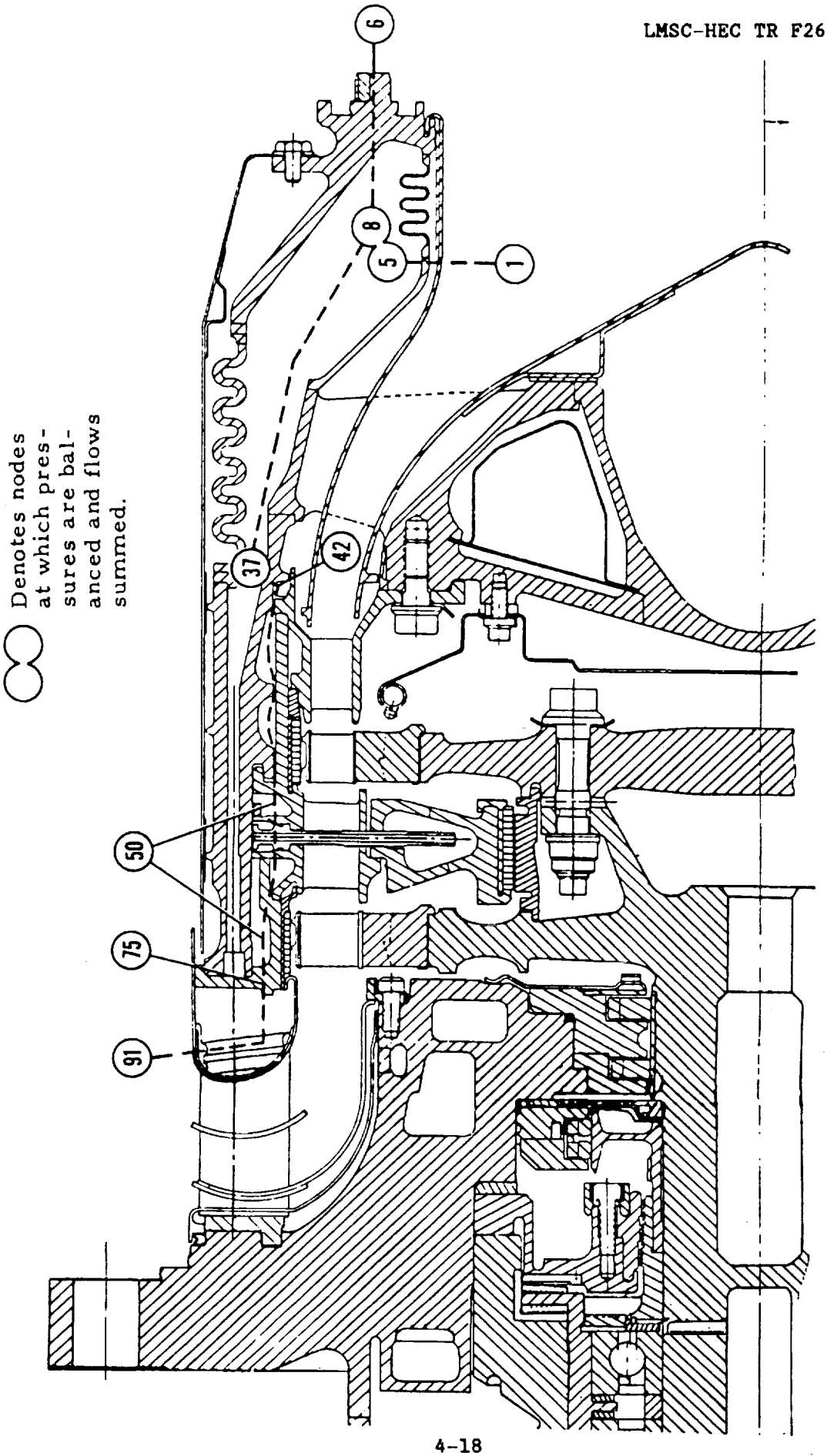


Figure 4-2e Flow Passage of Mixed Coolant from the Mixing Chamber at Station 8 to the Turbine Housing at Stations 42 through 50 and Exit Strut Region at Stations 75 through 90

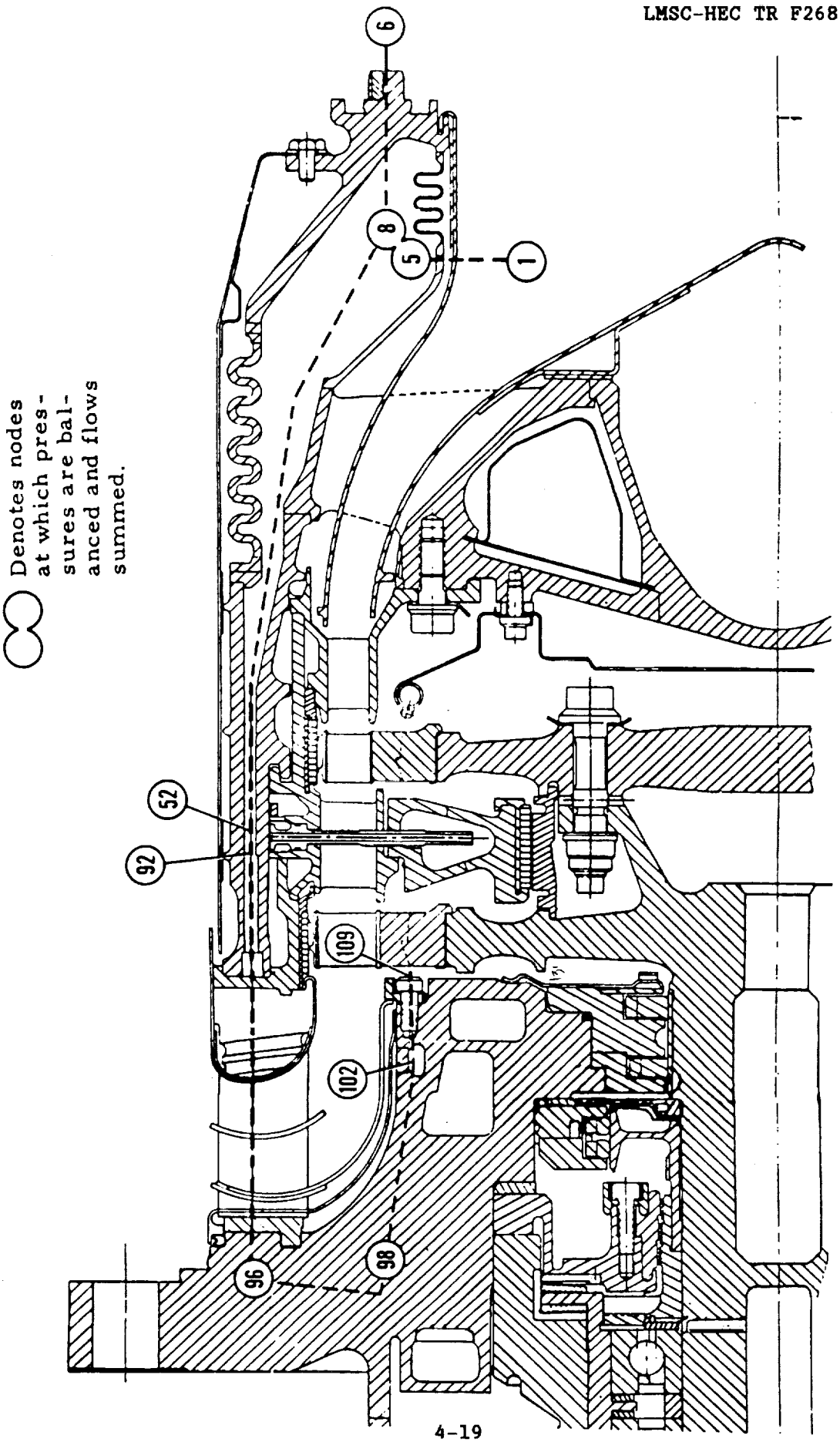


Figure 4-2f Flow Passage of Mixed Coolant from the Mixing Chamber at Station 8 to the Second Stage Rotor at Station 109

flows are computed. An input option is provided for terminating the execution at this point or continuing with another pass through each model if greater accuracy is desired.

An improved properties subroutine for computing thermodynamic and transport properties for a mixture of H_2 and H_2O has been added to the program. Refer to Section 2.4 for a detailed description of this calculation procedure.

4.3 RESULTS

The oxidizer turbine coolant system was analyzed at FPL, 104%, and MPL using Rocketdyne engine balance data obtained from Reference 8. The results of these analyses are presented in Tables 4-1 through 4-3.

4.4 PROGRAM INPUT GUIDE

This section describes the input data file required for execution of the HPOTP turbine coolant program.

Column	Parameter	Description
Line numbers 1 through 158, Format (I5, 5X, 6E10.4))		
1-5	IP	Flow type
11-20	A	Passage flow area, in^2
21-30	D	Passage hydraulic diameter, in.
31-40	XL	Passage effective length for frictional losses, in.
41-50	XR	Radial location, in.
51-60	XK	Flow loss coefficient
61-70	EFF	Ratio of fluid to shaft rotational speed.

Table 4-1 HPOTP TURBINE COOLANT ANALYSIS (FPL)

