WATKINS/ARMITAGE/TRACY

4220

AEROJET NUCLEAR SYSTEMS COMPANY
SACRAMENTO, CALIFORNIA

lhc

WS # 9d
BACK UP

PLS examine for compatibility with your
current work

To: A. D. Cornell

26 February 1971

From: W. E. Stephens

N4110:0067

WES:slt

Subject: State Points for the 1137400/Revision E Reference Engine

Distribution: D. Buden, K. R. Conn, J. R. Davolio, N. A. Edlebeck,
R. W. Froelich, M. Goldman, R. Gulde, R. A. Henderson,
W. J. Houghton, L. D. Johnson, P. Kluger, D. L. Petite,
M. J. Rieb, T. Shigemoto, L. A. Shurley, J. L. Smith,
R. R. Stiger, P. P. Ventura, R. J. Williams

Reference: (a) Memo N4110:2049, A. D. Cornell to D. Buden, dated
15 January 1971, Subject: Engine 1137400/Revision E
Input Data for NETAP
(b) Memo N4130:8227, D. Buden to A. D. Cornell, dated
5 February 1971, Subject: NERVA State Point and
Specification Extreme Data for the 1137400/Revision E
Reference Engine
(c) Memo N4130:4539, D. Buden to A. D. Cornell, dated
10 February 1971, Subject: Selection of Emergency
Mode Operating Point

Enclosure:

- (1) SOL Normal Design Point
- (2) EOL Normal Design Point
- (3) SOL 1 TPA 80% Thrust
- (4) EOL 1 TPA 80% Thrust
- (5) SOL Normal 60% Thrust
- (6) EOL Normal 60% Thrust
- (7) SOL 1 TPA 60% Thrust
- (8) EOL 1 TPA 60% Thrust
- (9) SOL 1 TPA, 1 SSCV Emergency Operating Point
- (10) 75K NERVA Flight Engine State Point Diagram, Drawing
No. 1137456G

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MASTER

This memo contains the state point conditions and specification extremes to be used in developing engine and component specifications for the Reference Engine 1137400/Revision E as defined in Reference (a).

The state points, Enclosures (1) through (8), were obtained from Reference (b). The state point values have been reviewed and some of the values were changed. The changes have been coordinated with Systems Analysis,

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such that when the startup and shutdown transients are plotted by machine they will be in agreement with Enclosures (1) and (5).

The whole numbered state points, 1 to 42, on the first two sheets are for use in the component and engine specifications and the decimal numbered state points (9.1, etc., to 37.3) are of value to the component designers only, and they are not to be included in the specifications.

The emergency operating point was obtained from Systems Analysis and is contained in Enclosure (9), and the selection of this point is discussed in Reference (c).

To assist the reader in locating the state points, Enclosure (10) is attached.

The component tolerances are based on 2.326 Sigma limits, which is at the 98% confidence level for a two-sided limit.

The turbine bypass ratio of 8% was used at the normal design point at start-of-life. The 8% turbine bypass requirement consists of 3% for the 2.326 component variations, 2% for hydrogen conversion uncertainty, and 3% for valve controllability margin. Since NETAP runs are made using 100% parahydrogen, any conversion will cause a reduction in the turbine bypass flow. As a result, the specification extremes at engine state points upstream of the turbine will be affected only on the positive side by the hydrogen conversion uncertainty. This is why the specification extreme pressure values at State Points 5 to 32 are not symmetrical about the nominal.

W. E. Stephens, Assistant Manager
Engine Design Section

STATE POINT CONDITIONS AND SIGNIFICATION EXTREMES

75K FULL FLOW NERVA ENGINE - DRAWING NUMBER 1137400E

REFER TO DRAWING NUMBER 1137456 FOR STATE POINT LOCATIONS

1137400E REFERENCE ENGINE - START OF LIFE - NORMAL DESIGN POINT

FC = 450. PSIA TRCV POSITION = 36.9 DEGREES THRUST = 75500. LBF TURBINE EFFICIENCY = 86.3 % PUMP EFFICIENCY = 66.7 %
TC = 4252. DEGREES R SSCV POSITION = 22.3 DEGREES ISP = 822.5 SEC BYPASS FRACTION = 8.0 % PUMP SPEED = 24239. RPM
CRUM POSITION = 45.2 DEGREES NPSP = 7.1 PSI FEEDBACK REACTIVITY = 1.10 %
PDCV POSITION = 90.0 DEGREES