STA	TOTAL PRESS (PSIA)	STATIC PRESS (PSIA)	TOTAL ENTHALPY (BTU/LBM)	TEMPER-ATURE (R)	DENSITY (LBM/FT3)	FLUID QUAL	VELO-CITY (FPS)	TANG VEL (FPS)	SONIC VEL (FPS)	FLOW RATE (LBM/SEC)	MASS FRACTIONS H2	MASS FRACTIONS H2O	ZFAC
1	5599.2	5594.4	3200.8	1561.3	1.087	1.00	196.1	0.0	5448.2	1.609	0.526	0.474	1.0691
2	5580.8	5553.6	3200.8	1559.2	1.081	1.00	481.0	0.0	5444.8	1.609	0.526	0.474	1.0686
3	5553.5	5548.1	3200.8	1560.8	1.079	1.00	214.4	0.0	5448.0	1.609	0.526	0.474	1.0685
4	5536.1	5501.2	3200.8	1558.5	1.072	1.00	547.0	0.0	5444.3	1.609	0.526	0.474	1.0679
5	5500.8	5500.8	2361.2	903.7	1.375	1.00	1.0	0.0	4720.5	2.518	0.697	0.303	1.1376
6	5988.7	5987.1	873.6	279.0	2.751	1.00	73.3	0.0	4871.2	0.908	1.000	0.000	1.4658
7	5830.6	5505.4	873.6	275.7	2.636	1.00	1061.0	0.0	4707.2	0.908	1.000	0.000	1.4233
8	5501.6	5501.6	2361.2	903.6	1.375	1.00	1.0	0.0	4720.4	2.518	0.697	0.303	1.1376
9	5500.3	5497.6	2361.2	903.5	1.374	1.00	133.8	0.0	4720.1	0.800	0.697	0.303	1.1375
10	5499.6	5497.0	2361.2	903.5	1.374	1.00	133.9	0.0	4720.1	0.800	0.697	0.303	1.1375
11	5497.0	5497.0	2361.2	903.7	1.374	1.00	1.0	0.0	4720.5	0.800	0.697	0.303	1.1375
12	5496.2	5494.6	2361.2	903.6	1.374	1.00	103.9	0.0	4720.3	0.800	0.697	0.303	1.1374
13	5494.6	5494.6	2361.2	903.7	1.374	1.00	1.0	0.0	4720.5	0.800	0.697	0.303	1.1374
14	5409.2	5235.4	2361.2	900.2	1.321	1.00	1100.8	0.0	4712.6	0.117	0.697	0.303	1.1311
15	5384.0	5209.3	2361.2	899.8	1.316	1.00	1107.0	0.0	4708.4	0.117	0.697	0.303	1.1305
16	5207.1	5083.3	2361.2	900.3	1.287	1.00	941.4	0.0	4712.7	0.117	0.697	0.303	1.1270
17	5074.4	4947.7	2361.2	900.5	1.257	1.00	963.4	0.0	4713.3	0.117	0.697	0.303	1.1234
18	4919.2	4862.0	2361.2	904.1	1.233	1.00	652.6	0.0	4721.8	0.117	0.697	0.303	1.1206
19	4918.1	4860.3	2361.2	904.0	1.233	1.00	658.8	0.0	4721.7	0.117	0.697	0.303	1.1205
20	4769.7	4230.9	2361.2	889.4	1.105	1.00	2116.6	0.0	4681.1	0.117	0.697	0.303	1.1061
21	4741.9	4198.5	2361.2	888.9	1.098	1.00	2134.5	0.0	4679.9	0.117	0.697	0.303	1.1054
22	4191.5	4191.5	2362.8	912.4	1.072	1.00	1.0	0.0	4740.9	0.800	0.697	0.303	1.1018
23	5404.7	5221.8	2361.2	900.1	1.318	1.00	1130.7	0.0	4712.3	0.683	0.697	0.303	1.1308
24	5237.3	5049.4	2361.2	900.8	1.279	1.00	1162.0	0.0	4713.9	0.683	0.697	0.303	1.1261
25	5047.8	5045.1	2361.2	906.3	1.272	1.00	138.7	0.0	4726.9	0.683	0.697	0.303	1.1250
26	5047.6	5044.9	2361.2	906.3	1.271	1.00	139.5	0.0	4726.9	0.683	0.697	0.303	1.1250
27	4776.2	4199.0	2361.2	886.7	1.101	1.00	2197.3	0.0	4673.9	0.683	0.697	0.303	1.1057
28	4191.6	4191.6	2361.2	911.6	1.072	1.00	1.0	0.0	4740.0	0.800	0.697	0.303	1.1019
29	5583.9	4190.8	3201.0	1451.4	0.891	1.00	968.1	3376.0	5256.8	65.430	0.526	0.474	1.0511
30	0.0	0.0	0.0	0.0	0.000	0.00	0.0	0.0	0.0	0.000	1.000	0.000	0.0000
31	0.0	0.0	0.0	0.0	0.000	0.00	0.0	0.0	0.0	0.000	1.000	0.000	0.0000
32	4320.1	4187.8	2385.2	912.4	1.071	1.00	145.9	1059.5	4740.8	0.145	0.697	0.303	1.1017

Table 4-1 HPOTP TURBINE COOLANT ANALYSIS (FPL) (Continued)

STA	TOTAL PRESS (PSIA)	STATIC PRESS (PSIA)	TOTAL ENTHALPY (BTU/LBM)	TEMPER-ATURE (R)	DENSITY (LBM/FT3)	FLUID QUAL	VELO-CITY (FPS)	TANG VEL (FPS)	SONIC VEL (FPS)	FLOW RATE (LBM/SEC)	MASS FRACTIONS H2	MASS FRACTIONS H2O	ZFAC
33	4315.1	4182.9	2385.2	912.4	1.070	1.00	146.0	1059.5	4740.9	0.145	0.697	0.303	1.1016
34	4310.0	4177.9	2385.2	912.4	1.069	1.00	146.1	1059.5	4741.0	0.145	0.697	0.303	1.1014
35	4304.9	4173.0	2385.2	912.5	1.067	1.00	146.3	1059.5	4741.0	0.145	0.697	0.303	1.1013
36	4173.0	4173.0	2764.9	1261.9	0.930	1.00	1.0	0.0	5018.7	1.848	0.592	0.408	1.0474
37	5501.6	5501.6	2361.2	903.7	1.375	1.00	2.0	0.0	4720.4	0.159	0.697	0.303	1.1376
38	5501.4	5500.9	2361.2	903.6	1.375	1.00	56.4	0.0	4720.3	0.159	0.697	0.303	1.1376
39	5501.4	5500.9	2361.2	903.6	1.375	1.00	56.4	0.0	4720.3	0.159	0.697	0.303	1.1376
40	5501.4	5500.9	2361.2	903.6	1.375	1.00	56.4	0.0	4720.3	0.159	0.697	0.303	1.1376
41	5501.4	5500.9	2361.2	903.6	1.375	1.00	56.4	0.0	4720.3	0.159	0.697	0.303	1.1376
42	5500.9	5500.9	2361.2	903.7	1.375	1.00	2.2	0.0	4720.4	0.159	0.697	0.303	1.1376
43	5500.9	5500.9	2361.2	903.7	1.375	1.00	11.7	0.0	4720.4	0.159	0.697	0.303	1.1376
44	5500.9	5500.9	2361.2	903.7	1.375	1.00	1.4	0.0	4720.4	0.159	0.697	0.303	1.1376
45	5500.8	5500.8	2361.2	903.7	1.375	1.00	11.9	0.0	4720.4	0.159	0.697	0.303	1.1376
46	5500.8	5500.8	2361.2	903.7	1.375	1.00	2.2	0.0	4720.4	0.159	0.697	0.303	1.1376
47	5500.8	5500.8	2361.2	903.7	1.375	1.00	15.4	0.0	4720.4	0.159	0.697	0.303	1.1376
48	5500.8	5500.8	2361.2	903.7	1.375	1.00	2.7	0.0	4720.4	0.159	0.697	0.303	1.1376
49	5500.8	5500.7	2361.2	903.7	1.375	1.00	14.0	0.0	4720.4	0.159	0.697	0.303	1.1376
50	5500.7	5500.7	2361.2	903.7	1.375	1.00	1.0	0.0	4720.4	0.159	0.697	0.303	1.1376
51	5501.6	5501.6	2361.2	903.7	1.375	1.00	17.8	0.0	4720.4	1.391	0.697	0.303	1.1376
52	5501.6	5501.5	2361.2	903.6	1.375	1.00	30.6	0.0	4720.4	1.391	0.697	0.303	1.1376
53	5493.3	5477.0	2361.2	902.9	1.371	1.00	331.5	0.0	4718.6	1.050	0.697	0.303	1.1371
54	0.0	0.0	0.0	0.0	0.000	0.00	0.0	0.0	0.0	0.000	1.000	0.000	0.0000
55	0.0	0.0	0.0	0.0	0.000	0.00	0.0	0.0	0.0	0.000	1.000	0.000	0.0000
56	5492.4	5467.2	2361.2	902.5	1.369	1.00	413.1	0.0	4717.6	1.050	0.697	0.303	1.1369
57	5483.4	5458.1	2361.2	902.5	1.367	1.00	413.6	0.0	4717.7	1.050	0.697	0.303	1.1367
58	5458.1	5458.1	2361.2	903.9	1.365	1.00	1.0	0.0	4721.1	1.050	0.697	0.303	1.1364
59	5443.7	5414.9	2361.2	902.6	1.358	1.00	442.2	0.0	4717.9	0.553	0.697	0.303	1.1355
60	5443.2	5414.2	2361.2	902.6	1.358	1.00	444.7	0.0	4717.9	0.553	0.697	0.303	1.1355
61	5144.4	4330.0	2361.2	872.3	1.148	1.00	2553.7	0.0	4635.7	0.553	0.697	0.303	1.1113
62	5023.0	4185.5	2361.2	870.2	1.116	1.00	2626.2	0.0	4630.2	0.553	0.697	0.303	1.1077
63	4171.6	4171.6	2764.3	1261.5	0.930	1.00	1.0	0.0	5017.5	1.848	0.592	0.408	1.0473
64	4966.1	3843.8	2361.2	849.5	1.056	1.00	3123.9	0.0	4576.2	0.497	0.697	0.303	1.1013
65	4853.9	3696.5	2361.2	845.1	1.024	1.00	3221.5	0.0	4564.9	0.497	0.697	0.303	1.0978
66	3675.1	3675.1	2687.1	1204.0	0.844	1.00	1.0	0.0	4830.8	2.345	0.612	0.388	1.0367

Table 4-1 HPOTP TURBINE COOLANT ANALYSIS (FPL) (Continued)

STA	TOTAL PRESS (PSIA)	STATIC PRESS (PSIA)	TOTAL ENTHALPY (BTU/LBM)	TEMPER-ATURE (R)	DENSITY (LBM/FT3)	FLUID QUAL	VELO-CITY (FPS)	TANG VEL (FPS)	SONIC VEL (FPS)	FLOW RATE (LBM/SEC)	MASS FRACTIONS H2	MASS FRACTIONS H2O	ZFAC
67	4075.1	3959.5	2764.3	1251.5	0.893	1.00	1092.3	0.0	5000.6	1.845	0.592	0.408	1.0445
68	3946.1	3671.1	2764.3	1235.3	0.842	1.00	1732.7	0.0	4968.9	1.845	0.592	0.408	1.0404
69	3666.4	3666.4	2678.7	1200.9	0.842	1.00	1.0	0.0	4806.7	2.342	0.614	0.386	1.0360
70	3760.7	3643.3	2701.2	1199.4	0.838	1.00	411.7	1059.5	4799.5	0.301	0.614	0.386	1.0356
71	3732.3	3615.3	2701.2	1198.7	0.832	1.00	413.6	1059.5	4806.1	0.301	0.614	0.386	1.0355
72	3703.4	3587.0	2701.2	1198.0	0.826	1.00	416.5	1059.5	4812.8	0.301	0.614	0.386	1.0354
73	3674.3	3558.5	2701.2	1197.3	0.820	1.00	419.5	1059.5	4819.6	0.301	0.614	0.386	1.0353
74	3558.3	3558.3	2521.6	1039.4	0.867	1.00	1.0	0.0	4854.6	0.642	0.658	0.342	1.0654
75	5493.1	5477.8	2361.2	903.0	1.371	1.00	320.8	0.0	4718.8	0.159	0.697	0.303	1.1371
76	5477.8	5477.7	2361.2	903.8	1.370	1.00	18.2	0.0	4720.8	0.159	0.697	0.303	1.1370
77	4967.8	3797.9	2361.2	845.6	1.049	1.00	3199.7	0.0	4566.0	0.080	0.697	0.303	1.1005
78	4911.4	3722.1	2361.2	843.5	1.032	1.00	3252.9	0.0	4560.7	0.080	0.697	0.303	1.0987
79	3663.8	3656.7	2361.2	913.5	0.945	1.00	261.9	0.0	4745.0	0.080	0.697	0.303	1.0880
80	3645.7	3609.6	2361.2	911.5	0.936	1.00	594.9	0.0	4740.6	0.080	0.697	0.303	1.0870
81	3642.8	3606.3	2361.2	911.5	0.935	1.00	600.8	0.0	4740.6	0.080	0.697	0.303	1.0870
82	3606.3	3606.3	2361.2	914.5	0.933	1.00	1.0	0.0	4747.4	0.080	0.697	0.303	1.0866
83	4997.1	3905.3	2361.2	852.1	1.068	1.00	3064.3	0.0	4582.9	0.078	0.697	0.303	1.1026
84	4857.0	3720.4	2361.2	846.7	1.028	1.00	3190.0	0.0	4569.0	0.078	0.697	0.303	1.0983
85	3670.4	3663.7	2361.2	913.5	0.947	1.00	254.9	0.0	4745.1	0.078	0.697	0.303	1.0882
86	3656.5	3649.8	2361.2	913.7	0.944	1.00	256.9	0.0	4745.6	0.078	0.697	0.303	1.0878
87	3639.4	3605.0	2361.2	911.7	0.935	1.00	580.9	0.0	4741.1	0.078	0.697	0.303	1.0869
88	3636.9	3602.2	2361.2	911.7	0.934	1.00	586.3	0.0	4741.0	0.078	0.697	0.303	1.0868
89	3602.2	3602.2	2361.2	914.5	0.932	1.00	1.0	0.0	4747.5	0.078	0.697	0.303	1.0865
90	3601.8	3600.9	2361.2	914.5	0.931	1.00	91.0	0.0	4747.4	0.159	0.697	0.303	1.0864
91	3600.9	3600.9	2361.2	914.5	0.931	1.00	1.0	0.0	4747.5	0.159	0.697	0.303	1.0864
92	5485.5	5453.4	2361.2	902.2	1.367	1.00	465.4	0.0	4716.9	0.341	0.697	0.303	1.1366
93	5482.6	5450.3	2361.2	902.2	1.366	1.00	468.3	0.0	4716.9	0.341	0.697	0.303	1.1365
94	5482.2	5456.8	2361.2	902.5	1.367	1.00	415.1	0.0	4717.7	0.341	0.697	0.303	1.1366
95	5475.5	5450.1	2361.2	902.5	1.365	1.00	414.8	0.0	4717.8	0.341	0.697	0.303	1.1364
96	5437.4	5412.0	2361.2	902.8	1.357	1.00	415.3	0.0	4718.4	0.341	0.697	0.303	1.1354
97	5434.9	5409.3	2361.2	902.8	1.356	1.00	417.9	0.0	4718.4	0.341	0.697	0.303	1.1353
98	5396.5	5370.9	2361.2	903.0	1.348	1.00	418.1	0.0	4719.0	0.341	0.697	0.303	1.1342
99	5392.8	5367.0	2361.2	903.0	1.347	1.00	420.8	0.0	4719.0	0.341	0.697	0.303	1.1341

Table 4-1 HPOTP TURBINE COOLANT ANALYSIS (FPL) (Continued)

STA	TOTAL PRESS (PSIA)	STATIC PRESS (PSIA)	TOTAL ENTHALPY (BTU/LBM)	TEMPER-ATURE (R)	DENSITY (LBM/FT3)	FLUID QUAL	VELO-CITY (FPS)	TANG VEL (FPS)	SONIC VEL (FPS)	FLOW RATE (LBM/SEC)	MASS FRACTIONS H2	MASS FRACTIONS H2O	ZFAC
100	5378.3	5298.2	2361.2	900.3	1.335	1.00	742.5	0.0	4712.7	0.341	0.697	0.303	1.1328
101	5376.1	5295.3	2361.2	900.3	1.334	1.00	749.0	0.0	4712.7	0.341	0.697	0.303	1.1327
102	5295.3	5295.3	2361.2	904.9	1.328	1.00	1.0	0.0	4723.5	0.341	0.697	0.303	1.1319
103	5289.6	5278.2	2361.2	904.4	1.325	1.00	281.6	0.0	4722.3	0.341	0.697	0.303	1.1315
104	5288.8	5277.5	2361.2	904.4	1.325	1.00	282.3	0.0	4722.3	0.341	0.697	0.303	1.1315
105	5287.8	5282.3	2361.2	904.7	1.326	1.00	196.1	0.0	4723.0	0.341	0.697	0.303	1.1316
106	5287.4	5281.9	2361.2	904.7	1.326	1.00	196.0	0.0	4723.0	0.341	0.697	0.303	1.1316
107	4839.1	3642.7	2361.2	841.8	1.014	1.00	3290.8	0.0	4556.3	0.341	0.697	0.303	1.0968
108	4798.5	3590.4	2361.2	838.9	1.004	1.00	3322.8	0.0	4548.8	0.341	0.697	0.303	1.0957
109	3566.2	3566.2	2520.6	1038.5	0.869	1.00	1.0	0.0	4854.1	0.642	0.658	0.342	1.0657
110	3566.1	3566.1	2520.6	1038.5	0.869	1.00	27.1	0.0	4854.1	0.598	0.658	0.342	1.0657
111	3566.1	3566.1	2520.6	1038.5	0.869	1.00	4.7	0.0	4854.1	0.598	0.658	0.342	1.0657
112	0.0	0.0	0.0	0.0	0.000	0.00	0.0	0.0	0.0	0.000	1.000	0.000	0.0000
113	0.0	0.0	0.0	0.0	0.000	0.00	0.0	0.0	0.0	0.000	1.000	0.000	0.0000
114	0.0	0.0	0.0	0.0	0.000	0.00	0.0	0.0	0.0	0.000	1.000	0.000	0.0000
115	0.0	0.0	0.0	0.0	0.000	0.00	0.0	0.0	0.0	0.000	1.000	0.000	0.0000
116	0.0	0.0	0.0	0.0	0.000	0.00	0.0	0.0	0.0	0.000	1.000	0.000	0.0000
117	0.0	0.0	0.0	0.0	0.000	0.00	0.0	0.0	0.0	0.000	1.000	0.000	0.0000
118	0.0	0.0	0.0	0.0	0.000	0.00	0.0	0.0	0.0	0.000	1.000	0.000	0.0000
119	0.0	0.0	0.0	0.0	0.000	0.00	0.0	0.0	0.0	0.000	1.000	0.000	0.0000
120	5349.6	5035.6	2361.2	898.9	1.278	1.00	1501.0	0.0	4705.9	0.165	0.697	0.303	1.1260
121	5283.6	5192.8	2361.2	900.1	1.312	1.00	803.7	0.0	4712.2	0.165	0.697	0.303	1.1300
122	4957.4	3731.4	2361.2	841.4	1.037	1.00	3296.4	0.0	4555.0	0.165	0.697	0.303	1.0993
123	4957.4	3721.0	2361.2	839.3	1.036	1.00	3324.3	0.0	4549.7	0.165	0.697	0.303	1.0992
124	4400.0	4280.4	2361.2	901.8	1.103	1.00	1007.1	0.0	4717.2	0.165	0.697	0.303	1.1056
125	4375.8	4257.2	2361.2	903.0	1.097	1.00	998.0	0.0	4719.9	0.165	0.697	0.303	1.1049
126	4255.4	4133.7	2361.2	903.3	1.067	1.00	1024.0	0.0	4720.7	0.165	0.697	0.303	1.1016
127	4241.8	4119.3	2361.2	903.3	1.064	1.00	1031.3	0.0	4720.7	0.165	0.697	0.303	1.1012
128	4117.6	3992.1	2361.2	903.6	1.034	1.00	1056.6	0.0	4721.6	0.165	0.697	0.303	1.0979
129	4097.2	3970.7	2361.2	903.5	1.029	1.00	1064.6	0.0	4721.5	0.165	0.697	0.303	1.0974
130	3979.4	3549.8	2361.2	895.7	0.936	1.00	2054.3	0.0	4699.0	0.165	0.697	0.303	1.0875
131	3543.3	3543.3	2361.2	914.9	0.917	1.00	1.0	0.0	4748.5	0.165	0.697	0.303	1.0849
132	5987.3	5984.4	873.6	279.0	2.750	1.00	97.8	0.0	4870.3	0.297	1.000	0.000	1.4656

Table 4-1 HPOTP TURBINE COOLANT ANALYSIS (FPL) (Concluded)

STA	TOTAL PRESS (PSIA)	STATIC PRESS (PSIA)	TOTAL ENTHALPY (BTU/LBM)	TEMPER-ATURE (R)	DENSITY (LBM/FT3)	FLUID QUAL	VELO-CITY (FPS)	TANG VEL (FPS)	SONIC VEL (FPS)	FLOW RATE (LBM/SEC)	MASS FRACTIONS H2	MASS FRACTIONS H2O	ZFAC
133	5979.5	5954.5	873.6	278.7	2.744	1.00	290.3	0.0	4860.3	0.297	1.000	0.000	1.4630
134	5801.9	5256.1	873.6	273.1	2.579	1.00	1382.1	0.0	4618.3	0.297	1.000	0.000	1.4023
135	5795.2	5242.1	873.6	273.0	2.575	1.00	1394.7	0.0	4613.3	0.297	1.000	0.000	1.4010
136	5490.3	5456.2	873.6	280.7	2.586	1.00	349.2	0.0	4699.3	0.297	1.000	0.000	1.4121
137	5441.0	5407.3	873.6	280.9	2.570	1.00	347.8	0.0	4683.3	0.297	1.000	0.000	1.4072
138	5441.0	5408.1	873.6	281.0	2.570	1.00	344.4	0.0	4683.6	0.297	1.000	0.000	1.4072
139	5440.2	5407.2	873.6	281.0	2.570	1.00	344.4	0.0	4683.3	0.297	1.000	0.000	1.4071
140	5420.6	5418.9	873.6	281.4	2.570	1.00	78.8	0.0	4688.1	0.297	1.000	0.000	1.4076
141	5418.9	5418.8	873.6	281.5	2.570	1.00	12.7	0.0	4688.1	0.297	1.000	0.000	1.4076
142	5418.8	5416.7	873.6	281.4	2.569	1.00	87.4	0.0	4687.4	0.297	1.000	0.000	1.4074
143	5418.2	5416.0	873.6	281.4	2.569	1.00	87.4	0.0	4687.2	0.297	1.000	0.000	1.4074
144	4788.7	3168.4	873.6	256.0	1.919	1.00	2646.2	0.0	3826.1	0.297	1.000	0.000	1.2119
145	3659.2	3636.6	873.6	287.7	1.920	1.00	330.1	0.0	4089.6	0.297	1.000	0.000	1.2373
146	3656.4	3633.8	873.6	287.7	1.918	1.00	330.1	0.0	4088.7	0.297	1.000	0.000	1.2370
147	3633.8	3616.0	873.6	287.9	1.910	1.00	293.7	0.0	4083.0	0.297	1.000	0.000	1.2354
148	3631.8	3613.9	873.6	287.9	1.910	1.00	294.9	0.0	4082.3	0.297	1.000	0.000	1.2352
149	3613.9	3613.9	873.6	288.3	1.907	1.00	1.0	0.0	4083.7	0.297	1.000	0.000	1.2350
150	3611.8	3607.7	873.6	288.2	1.905	1.00	141.9	0.0	4081.3	0.297	1.000	0.000	1.2345
151	3607.7	3607.7	873.6	288.3	1.905	1.00	1.0	0.0	4081.6	0.297	1.000	0.000	1.2344
152	3605.6	3601.4	873.6	288.2	1.903	1.00	142.1	0.0	4079.2	0.297	1.000	0.000	1.2339
153	3601.4	3601.4	873.6	288.3	1.902	1.00	1.0	0.0	4079.5	0.297	1.000	0.000	1.2339
154	3601.4	3601.4	873.6	288.3	1.902	1.00	14.5	0.0	4079.4	0.297	1.000	0.000	1.2338
155	3601.4	3601.1	873.6	288.3	1.902	1.00	39.9	0.0	4079.3	0.297	1.000	0.000	1.2338
156	3601.4	3601.0	873.6	288.3	1.902	1.00	39.9	0.0	4079.3	0.297	1.000	0.000	1.2338
157	3601.0	3601.0	873.6	288.3	1.902	1.00	13.4	0.0	4079.3	0.297	1.000	0.000	1.2338
158	3601.0	3601.0	873.6	288.3	1.902	1.00	1.0	0.0	4079.3	0.297	1.000	0.000	1.2338
159	4308.9	4172.5	3006.3	1458.7	0.880	1.00	1050.6	495.5	5279.5	66.084	0.528	0.472	1.0512
160	4271.9	3670.4	3006.2	1414.0	0.804	1.00	957.7	2312.2	5199.7	64.935	0.528	0.472	1.0446
161	3626.5	3562.6	2878.5	1401.1	0.785	1.00	837.0	132.9	5186.7	66.976	0.530	0.470	1.0433
162	3566.2	3566.2	2396.0	740.2	0.871	1.00	1.0	0.0	4855.0	0.211	0.925	0.075	1.1132