NETAP RESTART TAPE 21152 AT 271. SECONDS PLOTTED AT 271. SECONDS

	FLOW RATE (LBS/SEC)			PRESSURE (PSIA)			TEMPERATURE (DEGREES R)		
	NOMINAL	MIN	MAX	NOMINAL	MIN	MAX	NOMINAL	MIN	MAX
1 - PROPELLANT TANK OUTLET	46.2	45.4	47.0	22.0	21.2	22.8	36.5	36.2	36.8
2 - PROPELLANT SHUTOFF VALVE INLET	46.2	45.4	47.0	22.0	21.2	22.8	36.4	36.1	36.7
3 - PROPELLANT SHUTOFF VALVE OUTLET	46.2	45.4	47.0	21.9	21.1	22.7	36.4	36.1	36.7
4 - PUMP INLET	46.2	45.4	47.0	21.8	21.0	22.6	36.4	36.1	36.7
5 - PUMP OUTLET	45.9	45.1	46.7	1431	1398	1486	55.2	53.9	57.4
6 - PUMP DISCHARGE CHECK VALVE ACTUATOR INLET	45.9	45.1	46.7	1431	1398	1486	55.2	53.9	57.4
7 - PUMP DISCHARGE CHECK VALVE ACTUATOR OUTLET	45.9	45.1	46.7	1425	1393	1481	55.2	53.9	57.4
8 - PUMP DISCHARGE CHECK VALVE INLET	45.9	45.1	46.7	1425	1393	1481	55.2	53.9	57.4
9 - PUMP DISCHARGE CHECK VALVE OUTLET	45.9	45.1	46.7	1420	1387	1475	55.2	53.9	57.4
10 - PUMP DISCHARGE BLOCK VALVE INLET	42.3	41.5	43.2	1401	1369	1456	55.4	54.1	57.6
11 - PUMP DISCHARGE BLOCK VALVE OUTLET	42.3	41.5	43.2	1397	1365	1451	55.4	54.1	57.6
12 - PUMP DISCHARGE CONTROL VALVE OUTLET	42.3	41.5	43.2	1391	1359	1446	55.4	54.1	57.6
13 - STRUCTURAL SUPPORT BLOCK VALVE INLET	3.60	3.57	3.63	1403	1371	1458	55.4	54.1	57.6
14 - STRUCTURAL SUPPORT BLOCK VALVE OUTLET	3.60	3.57	3.63	1403	1371	1458	55.4	54.1	57.6
15 - STRUCTURAL SUPPORT CONTROL VALVE OUTLET	3.60	3.57	3.63	1180	1154	1224	57.3	56.0	59.5
16 - STRUCTURAL SUPPORT COOLANT LINE OUTLET (PV DCMF)	7.20	7.14	7.26	1178	1152	1222	57.3	56.0	59.5
17 - STRUCTURAL SUPPORT BYPASS ORIFICE INLET	3.01	2.95	3.07	1363	1332	1416	55.6	54.3	57.8
18 - STRUCTURAL SUPPORT BYPASS ORIFICE OUTLET	3.01	2.95	3.07	1169	1143	1212	55.6	54.3	57.8
19 - STRUCTURAL SUPPORT BYPASS LINE OUTLET (PV DCMF)	3.01	2.95	3.07	1151	1126	1194	55.9	54.6	58.1
20 - LOWER PUMP DISCHARGE LINE OUTLET	81.7	80.0	83.4	1374	1342	1427	55.8	54.5	58.0
22 - NOZZLE TUBES OUTLET	81.7	80.0	83.4	1190	1162	1237	187	176	199
23 - REFLECTOR PRESSURE VESSEL ANNULUS OUTLET	6.96	6.76	7.16	1133	1108	1176	259	248	271
24 - PERIPHERAL SHIELD PRESSURE VESSEL ANNULUS OUTLET	25.2	24.8	25.6	1124	1099	1166	276	265	288
25 - PERIPHERAL SHIELD OUTLET	66.7	65.5	67.9	1124	1099	1166	276	265	288
26 - DCMF TURBINE LINE INLET	91.9	90.0	93.5	1120	1095	1162	276	265	288