Table 4-2 HPOTP TURBINE COOLANT ANALYSIS (104%)

STA	TOTAL PRESS (PSIA)	STATIC PRESS (PSIA)	TOTAL ENTHALPY (BTU/LBM)	TEMPER-ATURE (R)	DENSITY (LBM/FT3)	FLUID QUAL	VELO-CITY (FPS)	TANG VEL (FPS)	SONIC VEL (FPS)	FLOW RATE (LBM/SEC)	MASS FRACTIONS H2	MASS FRACTIONS H2O	ZFAC
1	5253.0	5248.6	3124.9	1501.4	1.044	1.00	192.8	0.0	5391.6	1.394	0.539	0.461	1.0655
2	5238.0	5216.8	3124.9	1499.5	1.039	1.00	433.9	0.0	5388.4	1.394	0.539	0.461	1.0651
3	5216.7	5212.5	3124.9	1501.1	1.037	1.00	193.2	0.0	5391.7	1.394	0.539	0.461	1.0651
4	5203.1	5175.9	3124.9	1498.8	1.032	1.00	492.8	0.0	5387.9	1.394	0.539	0.461	1.0646
5	5175.6	5175.6	2260.8	859.8	1.331	1.00	1.0	0.0	4653.4	2.255	0.715	0.285	1.1374
6	5626.8	5625.1	861.5	277.7	2.657	1.00	75.9	0.0	4750.4	0.861	1.000	0.000	1.4325
7	5479.9	5177.5	861.5	274.4	2.545	1.00	1041.1	0.0	4593.8	0.861	1.000	0.000	1.3929
8	5173.9	5173.9	2260.8	859.9	1.331	1.00	1.0	0.0	4653.6	2.255	0.715	0.285	1.1373
9	5172.7	5170.2	2260.8	860.5	1.329	1.00	131.5	0.0	4655.4	0.761	0.715	0.285	1.1371
10	5172.1	5169.6	2260.8	860.5	1.329	1.00	131.7	0.0	4655.4	0.761	0.715	0.285	1.1371
11	5169.6	5169.6	2260.8	860.7	1.329	1.00	1.0	0.0	4655.8	0.761	0.715	0.285	1.1371
12	5168.8	5167.3	2260.8	860.6	1.328	1.00	102.2	0.0	4655.6	0.761	0.715	0.285	1.1370
13	5167.3	5167.3	2260.8	860.7	1.328	1.00	1.0	0.0	4655.8	0.761	0.715	0.285	1.1370
14	5087.8	4926.7	2260.8	852.7	1.284	1.00	1073.7	0.0	4634.7	0.111	0.715	0.285	1.1316
15	5064.3	4901.8	2260.8	853.1	1.278	1.00	1082.8	0.0	4635.7	0.111	0.715	0.285	1.1309
16	4899.6	4784.1	2260.8	856.3	1.247	1.00	923.4	0.0	4644.5	0.111	0.715	0.285	1.1270
17	4775.4	4657.1	2260.8	858.8	1.217	1.00	946.1	0.0	4645.7	0.111	0.715	0.285	1.1234
18	4630.5	4577.0	2260.8	860.9	1.193	1.00	641.0	0.0	4656.9	0.111	0.715	0.285	1.1206
19	4629.5	4575.5	2260.8	860.9	1.193	1.00	647.4	0.0	4656.8	0.111	0.715	0.285	1.1205
20	4491.8	3995.9	2260.8	834.5	1.087	1.00	2048.8	0.0	4587.2	0.111	0.715	0.285	1.1082
21	4466.2	3966.6	2260.8	834.3	1.080	1.00	2063.8	0.0	4586.6	0.111	0.715	0.285	1.1074
22	3960.3	3960.3	2262.5	868.5	1.041	1.00	1.0	0.0	4676.8	0.761	0.715	0.285	1.1027
23	5083.7	4914.1	2260.8	852.3	1.282	1.00	1102.1	0.0	4633.7	0.649	0.715	0.285	1.1313
24	4927.6	4752.7	2260.8	852.6	1.244	1.00	1137.0	0.0	4634.7	0.649	0.715	0.285	1.1267
25	4750.9	4748.4	2260.8	863.0	1.230	1.00	136.4	0.0	4662.3	0.649	0.715	0.285	1.1250
26	4750.7	4748.2	2260.8	863.0	1.230	1.00	137.2	0.0	4662.3	0.649	0.715	0.285	1.1250
27	4498.8	3967.5	2260.8	832.2	1.083	1.00	2126.6	0.0	4581.1	0.649	0.715	0.285	1.1077
28	3961.6	3961.6	2260.8	867.6	1.041	1.00	1.0	0.0	4675.6	0.761	0.715	0.285	1.1028
29	5240.3	3960.7	3125.0	1397.5	0.860	1.00	946.7	3301.6	5202.9	61.760	0.539	0.461	1.0482
30	0.0	0.0	0.0	0.0	0.000	0.00	0.0	0.0	0.0	0.000	1.000	0.000	0.0000
31	0.0	0.0	0.0	0.0	0.000	0.00	0.0	0.0	0.0	0.000	1.000	0.000	0.0000
32	4075.6	3957.2	2283.2	868.4	1.040	1.00	136.1	1018.0	4676.8	0.132	0.715	0.285	1.1026

Table 4-2 HPOTP TURBINE COOLANT ANALYSIS (104%) (Continued)

STA	TOTAL PRESS (PSIA)	STATIC PRESS (PSIA)	TOTAL ENTHALPY (BTU/LBM)	TEMPER-ATURE (R)	DENSITY (LBM/FT3)	FLUID QUAL	VELO-CITY (FPS)	TANG VEL (FPS)	SONIC VEL (FPS)	FLOW RATE (LBM/SEC)	MASS FRACTIONS H2	MASS FRACTIONS H2O	ZFAC
33	4071.4	3953.0	2283.2	868.5	1.039	1.00	136.2	1018.0	4676.8	0.132	0.715	0.285	1.1025
34	4067.0	3948.7	2283.2	868.5	1.038	1.00	136.4	1018.0	4676.9	0.132	0.715	0.285	1.1023
35	4062.7	3944.5	2283.2	868.5	1.037	1.00	136.5	1018.0	4677.0	0.132	0.715	0.285	1.1022
36	3944.5	3944.5	2704.8	1226.3	0.898	1.00	1.0	0.0	4896.8	1.726	0.601	0.399	1.0412
37	5173.9	5173.9	2260.8	860.7	1.330	1.00	1.9	0.0	4655.7	0.142	0.715	0.285	1.1372
38	5173.7	5173.3	2260.8	860.6	1.330	1.00	52.1	0.0	4655.7	0.142	0.715	0.285	1.1372
39	5173.7	5173.3	2260.8	860.6	1.330	1.00	52.1	0.0	4655.6	0.142	0.715	0.285	1.1372
40	5173.7	5173.3	2260.8	860.6	1.330	1.00	52.1	0.0	4655.7	0.142	0.715	0.285	1.1372
41	5173.7	5173.3	2260.8	860.6	1.330	1.00	52.1	0.0	4655.6	0.142	0.715	0.285	1.1372
42	5173.3	5173.3	2260.8	860.7	1.330	1.00	2.1	0.0	4655.7	0.142	0.715	0.285	1.1372
43	5173.3	5173.3	2260.8	860.7	1.330	1.00	10.8	0.0	4655.7	0.142	0.715	0.285	1.1372
44	5173.3	5173.3	2260.8	860.7	1.330	1.00	1.3	0.0	4655.7	0.142	0.715	0.285	1.1372
45	5173.3	5173.3	2260.8	860.7	1.330	1.00	11.0	0.0	4655.7	0.142	0.715	0.285	1.1372
46	5173.3	5173.3	2260.8	860.7	1.330	1.00	2.1	0.0	4655.7	0.142	0.715	0.285	1.1372
47	5173.3	5173.2	2260.8	860.7	1.330	1.00	14.3	0.0	4655.7	0.142	0.715	0.285	1.1372
48	5173.2	5173.2	2260.8	860.7	1.330	1.00	2.5	0.0	4655.7	0.142	0.715	0.285	1.1372
49	5173.2	5173.2	2260.8	860.7	1.330	1.00	12.9	0.0	4655.7	0.142	0.715	0.285	1.1372
50	5173.2	5173.2	2260.8	860.7	1.330	1.00	0.9	0.0	4655.7	0.142	0.715	0.285	1.1372
51	5173.9	5173.9	2260.8	860.6	1.330	1.00	15.8	0.0	4655.7	1.198	0.715	0.285	1.1372
52	5173.9	5173.8	2260.8	860.6	1.330	1.00	27.2	0.0	4655.7	1.198	0.715	0.285	1.1372
53	5167.6	5155.2	2260.8	860.1	1.326	1.00	294.0	0.0	4654.2	0.900	0.715	0.285	1.1368
54	0.0	0.0	0.0	0.0	0.000	0.00	0.0	0.0	0.0	0.000	1.000	0.000	0.0000
55	0.0	0.0	0.0	0.0	0.000	0.00	0.0	0.0	0.0	0.000	1.000	0.000	0.0000
56	5166.9	5147.7	2260.8	859.8	1.325	1.00	366.2	0.0	4653.3	0.900	0.715	0.285	1.1366
57	5159.9	5140.7	2260.8	859.8	1.323	1.00	366.5	0.0	4653.4	0.900	0.715	0.285	1.1364
58	5140.7	5140.7	2260.8	860.8	1.322	1.00	1.0	0.0	4656.2	0.900	0.715	0.285	1.1362
59	5129.9	5108.2	2260.8	859.8	1.316	1.00	389.4	0.0	4653.6	0.472	0.715	0.285	1.1355
60	5129.5	5107.8	2260.8	859.8	1.316	1.00	391.2	0.0	4653.6	0.472	0.715	0.285	1.1355
61	4882.5	4098.4	2260.8	817.5	0.866	0.96	2883.3	0.0	5697.0	0.472	0.715	0.285	1.1147
62	4763.2	3956.3	2260.8	814.6	0.842	0.96	2967.1	0.0	5687.5	0.472	0.715	0.285	1.1110
63	3943.2	3943.2	2704.3	1225.7	0.898	1.00	1.0	0.0	4893.1	1.726	0.602	0.398	1.0411
64	4726.0	3848.7	2260.8	799.7	0.821	0.93	3473.9	0.0	5822.1	0.429	0.715	0.285	1.1047
65	4616.6	3506.5	2260.8	795.8	0.798	0.93	3579.3	0.0	5807.7	0.429	0.715	0.285	1.1011
66	3492.2	3492.2	2611.1	1164.3	0.822	1.00	1.0	0.0	4394.1	2.155	0.625	0.375	1.0274

Table 4-2 HPOTP TURBINE COOLANT ANALYSIS (104%) (Continued)

STA	TOTAL PRESS (PSIA)	STATIC PRESS (PSIA)	TOTAL ENTHALPY (BTU/LBM)	TEMPER-ATURE (R)	DENSITY (LBM/FT3)	FLUID QUAL	VELO-CITY (FPS)	TANG VEL (FPS)	SONIC VEL (FPS)	FLOW RATE (LBM/SEC)	MASS FRACTIONS H2	MASS FRACTIONS H2O	ZFAC
67	3855.8	3751.2	2704.3	1216.3	0.863	1.00	1056.7	0.0	4875.1	1.726	0.602	0.398	1.0385
68	3738.0	3489.5	2704.3	1202.1	0.816	1.00	1673.6	0.0	4847.5	1.726	0.602	0.398	1.0348
69	3485.4	3485.4	2616.0	1164.2	0.822	1.00	1.0	0.0	4390.3	2.155	0.624	0.376	1.0271
70	3570.3	3464.3	2636.7	1164.3	0.817	1.00	398.0	1018.0	4389.8	0.284	0.624	0.376	1.0266
71	3543.9	3438.4	2636.7	1164.3	0.812	1.00	400.2	1018.0	4391.2	0.284	0.624	0.376	1.0261
72	3517.2	3412.2	2636.7	1164.2	0.806	1.00	403.1	1018.0	4391.4	0.284	0.624	0.376	1.0256
73	3490.3	3385.9	2636.7	1164.2	0.800	1.00	406.0	1018.0	4390.4	0.284	0.624	0.376	1.0251
74	3385.6	3385.6	2445.4	986.8	0.852	1.00	1.0	0.0	4812.9	0.581	0.670	0.330	1.0701
75	5166.9	5154.4	2260.8	860.1	1.326	1.00	295.7	0.0	4654.2	0.142	0.715	0.285	1.1368
76	5154.3	5154.3	2260.8	860.8	1.325	1.00	16.8	0.0	4656.0	0.142	0.715	0.285	1.1366
77	4691.7	3473.8	2260.8	791.4	0.805	0.91	3728.9	0.0	5586.6	0.072	0.715	0.285	1.1009
78	4632.5	3394.1	2260.8	788.9	0.792	0.91	3791.6	0.0	5577.4	0.072	0.715	0.285	1.0989
79	3473.1	3467.2	2260.8	869.6	0.921	1.00	244.3	0.0	4681.5	0.072	0.715	0.285	1.0893
80	3458.3	3428.7	2260.8	868.2	0.913	1.00	545.7	0.0	4678.0	0.072	0.715	0.285	1.0884
81	3455.8	3426.0	2260.8	868.2	0.912	1.00	550.6	0.0	4678.0	0.072	0.715	0.285	1.0884
82	3425.9	3425.9	2260.8	870.6	0.910	1.00	1.0	0.0	4684.3	0.072	0.715	0.285	1.0881
83	4721.1	3590.3	2260.8	796.7	0.816	0.92	3568.3	0.0	5609.2	0.070	0.715	0.285	1.1035
84	4574.7	3400.0	2260.8	791.4	0.785	0.92	3707.1	0.0	5589.8	0.070	0.715	0.285	1.0986
85	3479.6	3474.1	2260.8	869.6	0.922	1.00	236.7	0.0	4681.5	0.070	0.715	0.285	1.0895
86	3468.2	3462.7	2260.8	870.0	0.919	1.00	234.6	0.0	4682.6	0.070	0.715	0.285	1.0891
87	3454.3	3426.4	2260.8	868.4	0.912	1.00	530.3	0.0	4678.4	0.070	0.715	0.285	1.0884
88	3452.2	3424.1	2260.8	868.4	0.911	1.00	534.6	0.0	4678.4	0.070	0.715	0.285	1.0883
89	3424.1	3424.1	2260.8	870.6	0.909	1.00	1.0	0.0	4684.3	0.070	0.715	0.285	1.0880
90	3423.7	3423.1	2260.8	870.5	0.909	1.00	83.1	0.0	4684.2	0.142	0.715	0.285	1.0880
91	3423.1	3423.1	2260.8	870.6	0.909	1.00	1.0	0.0	4684.4	0.142	0.715	0.285	1.0880
92	5161.3	5136.0	2260.8	859.5	1.323	1.00	419.8	0.0	4652.7	0.297	0.715	0.285	1.1363
93	5158.9	5133.5	2260.8	859.5	1.322	1.00	422.0	0.0	4652.7	0.297	0.715	0.285	1.1363
94	5158.6	5138.6	2260.8	859.8	1.323	1.00	374.0	0.0	4653.4	0.297	0.715	0.285	1.1364
95	5153.2	5133.3	2260.8	859.8	1.322	1.00	373.8	0.0	4653.5	0.297	0.715	0.285	1.1362
96	5123.3	5103.3	2260.8	860.0	1.315	1.00	374.2	0.0	4653.9	0.297	0.715	0.285	1.1353
97	5121.3	5101.2	2260.8	860.0	1.314	1.00	376.1	0.0	4653.9	0.297	0.715	0.285	1.1353
98	5091.2	5071.1	2260.8	860.1	1.307	1.00	376.3	0.0	4654.4	0.297	0.715	0.285	1.1344
99	5088.2	5068.0	2260.8	860.2	1.307	1.00	378.3	0.0	4654.5	0.297	0.715	0.285	1.1343

Table 4-2 HPOTP TURBINE COOLANT ANALYSIS (104%) (Continued)

STA	TOTAL PRESS (PSIA)	STATIC PRESS (PSIA)	TOTAL ENTHALPY (BTU/LBM)	TEMPER-ATURE (R)	DENSITY (LBM/FT3)	FLUID QUAL	VELO-CITY (FPS)	TANG VEL (FPS)	SONIC VEL (FPS)	FLOW RATE (LBM/SEC)	MASS FRACTIONS H2	MASS FRACTIONS H2O	ZFAC
100	5076.9	5014.0	2260.8	858.1	1.297	1.00	667.5	0.0	4649.0	0.297	0.715	0.285	1.1332
101	5075.1	5011.8	2260.8	858.1	1.297	1.00	672.4	0.0	4649.0	0.297	0.715	0.285	1.1331
102	5011.8	5011.8	2260.8	861.6	1.292	1.00	1.0	0.0	4658.4	0.297	0.715	0.285	1.1325
103	5007.3	4998.4	2260.8	861.2	1.289	1.00	252.6	0.0	4657.3	0.297	0.715	0.285	1.1322
104	5006.7	4997.8	2260.8	861.2	1.289	1.00	253.1	0.0	4657.3	0.297	0.715	0.285	1.1322
105	5005.9	5001.6	2260.8	861.4	1.290	1.00	175.8	0.0	4657.9	0.297	0.715	0.285	1.1323
106	5005.6	5001.3	2260.8	861.4	1.290	1.00	175.7	0.0	4657.9	0.297	0.715	0.285	1.1323
107	4622.4	3459.9	2260.8	793.0	0.795	0.92	3665.9	0.0	5595.6	0.297	0.715	0.285	1.1002
108	4582.4	3404.2	2260.8	791.2	0.787	0.92	3715.3	0.0	5588.5	0.297	0.715	0.285	1.0988
109	3392.2	3392.2	2444.4	986.0	0.853	1.00	1.0	0.0	4812.2	0.581	0.671	0.329	1.0704
110	3392.1	3392.1	2444.4	985.8	0.854	1.00	24.5	0.0	4811.7	0.531	0.671	0.329	1.0704
111	3392.1	3392.1	2444.4	985.8	0.854	1.00	4.2	0.0	4811.7	0.531	0.671	0.329	1.0704
112	0.0	0.0	0.0	0.0	0.000	0.00	0.0	0.0	0.0	0.000	1.000	0.000	0.0000
113	0.0	0.0	0.0	0.0	0.000	0.00	0.0	0.0	0.0	0.000	1.000	0.000	0.0000
114	0.0	0.0	0.0	0.0	0.000	0.00	0.0	0.0	0.0	0.000	1.000	0.000	0.0000
115	0.0	0.0	0.0	0.0	0.000	0.00	0.0	0.0	0.0	0.000	1.000	0.000	0.0000
116	0.0	0.0	0.0	0.0	0.000	0.00	0.0	0.0	0.0	0.000	1.000	0.000	0.0000
117	0.0	0.0	0.0	0.0	0.000	0.00	0.0	0.0	0.0	0.000	1.000	0.000	0.0000
118	0.0	0.0	0.0	0.0	0.000	0.00	0.0	0.0	0.0	0.000	1.000	0.000	0.0000
119	0.0	0.0	0.0	0.0	0.000	0.00	0.0	0.0	0.0	0.000	1.000	0.000	0.0000
120	5042.4	4772.6	2260.8	847.5	1.256	1.00	1405.2	0.0	4621.0	0.152	0.715	0.285	1.1281
121	4985.5	4906.6	2260.8	857.7	1.273	1.00	760.4	0.0	4648.0	0.152	0.715	0.285	1.1302
122	4672.6	3318.8	2260.8	783.1	0.792	0.90	3966.1	0.0	5551.3	0.152	0.715	0.285	1.0976
123	4672.6	3308.9	2260.8	782.0	0.793	0.90	3995.0	0.0	5546.0	0.152	0.715	0.285	1.0975
124	4133.4	4029.6	2260.8	858.2	1.068	1.00	952.0	0.0	4650.2	0.152	0.715	0.285	1.1059
125	4112.2	4009.0	2260.8	860.3	1.061	1.00	946.1	0.0	4655.9	0.152	0.715	0.285	1.1051
126	4007.3	3901.5	2260.8	860.7	1.035	1.00	970.2	0.0	4657.0	0.152	0.715	0.285	1.1021
127	3995.4	3889.0	2260.8	860.5	1.032	1.00	976.5	0.0	4656.7	0.152	0.715	0.285	1.1018
128	3887.6	3778.8	2260.8	860.9	1.005	1.00	998.5	0.0	4657.8	0.152	0.715	0.285	1.0988
129	3869.8	3760.1	2260.8	860.8	1.000	1.00	1005.5	0.0	4657.5	0.152	0.715	0.285	1.0983
130	3768.5	3404.0	2260.8	842.8	0.931	1.00	1898.7	0.0	4610.1	0.152	0.715	0.285	1.0908
131	3397.8	3397.8	2260.8	870.3	0.903	1.00	1.0	0.0	4683.7	0.152	0.715	0.285	1.0874
132	5625.5	5622.9	861.5	277.7	2.657	1.00	95.8	0.0	4749.6	0.281	1.000	0.000	1.4323