16.0

STATE POINT CONDITIONS AND SPECIFICATION EXTREMES

75K FULL FLOW NERVA ENGINE - DRAWING NUMBER 1137400E

REFER TO DRAWING NUMBER 1137456 FOR STATE POINT LOCATIONS

1137400E REFERENCE ENGINE - START OF LIFE - NORMAL DESIGN POINT

PC = 450. PSIA TBCV POSITION = 36.9 DEGREES THRUST = 75500. LRF TURBINE EFFICIENCY = 86.3 % PUMP EFFICIENCY = 66.7 %
 TC = 4252. DEGREES R SSCV POSITION = 22.3 DEGREES ISP = 822.5 SEC BYPASS FRACTION = 8.0 % PUMP SPEED = 24239. RPM
 CPUM POSITION = 45.2 DEGREES NPSP = 7.1 PSI FEEDBACK REACTIVITY = 1.10 \$
 PDCV POSITION = 90.0 DEGREES

NETAP RESTART TAPE 21152 AT 271. SECONDS PLOTTED AT 271. SECONDS

	FLOW RATE (LBS/SEC)			PRESSURE (PSIA)			TEMPERATURE (DEGREES R)		
	NOMINAL	MIN	MAX	NOMINAL	MIN	MAX	NOMINAL	MIN	MAX
27 - TURBINE BYPASS BLOCK VALVE INLET	3.68	1.43	4.98	1111	1087	1153	276	265	288
28 - TURBINE BYPASS BLOCK VALVE OUTLET	3.68	1.43	4.98	1111	1087	1152	276	265	288
29 - TURBINE BYPASS CONTROL VALVE OUTLET	3.68	1.43	4.98	737	724	750	276	264	288
30 - TURBINE BLOCK VALVE INLET	42.3	40.8	44.8	1096	1072	1136	276	265	288
31 - TURBINE BLOCK VALVE OUTLET	42.3	40.8	44.8	1088	1065	1128	276	265	288
32 - TURBINE INLET	42.3	40.8	44.8	1088	1065	1128	276	265	288
33 - TURBINE OUTLET	42.5	41.0	45.1	733	720	746	252	241	263
34 - TURBINE DISCHARGE BLOCK VALVE INLET	42.5	41.0	45.1	732	719	745	252	241	263
35 - TURBINE DISCHARGE BLOCK VALVE OUTLET	42.5	41.0	45.1	722	709	735	252	241	263
36 - STAGE PRESSURANT LINE INLET	0.60	0.54	0.66	705	693	718	255	244	266
37 - COME INLET LINE OUTLET	91.8	90.2	93.4	692	681	703	255	244	266
38 - THRUST CHAMBER	91.9	90.2	93.4	450	446	455	4253	4210	4295
39 - PROPELLANT TANK OUTLET	0.0	0.0	0.0	22.0	21.2	22.8	36.5	36.2	36.8
40 - COOLDOWN SHUTOFF VALVE INLET	0.0	0.0	0.0	22.0	21.2	22.8	36.5	36.2	36.8
41 - COOLDOWN SHUTOFF VALVE OUTLET	0.0	0.0	0.0	0.0	0.0	0.0	46.9	46.1	48.1
42 - COOLDOWN SUPPLY CONTROL VALVE OUTLET	0.0	0.0	0.0	1179	1150	1220	57.3	56.0	59.5

Reactivity (\$)

	Pos +	Neg -
Total Feedback	1.10	
Stem Hydrogen Worth	1.88	--
Core Hydrogen Worth	1.08	--
Reflector Hydrogen Worth	0.42	--
Core Temperature	-- 3.38	2.28 2.28
Drum Worth	-- 3.38	1.10 3.38

STATE POINT CONDITIONS AND SPECIFICATION EXTREMES
75K FULL FLOW NERVA ENGINE - DRAWING NUMBER 1137400E

REFER TO DRAWING NUMBER 1137456 FOR STATE POINT LOCATIONS

1137400E REFERENCE ENGINE - START OF LIFE - NORMAL DESIGN POINT

PC = 450. PSIA TBCV POSITION = 36.9 DEGREES THRUST = 75500. LBF TURBINE EFFICIENCY = 86.3 % PUMP EFFICIENCY = 66.7 %
TC = 4252. DEGREES R SSCV POSITION = 22.2 DEGREES ISP = 822.5 SEC BYPASS FRACTION = 8.0 % PUMP SPEED = 24239. RPM
PRUM POSITION = 45.2 DEGREES NPSP = 7.1 PSI FEEDBACK REACTIVITY = 1.10 \$
PDCV POSITION = 90.0 DEGREES