Table 4-2 HPOTP TURBINE COOLANT ANALYSIS (104%) (Concluded)

STA	TOTAL PRESS (PSIA)	STATIC PRESS (PSIA)	TOTAL ENTHALPY (BTU/LBM)	TEMPER-ATURE (R)	DENSITY (LBM/FT3)	FLUID QUAL	VELO-CITY (FPS)	TANG VEL (FPS)	SONIC VEL (FPS)	FLOW RATE (LBM/SEC)	MASS FRACTIONS H2	MASS FRACTIONS H20	ZFAC
133	5618.3	5595.2	861.5	277.4	2.650	1.00	284.2	0.0	4740.0	0.281	1.000	0.000	1.4299
134	5453.9	4948.6	861.5	271.8	2.491	1.00	1353.2	0.0	4509.9	0.281	1.000	0.000	1.3734
135	5447.7	4935.5	861.5	271.7	2.487	1.00	1365.6	0.0	4505.2	0.281	1.000	0.000	1.3723
136	5165.4	5133.9	861.5	279.2	2.498	1.00	341.9	0.0	4587.7	0.281	1.000	0.000	1.3829
137	5119.5	5088.3	861.5	279.4	2.482	1.00	340.4	0.0	4572.6	0.281	1.000	0.000	1.3783
138	5119.4	5089.0	861.5	279.4	2.483	1.00	337.1	0.0	4572.8	0.281	1.000	0.000	1.3784
139	5118.7	5088.2	861.5	279.4	2.482	1.00	337.1	0.0	4572.6	0.281	1.000	0.000	1.3783
140	5100.5	5099.0	861.5	279.9	2.483	1.00	77.1	0.0	4577.2	0.281	1.000	0.000	1.3788
141	5099.0	5098.9	861.5	279.9	2.482	1.00	12.4	0.0	4577.2	0.281	1.000	0.000	1.3788
142	5098.9	5097.0	861.5	279.9	2.482	1.00	85.6	0.0	4576.5	0.281	1.000	0.000	1.3786
143	5098.3	5096.3	861.5	279.9	2.482	1.00	85.6	0.0	4576.3	0.281	1.000	0.000	1.3786
144	4517.5	3033.3	861.5	255.2	1.862	1.00	2572.4	0.0	3773.5	0.281	1.000	0.000	1.1995
145	3476.7	3455.8	861.5	285.4	1.861	1.00	321.8	0.0	4019.4	0.281	1.000	0.000	1.2228
146	3474.1	3453.2	861.5	285.4	1.860	1.00	321.9	0.0	4018.5	0.281	1.000	0.000	1.2226
147	3453.2	3436.8	861.5	285.5	1.852	1.00	286.5	0.0	4013.3	0.281	1.000	0.000	1.2211
148	3451.4	3434.8	861.5	285.5	1.851	1.00	287.6	0.0	4012.7	0.281	1.000	0.000	1.2209
149	3434.8	3434.8	861.5	285.9	1.849	1.00	1.0	0.0	4014.0	0.281	1.000	0.000	1.2207
150	3432.9	3429.1	861.5	285.8	1.847	1.00	138.4	0.0	4011.7	0.281	1.000	0.000	1.2203
151	3429.1	3429.1	861.5	285.9	1.847	1.00	1.0	0.0	4012.0	0.281	1.000	0.000	1.2202
152	3427.2	3423.4	861.5	285.9	1.845	1.00	138.6	0.0	4009.8	0.281	1.000	0.000	1.2198
153	3423.4	3423.4	861.5	285.9	1.844	1.00	1.0	0.0	4010.1	0.281	1.000	0.000	1.2197
154	3423.4	3423.3	861.5	285.9	1.844	1.00	14.1	0.0	4010.1	0.281	1.000	0.000	1.2197
155	3423.3	3423.0	861.5	285.9	1.844	1.00	38.9	0.0	4010.0	0.281	1.000	0.000	1.2197
156	3423.3	3423.0	861.5	285.9	1.844	1.00	38.9	0.0	4010.0	0.281	1.000	0.000	1.2197
157	3423.0	3423.0	861.5	285.9	1.844	1.00	13.1	0.0	4010.0	0.281	1.000	0.000	1.2197
158	3423.0	3423.0	861.5	285.9	1.844	1.00	1.0	0.0	4010.0	0.281	1.000	0.000	1.2197
159	4073.4	3945.8	2940.1	1404.5	0.850	1.00	1027.0	506.0	5226.2	62.389	0.541	0.459	1.0485
160	4037.8	3487.2	2939.9	1362.9	0.779	1.00	932.8	2252.0	5148.9	61.266	0.541	0.459	1.0422
161	3448.5	3389.8	2819.2	1351.1	0.762	1.00	813.4	143.3	5136.1	63.134	0.543	0.457	1.0410
162	3392.2	3392.2	2308.4	721.7	0.861	1.00	1.0	0.0	4770.8	0.205	0.915	0.085	1.1098

Table 4-3 HPOTP TURBINE COOLANT ANALYSIS (MPL)

STA	TOTAL PRESS (PSIA)	STATIC PRESS (PSIA)	TOTAL ENTHALPY (BTU/LBM)	TEMPER-ATURE (R)	DENSITY (LBM/FT3)	FLUID QUAL	VELO-CITY (FPS)	TANG VEL (FPS)	SONIC VEL (FPS)	FLOW RATE (LBM/SEC)	MASS FRACTIONS H2	MASS FRACTIONS H2O	ZFAC
1	2877.9	2875.8	2581.3	1091.6	0.693	1.00	166.7	0.0	4853.0	0.716	0.647	0.353	1.0405
2	2871.6	2863.1	2581.3	1091.3	0.690	1.00	335.6	0.0	4853.0	0.716	0.647	0.353	1.0403
3	2863.1	2861.4	2581.3	1093.1	0.689	1.00	149.3	0.0	4852.9	0.716	0.647	0.353	1.0399
4	2857.7	2846.9	2581.3	1090.7	0.687	1.00	381.0	0.0	4853.0	0.716	0.647	0.353	1.0401
5	2846.8	2846.8	1842.3	696.0	0.813	0.86	1.0	0.0	5073.1	1.262	0.800	0.200	1.0948
6	3135.5	3132.9	873.2	289.5	1.704	1.00	118.3	0.0	3922.7	0.546	1.000	0.000	1.1935
7	3042.6	2849.1	873.2	285.0	1.603	1.00	1045.5	0.0	3810.1	0.546	1.000	0.000	1.1720
8	2845.7	2845.7	1842.3	695.9	0.812	0.86	1.0	0.0	5072.8	1.262	0.800	0.200	1.0948
9	2845.1	2844.0	1842.3	696.1	0.811	0.86	114.9	0.0	5073.9	0.406	0.800	0.200	1.0947
10	2844.8	2843.7	1842.3	696.1	0.811	0.86	115.1	0.0	5073.9	0.406	0.800	0.200	1.0947
11	2843.7	2843.7	1842.3	696.2	0.811	0.86	1.0	0.0	5074.2	0.406	0.800	0.200	1.0947
12	2843.3	2842.6	1842.3	696.2	0.811	0.86	89.3	0.0	5074.0	0.406	0.800	0.200	1.0946
13	2842.6	2842.6	1842.3	696.2	0.811	0.86	1.0	0.0	5074.2	0.406	0.800	0.200	1.0946
14	2805.8	2731.3	1842.3	691.8	0.789	0.86	931.8	0.0	5057.7	0.059	0.800	0.200	1.0914
15	2794.0	2719.0	1842.3	691.6	0.786	0.86	938.7	0.0	5057.1	0.059	0.800	0.200	1.0910
16	2718.1	2664.9	1842.3	692.8	0.768	0.86	798.7	0.0	5062.7	0.059	0.800	0.200	1.0890
17	2656.0	2601.6	1842.3	692.5	0.750	0.86	817.3	0.0	5062.5	0.059	0.800	0.200	1.0869
18	2589.4	2564.8	1842.3	694.1	0.736	0.86	553.3	0.0	5069.8	0.059	0.800	0.200	1.0855
19	2588.8	2564.1	1842.3	694.1	0.736	0.86	558.5	0.0	5069.6	0.059	0.800	0.200	1.0855
20	2526.4	2304.7	1842.3	680.4	0.687	0.85	1720.9	0.0	5016.6	0.059	0.800	0.200	1.0782
21	2513.9	2290.1	1842.3	680.1	0.683	0.85	1737.2	0.0	5015.6	0.059	0.800	0.200	1.0777
22	2287.6	2287.6	1843.7	695.3	0.654	0.87	1.0	0.0	5080.1	0.406	0.799	0.201	1.0762
23	2803.7	2724.9	1842.3	691.6	0.787	0.86	958.9	0.0	5056.8	0.347	0.800	0.200	1.0912
24	2725.1	2644.0	1842.3	691.2	0.765	0.86	986.9	0.0	5056.2	0.347	0.800	0.200	1.0885
25	2643.2	2642.0	1842.3	695.7	0.755	0.86	118.5	0.0	5075.2	0.347	0.800	0.200	1.0879
26	2643.0	2641.9	1842.3	695.7	0.755	0.86	119.3	0.0	5075.2	0.347	0.800	0.200	1.0879
27	2527.9	2289.1	1842.3	679.3	0.685	0.85	1791.0	0.0	5012.4	0.347	0.800	0.200	1.0778
28	2285.4	2285.4	1842.3	694.7	0.655	0.87	1.0	0.0	5077.0	0.406	0.800	0.200	1.0762
29	2881.0	2287.6	2582.8	1015.3	0.594	1.00	787.2	2745.2	4782.0	35.460	0.647	0.353	1.0392
30	0.0	0.0	0.0	0.0	0.000	0.00	0.0	0.0	0.0	0.000	1.000	0.000	0.0000
31	0.0	0.0	0.0	0.0	0.000	0.00	0.0	0.0	0.0	0.000	1.000	0.000	0.0000
32	0.0	0.0	1853.7	695.4	0.654	0.87	0.2	709.9	5080.2	0.000	0.799	0.201	1.0762

Table 4-3 HPOTP TURBINE COOLANT ANALYSIS (MPL) (Continued)