NFTAP RESTART TAPE 21152 AT 271. SECONDS PLOTTED AT 271. SECONDS

	FLOW RATE (LBS/SEC)			PRESSURE (PSIA)			TEMPERATURE (DEGREES R)		
	NOMINAL	MIN	MAX	NOMINAL	MIN	MAX	NOMINAL	MIN	MAX
9.1 - PUMP DISCHARGE JUNCTION INLET	45.9	45.1	46.7	1416	1383	1471	55.2	53.9	57.4
9.2 - PUMP DISCHARGE LINE JUNCTION OUTLET	91.9	90.3	93.5	1409	1376	1464	55.2	53.9	57.4
9.3 - STRUCTURAL SUPPORT COOLANT LINE INLET	7.20	7.14	7.26	1405	1373	1460	55.4	54.1	57.6
9.4 - PUMP DISCHARGE VALVE MODULE INLET	84.7	83.0	86.4	1402	1370	1457	55.4	54.1	57.6
9.5 - STRUCTURAL SUPPORT MODULE INLET	7.20	7.14	7.26	1404	1371	1458	55.4	54.1	57.6
12.1 - MIDDLE PUMP DISCHARGE LINE INLET	84.7	83.0	86.4	1383	1351	1437	55.6	54.3	57.8
15.1 - STRUCTURAL SUPPORT MODULE OUTLET	7.20	7.14	7.26	1179	1153	1223	57.3	56.0	59.5
15.2 - COOLDOWN SUPPLY LINE OUTLET	7.20	7.14	7.26	1178	1152	1222	57.3	56.0	59.5
16.1 - STRUCTURAL SUPPORT BYPASS LINE INLET	3.01	2.95	3.07	1378	1346	1431	55.6	54.3	57.8
19.1 - STEM OUTLET IN CORE SUPPORT PLATE	7.20	7.14	7.26	1134	1109	1177	824	694	954
22.1 - REFLECTOR PRESSURE VESSEL ANNULUS - MIDPOINT	6.96	6.75	7.16	1190	1162	1237	223	212	235
23.1 - REFLECTOR OUTLET	74.7	73.2	76.2	1133	1108	1176	240	228	252
23.2 - STRUCTURAL SUPPORT OUTLET	10.2	10.2	10.3	1133	1108	1176	569	510	628
23.3 - PERIPHERAL SHIELD INLET	66.7	65.5	67.9	1133	1108	1176	276	264	288
26.1 - TURBINE BYPASS LINE INLET	7.35	2.95	9.95	1112	1088	1153	276	265	288
26.2 - TURBINE BYPASS MODULE INLET	7.35	2.95	9.95	1112	1087	1153	276	265	288
29.1 - TURBINE BYPASS MODULE OUTLET	7.35	2.95	9.95	736	723	748	276	264	288
29.2 - TURBINE BYPASS LINE OUTLET	7.35	2.95	9.95	721	708	733	276	265	287
29.3 - TURBINE LINE JUNCTION INLET	84.5	81.5	89.6	1112	1088	1153	276	265	288
29.4 - TURBINE LINE DUAL LFG INLET	42.3	40.9	44.8	1097	1073	1137	276	265	288
35.1 - TURBINE DISCHARGE LINE JUNCTION INLET	42.5	41.0	45.1	721	708	733	252	241	253
35.2 - TURBINE DISCHARGE LINE SINGLE LFG INLET	92.4	90.8	94.0	708	696	720	255	244	266
37.1 - CENTRAL SHIELD INLET	91.8	90.2	93.4	643	631	653	255	244	266
37.2 - CORE SUPPORT PLATE INLET	91.8	90.2	93.4	634	623	644	256	245	267
37.3 - CORE INLET	91.8	90.2	93.4	622	612	632	259	249	270

STATE POINT CONDITIONS AND SPECIFICATION EXTREMES

75K FULL FLOW NERVA ENGINE - DRAWING NUMBER 1137400E

REFER TO DRAWING NUMBER 1137456 FOR STATE POINT LOCATIONS

1137400E REFERENCE ENGINE - END OF LIFE - NORMAL DESIGN POINT

PC = 450. PSIA TRCV POSITION = 38.7 DEGREES THRUST = 75500. LBF TURBINE EFFICIENCY = 86.3 % PUMP EFFICIENCY = 67.0 %
TC = 4252. DEGREES P SSCV POSITION = 36.5 DEGREES ISP = 822.4 SEC BYPASS FRACTION = 8.8 % PUMP SPEED = 24738. RPM
DRUM POSITION = 45.2 DEGREES NPSP = 0.0 PSI FEEDBACK REACTIVITY = 1.11 \$
PDCV POSITION = 90.0 DEGREES

NETAP RESTART TAPE 21298 AT 274. SECONDS PLOTTED AT 274. SECONDS

	FLOW RATE (LBS/SEC)			PRESSURE (PSIA)			TEMPERATURE (DEGREES R)		
	NOMINAL	MIN	MAX	NOMINAL	MIN	MAX	NOMINAL	MIN	MAX
1 - PROPELLANT TANK OUTLET	46.2	45.4	47.0	28.0	27.2	28.8	40.6	40.3	40.9
2 - PROPELLANT SHUTOFF VALVE INLET	46.2	45.4	47.0	28.0	27.2	28.8	40.7	40.4	41.0
3 - PROPELLANT SHUTOFF VALVE OUTLET	46.2	45.4	47.0	27.9	27.1	28.7	40.7	40.4	41.0
4 - PUMP INLET	46.2	45.4	47.0	27.8	27.0	28.6	40.6	40.3	40.9
5 - PUMP OUTLET	45.9	45.1	46.7	1431	1398	1487	60.2	58.9	62.4
6 - PUMP DISCHARGE CHECK VALVE ACTUATOR INLET	45.9	45.1	46.7	1431	1398	1487	60.2	58.9	62.4
7 - PUMP DISCHARGE CHECK VALVE ACTUATOR OUTLET	45.9	45.1	46.7	1425	1393	1481	60.2	58.9	62.4
8 - PUMP DISCHARGE CHECK VALVE INLET	45.9	45.1	46.7	1425	1393	1481	60.2	58.9	62.4
9 - PUMP DISCHARGE CHECK VALVE OUTLET	45.9	45.1	46.7	1420	1387	1475	60.2	58.9	62.4
10 - PUMP DISCHARGE BLOCK VALVE INLET	40.3	39.5	41.2	1401	1368	1455	60.4	59.1	62.6
11 - PUMP DISCHARGE BLOCK VALVE OUTLET	40.3	39.5	41.2	1396	1364	1451	60.4	59.1	62.6
12 - PUMP DISCHARGE CONTROL VALVE OUTLET	40.3	39.5	41.2	1391	1359	1446	60.4	59.1	62.6
13 - STRUCTURAL SUPPORT BLOCK VALVE INLET	5.62	5.59	5.65	1400	1368	1455	60.4	59.1	62.6
14 - STRUCTURAL SUPPORT BLOCK VALVE OUTLET	5.62	5.59	5.65	1400	1368	1455	60.4	59.1	62.6
15 - STRUCTURAL SUPPORT CONTROL VALVE OUTLET	5.62	5.59	5.65	1215	1188	1260	61.7	60.4	63.9
16 - STRUCTURAL SUPPORT COOLANT LINE OUTLET (PV DCME)	11.2	11.2	11.3	1210	1184	1256	61.8	60.5	64.0
17 - STRUCTURAL SUPPORT BYPASS ORIFICE INLET	2.89	2.83	2.95	1365	1333	1417	60.6	59.3	62.8
18 - STRUCTURAL SUPPORT BYPASS ORIFICE OUTLET	2.89	2.83	2.95	1180	1154	1223	60.6	59.3	62.8
19 - STRUCTURAL SUPPORT BYPASS LINE OUTLET (PV DCME)	2.89	2.83	2.95	1163	1137	1205	60.8	59.5	63.0
20 - LOWER PUMP DISCHARGE LINE OUTLET	77.8	76.1	79.5	1375	1344 ¹²²⁸	1428	60.7	59.4	62.9
22 - NOZZLE TUBES OUTLET	77.8	76.1	79.5	1198	1171	1245	197	186	208
23 - REFLECTOR PRESSURE VESSEL ANNULUS OUTLET	6.64	6.44	6.84	1144	1118	1186	271	260	284
24 - PERIPHERAL SHIELD PRESSURE VESSEL ANNULUS OUTLET	25.2	24.8	25.6	1134	1109	1176	286	275	299
25 - PERIPHERAL SHIELD OUTLET	66.7	65.5	67.9	1134	1109	1176	287	276	299
26 - DCME TURBINE LINE INLET	91.9	90.3	93.5	1130	1105	1172	287	275	299