STA	TOTAL PRESS (PSIA)	STATIC PRESS (PSIA)	TOTAL ENTHALPY (BTU/LBM)	TEMPER-ATURE (R)	DENSITY (LBM/FT3)	FLUID QUAL	VELO-CITY (FPS)	TANG VEL (FPS)	SONIC VEL (FPS)	FLOW RATE (LBM/SEC)	MASS FRACTIONS H2	MASS FRACTIONS H2O	ZFAC
33	0.0	0.0	1853.7	695.4	0.654	0.87	0.2	709.9	5080.2	0.000	0.799	0.201	1.0762
34	0.0	0.0	1853.7	695.4	0.654	0.87	0.2	709.9	5080.2	0.000	0.799	0.201	1.0762
35	0.0	0.0	1853.7	695.4	0.654	0.87	0.2	709.9	5080.2	0.000	0.799	0.201	1.0762
36	2313.9	2313.9	2282.3	899.7	0.630	1.00	1.0	0.0	4699.0	0.934	0.693	0.307	1.0552
37	2845.7	2845.7	1842.3	696.2	0.812	0.86	1.7	0.0	5074.2	0.079	0.800	0.200	1.0947
38	2845.6	2845.4	1842.3	696.2	0.812	0.86	47.7	0.0	5074.1	0.079	0.800	0.200	1.0947
39	2845.6	2845.4	1842.3	696.2	0.812	0.86	47.7	0.0	5074.1	0.079	0.800	0.200	1.0947
40	2845.6	2845.4	1842.3	696.2	0.812	0.86	47.7	0.0	5074.1	0.079	0.800	0.200	1.0947
41	2845.6	2845.4	1842.3	696.2	0.812	0.86	47.7	0.0	5074.1	0.079	0.800	0.200	1.0947
42	2845.4	2845.4	1842.3	696.2	0.812	0.86	1.9	0.0	5074.2	0.079	0.800	0.200	1.0947
43	2845.4	2845.4	1842.3	696.2	0.812	0.86	9.9	0.0	5074.2	0.079	0.800	0.200	1.0947
44	2845.4	2845.4	1842.3	696.2	0.812	0.86	1.2	0.0	5074.2	0.079	0.800	0.200	1.0947
45	2845.4	2845.4	1842.3	696.2	0.812	0.86	10.1	0.0	5074.2	0.079	0.800	0.200	1.0947
46	2845.4	2845.4	1842.3	696.2	0.812	0.86	1.9	0.0	5074.2	0.079	0.800	0.200	1.0947
47	2845.4	2845.4	1842.3	696.2	0.812	0.86	13.0	0.0	5074.2	0.079	0.800	0.200	1.0947
48	2845.4	2845.4	1842.3	696.2	0.812	0.86	2.3	0.0	5074.2	0.079	0.800	0.200	1.0947
49	2845.4	2845.4	1842.3	696.2	0.812	0.86	11.8	0.0	5074.2	0.079	0.800	0.200	1.0947
50	2845.4	2845.4	1842.3	696.2	0.812	0.86	0.8	0.0	5074.2	0.079	0.800	0.200	1.0947
51	2845.7	2845.7	1842.3	696.2	0.812	0.86	15.0	0.0	5074.2	0.695	0.800	0.200	1.0947
52	2845.7	2845.7	1842.3	696.2	0.812	0.86	25.9	0.0	5074.2	0.695	0.800	0.200	1.0947
53	2842.2	2835.3	1842.3	695.8	0.810	0.86	280.3	0.0	5072.6	0.524	0.800	0.200	1.0944
54	0.0	0.0	0.0	0.0	0.000	0.00	0.0	0.0	0.0	0.000	1.000	0.000	0.0000
55	0.0	0.0	0.0	0.0	0.000	0.00	0.0	0.0	0.0	0.000	1.000	0.000	0.0000
56	2841.9	2831.2	1842.3	695.6	0.809	0.86	349.1	0.0	5071.8	0.524	0.800	0.200	1.0943
57	2837.7	2827.0	1842.3	695.6	0.808	0.86	349.4	0.0	5071.8	0.524	0.800	0.200	1.0942
58	2827.0	2827.0	1842.3	696.2	0.806	0.86	1.0	0.0	5074.3	0.524	0.800	0.200	1.0941
59	2821.0	2808.9	1842.3	695.5	0.803	0.86	372.3	0.0	5071.6	0.275	0.800	0.200	1.0936
60	2820.8	2808.6	1842.3	695.5	0.803	0.86	373.9	0.0	5071.6	0.275	0.800	0.200	1.0936
61	2698.8	2377.4	1842.3	675.2	0.718	0.85	2026.8	0.0	4993.7	0.275	0.800	0.200	1.0812
62	2646.5	2316.9	1842.3	673.5	0.703	0.85	2078.3	0.0	4987.9	0.275	0.800	0.200	1.0793
63	2313.4	2313.4	2281.9	899.4	0.630	1.00	1.0	0.0	4698.4	0.934	0.693	0.307	1.0552
64	2625.0	2184.9	1842.3	664.9	0.679	0.84	2442.2	0.0	4953.7	0.249	0.800	0.200	1.0756
65	2577.1	2126.4	1842.3	663.6	0.663	0.84	2500.8	0.0	4949.3	0.249	0.800	0.200	1.0737
66	2119.6	2119.6	2186.6	847.1	0.595	1.00	1.0	0.0	4627.4	1.184	0.716	0.284	1.0556

Table 4-3 HPOTP TURBINE COOLANT ANALYSIS (MPL) (Continued)

STA	TOTAL PRESS (PSIA)	STATIC PRESS (PSIA)	TOTAL ENTHALPY (BTU/LBM)	TEMPER-ATURE (R)	DENSITY (LBM/FT3)	FLUID QUAL	VELO-CITY (FPS)	TANG VEL (FPS)	SONIC VEL (FPS)	FLOW RATE (LBM/SEC)	MASS FRACTIONS H2	MASS FRACTIONS H2O	ZFAC
67	2276.6	2232.8	2281.9	899.5	0.609	1.00	812.9	0.0	4698.8	0.939	0.693	0.307	1.0531
68	2224.4	2121.1	2281.9	896.1	0.582	1.00	1278.5	0.0	4690.0	0.939	0.693	0.307	1.0506
69	2119.8	2119.8	2189.6	847.9	0.596	1.00	1.0	0.0	4627.4	1.189	0.715	0.285	1.0555
70	2149.4	2111.5	2199.7	847.2	0.594	1.00	293.1	709.9	4625.5	0.152	0.715	0.285	1.0553
71	2138.6	2100.8	2199.7	847.2	0.591	1.00	293.9	709.9	4625.7	0.152	0.715	0.285	1.0550
72	2127.7	2090.0	2199.7	847.3	0.588	1.00	295.3	709.9	4625.8	0.152	0.715	0.285	1.0547
73	2116.8	2079.2	2199.7	847.3	0.585	1.00	296.8	709.9	4626.0	0.152	0.715	0.285	1.0544
74	2079.1	2079.1	2011.1	753.5	0.497	0.96	1.0	0.0	5401.4	0.322	0.760	0.240	1.0633
75	2842.1	2835.7	1842.3	695.8	0.810	0.86	270.6	0.0	5072.7	0.079	0.800	0.200	1.0944
76	2835.7	2835.7	1842.3	696.2	0.809	0.86	15.4	0.0	5074.2	0.079	0.800	0.200	1.0944
77	2629.7	2179.8	1842.3	864.2	0.678	0.84	2469.4	0.0	4950.9	0.040	0.800	0.200	1.0755
78	2605.9	2149.9	1842.3	863.2	0.671	0.84	2503.0	0.0	4947.3	0.040	0.800	0.200	1.0745
79	2127.3	2124.6	1842.3	693.8	0.609	0.88	202.5	0.0	5076.8	0.040	0.800	0.200	1.0709
80	2120.4	2106.5	1842.3	692.9	0.606	0.88	460.0	0.0	5073.1	0.040	0.800	0.200	1.0704
81	2119.2	2105.2	1842.3	692.9	0.605	0.88	462.7	0.0	5073.0	0.040	0.800	0.200	1.0703
82	2105.1	2105.1	1842.3	693.8	0.603	0.88	1.0	0.0	5077.3	0.040	0.800	0.200	1.0703
83	2641.7	2220.7	1842.3	866.6	0.687	0.84	2375.0	0.0	4960.3	0.039	0.800	0.200	1.0767
84	2583.0	2150.8	1842.3	865.2	0.668	0.84	2438.5	0.0	4955.8	0.039	0.800	0.200	1.0744
85	2128.8	2126.3	1842.3	693.9	0.610	0.88	197.0	0.0	5076.8	0.039	0.800	0.200	1.0710
86	2123.0	2120.4	1842.3	693.7	0.608	0.88	198.6	0.0	5076.5	0.039	0.800	0.200	1.0708
87	2116.4	2103.2	1842.3	692.9	0.605	0.88	448.4	0.0	5073.3	0.039	0.800	0.200	1.0703
88	2115.4	2102.1	1842.3	692.9	0.604	0.88	451.0	0.0	5073.3	0.039	0.800	0.200	1.0702
89	2102.1	2102.1	1842.3	693.8	0.603	0.88	1.0	0.0	5077.3	0.039	0.800	0.200	1.0702
90	2102.0	2101.7	1842.3	693.8	0.603	0.88	70.0	0.0	5077.2	0.079	0.800	0.200	1.0701
91	2101.7	2101.7	1842.3	693.8	0.602	0.88	1.0	0.0	5077.3	0.079	0.800	0.200	1.0701
92	2838.9	2825.2	1842.3	695.4	0.808	0.86	395.1	0.0	5071.1	0.171	0.800	0.200	1.0941
93	2837.5	2823.8	1842.3	695.4	0.807	0.86	397.1	0.0	5071.1	0.171	0.800	0.200	1.0941
94	2837.4	2826.6	1842.3	695.6	0.808	0.86	352.0	0.0	5071.8	0.171	0.800	0.200	1.0942
95	2834.2	2823.5	1842.3	695.6	0.807	0.86	351.8	0.0	5071.8	0.171	0.800	0.200	1.0940
96	2818.0	2807.2	1842.3	695.5	0.802	0.86	352.2	0.0	5071.9	0.171	0.800	0.200	1.0935
97	2816.9	2806.0	1842.3	695.5	0.802	0.86	354.1	0.0	5071.9	0.171	0.800	0.200	1.0935
98	2800.6	2789.7	1842.3	695.5	0.797	0.86	354.3	0.0	5072.0	0.171	0.800	0.200	1.0929
99	2798.9	2787.9	1842.3	695.5	0.797	0.86	356.3	0.0	5072.0	0.171	0.800	0.200	1.0929

Table 4-3 HPOTP TURBINE COOLANT ANALYSIS (MPL) (Continued)