15.0

STATE POINT CONDITIONS AND SPECIFICATION EXTREMES

75K FULL FLOW NERVA ENGINE - DRAWING NUMBER 1137400E

REFER TO DRAWING NUMBER 1137456 FOR STATE POINT LOCATIONS

1137400E REFERENCE ENGINE - END OF LIFE - NORMAL DESIGN POINT

PC = 450. PSIA TBCV POSITION = 38.7 DEGREES THRUST = 75500. LBF TURBINE EFFICIENCY = 86.3 % PUMP EFFICIENCY = 67.0 %
 TC = 4252. DEGREES R SSCV POSITION = 36.5 DEGREES IAP = 822.4 SEC BYPASS FRACTION = 8.8 % PUMP SPEED = 24738. RPM
 DRUM POSITION = 45.2 DEGREES NPSP = 0.0 PSI FEEDBACK REACTIVITY = 1.11 %
 PDCV POSITION = 90.0 DEGREES

NETAP RESTART TAPE 21298 AT 274. SECONDS PLOTTED AT 274. SECONDS

	FLOW RATE (LBS/SEC)			PRESSURE (PSIA)			TEMPERATURE (DEGREES R)		
	NOMINAL	MIN	MAX	NOMINAL	MIN	MAX	NOMINAL	MIN	MAX
27 - TURBINE BYPASS BLOCK VALVE INLET	4.05	1.90	5.35	1121	1097	1162	287	276	299
28 - TURBINE BYPASS BLOCK VALVE OUTLET	4.05	1.90	5.35	1121	1097	1162	287	276	299
29 - TURBINE BYPASS CONTROL VALVE OUTLET	4.05	1.90	5.35	747	734	759	286	275	299
30 - TURBINE BLOCK VALVE INLET	41.9	40.4	44.4	1106	1082	1146	287	275	299
31 - TURBINE BLOCK VALVE OUTLET	41.9	40.4	44.4	1098	1075	1137	287	275	299
32 - TURBINE INLET	41.9	40.4	44.4	1098	1075	1136	287	275	299
33 - TURBINE OUTLET	42.2	40.7	44.7	739	726	752	262	251	273
34 - TURBINE DISCHARGE BLOCK VALVE INLET	42.2	40.7	44.7	738	725	751	262	251	273
35 - TURBINE DISCHARGE BLOCK VALVE OUTLET	42.2	40.7	44.7	728	715	740	262	251	273
36 - STAGE PRESSURANT LINE INLET	0.60	0.54	0.66	710	698	723	265	254	275
37 - CORE INLET LINE OUTLET	91.8	90.2	93.4	697	635	708	265	254	275
38 - THRUST CHAMBER	91.8	90.2	93.4	450	445	455	4252	4210	4295 4293
39 - PROPELLANT TANK OUTLET	0.0	0.0	0.0	28.0	27.2	28.8	40.6	40.3	40.9
40 - COOLDOWN SHUTOFF VALVE INLET	0.0	0.0	0.0	28.0	27.2	28.8	40.6	40.3	40.9
41 - COOLDOWN SHUTOFF VALVE OUTLET	0.0	0.0	0.0	0.0	0.0	0.0	51.2	50.4	52.4
42 - COOLDOWN SUPPLY CONTROL VALVE OUTLET	0.0	0.0	0.0	1212	1186	1250	61.8	60.5	64.0

Reactivity (\$)

	Pos	Neg
	+	-
Total Feedback	1.11	
Stem Hydrogen Worth	2.91	--
Core Hydrogen Worth	1.07	--
Reflector Hydrogen Worth	0.40	--
Core Temperature + Corrosion	--	3.27
	4.38	
Drum Worth	--	1.11
	4.38	4.38

STATE POINT CONDITIONS AND SPECIFICATION EXTREMES

75K FULL FLOW NERVA ENGINE - DRAWING NUMBER 1137400E

REFER TO DRAWING NUMBER 1137456 FOR STATE POINT LOCATIONS

1137400E REFERENCE ENGINE - END OF LIFE - NORMAL DESIGN POINT

PC = 450. PSIA TRCV POSITION = 39.7 DEGREES THRUST = 75500. LBF TURBINE EFFICIENCY = 86.3 % PUMP EFFICIENCY = 67.0 %
 TC = 4252. DEGREES R SSCV POSITION = 36.5 DEGREES ISP = 822.4 SEC BYPASS FRACTION = 8.8 % PUMP SPEED = 24738. RPM
 DRUM POSITION = 45.2 DEGREES NPSP = 0.0 PSI FEEDBACK REACTIVITY = 1.11 \$
 PDCV POSITION = 90.0 DEGREES

NETAP RESTART TAPE 21298 AT 274. SECONDS PLOTTED AT 274. SECONDS

	FLOW RATE (LBS/SEC)			PRESSURE (PSIA)			TEMPERATURE (DEGREES R)		
	NOMINAL	MIN	MAX	NOMINAL	MIN	MAX	NOMINAL	MIN	MAX
9.1 - PUMP DISCHARGE JUNCTION INLET	45.9	45.1	46.7	1415	1383	1470	60.2	58.9	62.4
9.2 - PUMP DISCHARGE LINE JUNCTION OUTLET	91.9	90.3	93.5	1408	1376	1463	60.2	58.9	62.4
9.3 - STRUCTURAL SUPPORT COOLANT LINE INLET	11.2	11.2	11.3	1404	1372	1459	60.4	59.1	62.5
9.4 - PUMP DISCHARGE VALVE MODULE INLET	80.6	78.9	82.3	1401	1369	1456	60.4	59.1	62.6
9.5 - STRUCTURAL SUPPORT MODULE INLET	11.2	11.2	11.3	1401	1368	1455	60.4	59.1	62.6
12.1 - MIDDLE PUMP DISCHARGE LINE INLET	80.6	78.9	82.3	1383	1351	1437	60.5	59.2	62.7
15.1 - STRUCTURAL SUPPORT MODULE OUTLET	11.2	11.2	11.3	1213	1186	1258	61.7	60.4	63.9
15.2 - COOLDOWN SUPPLY LINE OUTLET	11.2	11.2	11.3	1210	1184	1256	61.8	60.5	64.0
16.1 - STRUCTURAL SUPPORT BYPASS LINE INLET	2.89	2.83	2.95	1379	1347	1432	60.6	59.3	62.8
19.1 - STEM OUTLET IN CORE SUPPORT PLATE	11.2	11.2	11.3	1147	1122	1190	563	433	693
22.1 - REFLECTOR PRESSURE VESSEL ANNULUS - MIDPOINT	6.64	6.44	6.84	1148	1171	1245	235	224	247
23.1 - REFLECTOR OUTLET	71.1	69.6	72.6	1144	1118	1186	257	246	269
23.2 - STRUCTURAL SUPPORT OUTLET	14.1	14.1	14.2	1144	1118	1186	449	350	508
27.3 - PERIPHERAL SHIELD INLET	66.7	65.5	67.9	1144	1118	1186	286	275	299
26.1 - TURBINE BYPASS LINE INLET	8.11	3.61	10.7	1122	1098	1164	287	275	299
26.2 - TURBINE BYPASS MODULE INLET	8.11	3.61	10.7	1122	1097	1163	287	276	299
29.1 - TURBINE BYPASS MODULE OUTLET	8.11	3.61	10.7	745	732	757	286	275	299
29.2 - TURBINE BYPASS LINE OUTLET	8.11	3.61	10.7	726	714	739	287	276	297
29.3 - TURBINE LINE JUNCTION INLET	83.8	80.8	88.9	1122	1098	1164	287	275	299
29.4 - TURBINE LINE DUAL LEG INLET	41.9	40.4	44.4	1106	1083	1146	287	275	299
35.1 - TURBINE DISCHARGE LINE JUNCTION INLET	42.2	40.7	44.7	726	714	739	262	251	273
35.2 - TURBINE DISCHARGE LINE SINGLE LEG INLET	92.4	90.8	94.0	714	701	726	265	254	275
37.1 - CENTRAL SHIELD INLET	91.8	90.2	93.4	645	634	655	265	254	275
37.2 - CORE SUPPORT PLATE INLET	91.8	90.2	93.4	636	625	646	266	255	276
37.3 - CORE INLET	91.8	90.2	93.4	624	613	634	269	258	280

STATE POINT CONDITIONS AND SPECIFICATION EXTREMES

75K FULL FLOW NEPVA ENGINE - DRAWING NUMBER 1137400E

REFER TO DRAWING NUMBER 1137456 FOR STATE POINT LOCATIONS

1137400E REFERENCE ENGINE - START OF LIFE - 1 TPA 80% THRUST

PC = 361. PSIA TPCV POSITION = 63.9 DEGREES THRUST = 60500. LBF TURBINE EFFICIENCY = 85.7 % PUMP EFFICIENCY = 64.8 %
 TC = 4254. DEGREES R SSCV POSITION = 26.0 DEGREES ISP = 823.0 SEC BYPASS FRACTION = 39.5 % PUMP SPEED = 26527. RPM
 DRUM POSITION = 58.5 DEGREES NPSP = 8.8 PSI FEEDBACK REACTIVITY = 0.73 %
 PDCV POSITION = 90.0 DEGREES