STA	TOTAL PRESS (PSIA)	STATIC PRESS (PSIA)	TOTAL ENTHALPY (BTU/LBM)	TEMPER-ATURE (R)	DENSITY (LBM/FT3)	FLUID QUAL	VELO-CITY (FPS)	TANG VEL (FPS)	SONIC VEL (FPS)	FLOW RATE (LBM/SEC)	MASS FRACTIONS H2	MASS FRACTIONS H2O	ZFAC
100	2792.7	2758.7	1842.3	694.1	0.792	0.86	628.7	0.0	5066.7	0.171	0.800	0.200	1.0920
101	2791.7	2757.5	1842.3	694.1	0.791	0.86	632.9	0.0	5066.6	0.171	0.800	0.200	1.0920
102	2757.5	2757.5	1842.3	696.1	0.787	0.86	1.0	0.0	5074.8	0.171	0.800	0.200	1.0918
103	2755.1	2750.2	1842.3	695.8	0.786	0.86	238.2	0.0	5073.7	0.171	0.800	0.200	1.0916
104	2754.7	2749.9	1842.3	695.8	0.786	0.86	238.6	0.0	5073.7	0.171	0.800	0.200	1.0916
105	2754.3	2751.9	1842.3	695.9	0.786	0.86	165.8	0.0	5074.2	0.171	0.800	0.200	1.0916
106	2754.1	2751.8	1842.3	695.9	0.786	0.86	165.7	0.0	5074.2	0.171	0.800	0.200	1.0916
107	2571.8	2109.2	1842.3	662.3	0.660	0.84	2538.8	0.0	4944.0	0.171	0.800	0.200	1.0732
108	2554.6	2088.5	1842.3	661.8	0.654	0.84	2558.7	0.0	4942.5	0.171	0.800	0.200	1.0725
109	2080.4	2080.4	2010.3	753.6	0.497	0.97	1.0	0.0	5401.5	0.322	0.760	0.240	1.0633
110	2080.4	2080.4	2010.3	753.1	0.499	0.96	20.6	0.0	5399.1	0.261	0.760	0.240	1.0634
111	2080.4	2080.4	2010.3	753.1	0.499	0.96	3.5	0.0	5399.1	0.261	0.760	0.240	1.0634
112	0.0	0.0	0.0	0.0	0.000	0.00	0.0	0.0	0.0	0.000	1.000	0.000	0.0000
113	0.0	0.0	0.0	0.0	0.000	0.00	0.0	0.0	0.0	0.000	1.000	0.000	0.0000
114	0.0	0.0	0.0	0.0	0.000	0.00	0.0	0.0	0.0	0.000	1.000	0.000	0.0000
115	0.0	0.0	0.0	0.0	0.000	0.00	0.0	0.0	0.0	0.000	1.000	0.000	0.0000
116	0.0	0.0	0.0	0.0	0.000	0.00	0.0	0.0	0.0	0.000	1.000	0.000	0.0000
117	0.0	0.0	0.0	0.0	0.000	0.00	0.0	0.0	0.0	0.000	1.000	0.000	0.0000
118	0.0	0.0	0.0	0.0	0.000	0.00	0.0	0.0	0.0	0.000	1.000	0.000	0.0000
119	0.0	0.0	0.0	0.0	0.000	0.00	0.0	0.0	0.0	0.000	1.000	0.000	0.0000
120	2785.3	2662.1	1842.3	688.8	0.775	0.85	1209.7	0.0	5046.3	0.080	0.800	0.200	1.0894
121	2759.3	2723.1	1842.3	693.9	0.782	0.86	658.2	0.0	5066.3	0.080	0.800	0.200	1.0909
122	2635.0	2191.1	1842.3	665.1	0.680	0.84	2450.4	0.0	4954.6	0.080	0.800	0.200	1.0758
123	2635.0	2188.0	1842.3	664.2	0.681	0.84	2467.5	0.0	4950.7	0.080	0.800	0.200	1.0758
124	2428.8	2383.4	1842.3	692.1	0.688	0.87	783.4	0.0	5064.5	0.080	0.800	0.200	1.0797
125	2418.6	2373.6	1842.3	692.1	0.685	0.87	779.2	0.0	5064.7	0.080	0.800	0.200	1.0794
126	2373.2	2327.5	1842.3	691.9	0.672	0.87	789.8	0.0	5064.6	0.080	0.800	0.200	1.0778
127	2367.6	2321.4	1842.3	691.8	0.671	0.87	797.6	0.0	5064.3	0.080	0.800	0.200	1.0776
128	2321.0	2274.0	1842.3	691.6	0.657	0.87	811.5	0.0	5064.3	0.080	0.800	0.200	1.0761
129	2312.6	2265.4	1842.3	691.5	0.655	0.87	815.8	0.0	5063.9	0.080	0.800	0.200	1.0758
130	2268.2	2115.5	1842.3	683.5	0.625	0.86	1498.8	0.0	5033.1	0.080	0.800	0.200	1.0715
131	2112.6	2112.6	1842.3	693.9	0.606	0.88	1.0	0.0	5077.4	0.080	0.800	0.200	1.0705
132	3134.9	3133.6	873.2	289.5	1.704	1.00	82.4	0.0	3923.1	0.155	1.000	0.000	1.1936

Table 4-3 HPOTP TURBINE COOLANT ANALYSIS (MPL) (Concluded)

STA	TOTAL PRESS (PSIA)	STATIC PRESS (PSIA)	TOTAL ENTHALPY (BTU/LBM)	TEMPER-ATURE (R)	DENSITY (LBM/FT3)	FLUID QUAL	VELO-CITY (FPS)	TANG VEL (FPS)	SONIC VEL (FPS)	FLOW RATE (LBM/SEC)	MASS FRACTIONS H2	MASS FRACTIONS H20	ZFAC
133	3131.5	3120.5	873.2	289.3	1.699	1.00	244.4	0.0	3917.8	0.155	1.000	0.000	1.1926
134	3053.4	2812.9	873.2	283.8	1.593	1.00	1166.3	0.0	3793.3	0.155	1.000	0.000	1.1694
135	3050.2	2806.3	873.2	283.7	1.590	1.00	1177.6	0.0	3790.6	0.155	1.000	0.000	1.1689
136	2915.9	2900.9	873.2	289.7	1.602	1.00	294.9	0.0	3845.6	0.155	1.000	0.000	1.1746
137	2892.0	2877.2	873.2	289.8	1.591	1.00	292.8	0.0	3837.9	0.155	1.000	0.000	1.1727
138	2892.0	2877.6	873.2	289.8	1.591	1.00	290.1	0.0	3838.0	0.155	1.000	0.000	1.1727
139	2891.6	2877.2	873.2	289.8	1.591	1.00	290.1	0.0	3837.9	0.155	1.000	0.000	1.1726
140	2883.0	2882.3	873.2	290.2	1.591	1.00	66.4	0.0	3841.0	0.155	1.000	0.000	1.1729
141	2882.3	2882.2	873.2	290.2	1.591	1.00	10.7	0.0	3841.1	0.155	1.000	0.000	1.1729
142	2882.2	2881.3	873.2	290.2	1.591	1.00	73.6	0.0	3840.7	0.155	1.000	0.000	1.1729
143	2881.9	2881.0	873.2	290.2	1.591	1.00	73.6	0.0	3840.6	0.155	1.000	0.000	1.1728
144	2608.5	1922.5	873.2	268.7	1.218	1.00	2173.3	0.0	3438.5	0.155	1.000	0.000	1.1035
145	2124.8	2115.1	873.2	291.2	1.224	1.00	271.1	0.0	3601.7	0.155	1.000	0.000	1.1151
146	2123.5	2113.9	873.2	291.2	1.223	1.00	269.9	0.0	3601.4	0.155	1.000	0.000	1.1150
147	2113.9	2106.3	873.2	291.3	1.219	1.00	240.2	0.0	3599.5	0.155	1.000	0.000	1.1145
148	2112.9	2105.3	873.2	291.3	1.219	1.00	241.0	0.0	3599.2	0.155	1.000	0.000	1.1144
149	2105.3	2105.3	873.2	291.6	1.218	1.00	1.0	0.0	3600.5	0.155	1.000	0.000	1.1144
150	2104.4	2102.6	873.2	291.5	1.216	1.00	115.9	0.0	3599.4	0.155	1.000	0.000	1.1142
151	2102.6	2102.6	873.2	291.6	1.216	1.00	1.0	0.0	3599.7	0.155	1.000	0.000	1.1142
152	2101.8	2100.0	873.2	291.5	1.215	1.00	116.0	0.0	3598.6	0.155	1.000	0.000	1.1140
153	2100.0	2100.0	873.2	291.6	1.215	1.00	1.0	0.0	3598.9	0.155	1.000	0.000	1.1140
154	2100.0	2100.0	873.2	291.6	1.215	1.00	11.8	0.0	3598.9	0.155	1.000	0.000	1.1140
155	2100.0	2099.8	873.2	291.6	1.215	1.00	32.6	0.0	3598.8	0.155	1.000	0.000	1.1140
156	2100.0	2099.8	873.2	291.6	1.215	1.00	32.6	0.0	3598.8	0.155	1.000	0.000	1.1140
157	2099.8	2099.8	873.2	291.6	1.215	1.00	11.0	0.0	3598.8	0.155	1.000	0.000	1.1140
158	2099.8	2099.8	873.2	291.6	1.215	1.00	1.0	0.0	3598.8	0.155	1.000	0.000	1.1140
159	2384.5	2313.9	2465.3	1024.1	0.594	1.00	847.3	575.3	4801.1	35.866	0.648	0.352	1.0387
160	2365.7	2115.1	2469.2	1000.6	0.557	1.00	751.3	1813.9	4764.9	35.207	0.648	0.352	1.0372
161	2112.8	2083.4	2396.4	995.6	0.550	1.00	647.4	236.1	4762.9	36.238	0.650	0.350	1.0372
162	2080.4	2080.4	1914.8	640.2	0.612	0.93	1.0	0.0	4765.9	0.141	0.896	0.104	1.0741

Column	Parameter	Description
Line number 159, Format (8E10.4))		
1-10	SEALCL	Primary turbine seal operating clearance, in.
Line number 160, Format (8E10.4)		
1-10	RPM	Pump speed, rpm
11-20	ROF	Preburner mixture ratio
21-30	XPL	Power level ratio.
Line number 161, Format (8E10.4)		
1-10	WDPB	Turbine inlet flow rate, lbm/s
11-20	PPB	Turbine inlet total pressure, psia
21-30	TPB	Turbine inlet total temperature, °R
31-40	HPA	Turbine horsepower, hp
41-50	TFTD	Turbine discharge total temperature, °R
51-60	PFTD	Turbine discharge total pressure, psia
61-70	ETANZ	Nozzle efficiency, K_n^2
71-80	XKB	Blade coefficient, Kb.
Line number 162, Format (8I5)		
1-5	IOPT	= 1 Fixed blade coefficient and iterates to determine flow rate = 2 Fixed flow rate and iterates to determine blade coefficient
6-10	ITURB	= 1 Uses programmed turbine leakage flows and makes one pass through turbine and coolant flow models = 2 Uses computed leakage flows from first pass and makes an additional pass through each model.

Column	Parameter	Description
Line number 163, Format (8E10.4)		
1-10	PKNOWN(2)	Hydrogen coolant supply pressure, psia
11-20	TKNOWN(2)	Hydrogen coolant supply temperature, °R
21-30	WKNOWN(2)	Estimated hydrogen coolant flow rate, lbm/s
31-40	RKNOWN(2)	Estimated hydrogen coolant density, lbm/ft^3
41-50	VTKNON(2)	Coolant supply tangential velocity, ft/s.
Line number 164, Format (8E10.4)		
1-80	WDLEG	Legs 1 through 8 estimated flow rate at FPL, lbm/s
Line number 165, Format (8E10.4)		
1-80	WDLEG	Legs 9 through 16 estimated flow rate at FPL, lbm/s
Line number 166, Format (8E10.4)		
1-80	WDLEG	Legs 17 through 24 estimated flow rate at FPL, lbm/s Leg 19 is no longer used, input 0.0
Line number 167, Format (8E10.4)		
1-30	WDLEG	Legs 25 through 27 estimated flow rate at FPL, lbm/s.

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