NETAP RESTART TAPE 21234 AT 278. SECONDS PLOTTED AT 278. SECONDS

	FLOW RATE (LBS/SEC)			PRESSURE (PSIA)			TEMPERATURE (DEGREES R)		
	NOMINAL	MIN	MAX	NOMINAL	MIN	MAX	NOMINAL	MIN	MAX
1 - PROPELLANT TANK OUTLET	74.0	72.4	75.6	24.0	23.2	24.8	36.5	36.2	36.8
2 - PROPELLANT SHUTOFF VALVE INLET	74.0	72.4	75.6	24.0	23.2	24.8	36.4	36.1	36.7
3 - PROPELLANT SHUTOFF VALVE OUTLET	74.0	72.4	75.6	24.0	23.2	24.8	36.4	36.1	36.7
4 - PUMP INLET	74.0	72.4	75.6	23.6	22.8	24.4	36.4	36.1	36.7
5 - PUMP OUTLET	73.4	71.8	75.0	1333	1301	1386	54.7	53.4	56.9
6 - PUMP DISCHARGE CHECK VALVE ACTUATOR INLET	73.4	71.8	75.0	1333	1301	1386	54.7	53.4	56.9
7 - PUMP DISCHARGE CHECK VALVE ACTUATOR OUTLET	73.4	71.8	75.0	1329	1298	1382	54.7	53.4	56.9
8 - PUMP DISCHARGE CHECK VALVE INLET	73.4	71.8	75.0	1329	1298	1382	54.7	53.4	56.9
9 - PUMP DISCHARGE CHECK VALVE OUTLET	73.4	71.8	75.0	1326	1295	1378	54.7	53.4	56.9
10 - PUMP DISCHARGE FLOCK VALVE INLET	33.5	32.7	34.4	1279	1249	1329	55.2	53.9	57.4
11 - PUMP DISCHARGE FLOCK VALVE OUTLET	33.5	32.7	34.4	1276	1246	1326	55.2	53.9	57.4
12 - PUMP DISCHARGE CONTROL VALVE OUTLET	33.5	32.7	34.4	1273	1243	1323	55.2	53.9	57.4
13 - STRUCTURAL SUPPORT FLOCK VALVE INLET	3.18	3.15	3.21	1281	1251	1332	55.2	53.9	57.4
14 - STRUCTURAL SUPPORT FLOCK VALVE OUTLET	3.18	3.15	3.21	1281	1251	1331	55.2	53.9	57.4
15 - STRUCTURAL SUPPORT CONTROL VALVE OUTLET	3.18	3.15	3.21	1135	1110	1178	56.5	55.2	58.7
16 - STRUCTURAL SUPPORT COOLANT LINE OUTLET (PV DCMF)	6.35	6.30	6.42	1134	1109	1177	56.5	55.2	58.7
17 - STRUCTURAL SUPPORT BYPASS ORIFICE INLET	2.49	2.43	2.55	1254	1225	1303	55.3	54.0	57.5
18 - STRUCTURAL SUPPORT BYPASS ORIFICE OUTLET	2.49	2.43	2.55	1120	1095	1162	55.3	54.0	57.5
19 - STRUCTURAL SUPPORT BYPASS LINE OUTLET (PV DCMF)	2.49	2.43	2.55	1108	1084	1149	55.5	54.2	57.7
20 - LOWER PUMP DISCHARGE LINE OUTLET	64.6	62.9	66.3	1261	1232	1311	55.4	54.1	57.6
22 - NOZZLE TURBS OUTLET	64.6	62.9	66.3	1134	1108	1178	195.	184	208
23 - REFLECTOR PRESSURE VESSEL ANNULUS OUTLET	5.51	5.31	5.71	1095	1071	1136	268	255	282
24 - PERIPHERAL SHIELD PRESSURE VESSEL ANNULUS OUTLET	20.2	19.8	20.6	1088	1064	1129	290	276	305
25 - PERIPHERAL SHIELD OUTLET	53.2	52.0	54.4	1088	1064	1129	291	277	305
26 - COME TURBINE LINE INLET	73.4	71.8	75.0	1085	1061	1126	290	277	305

10.1

STATE POINT CONDITIONS AND SPECIFICATION EXTREMES
75K FULL FLOW NERVA ENGINE - DRAWING NUMBER 1137400E

REFER TO DRAWING NUMBER 1137456 FOR STATE POINT LOCATIONS

1137400E REFERENCE ENGINE - START OF LIFE - 1 TPA 80% THRUST

PC = 361. PSIA TRCV POSITION = 63.9 DEGREES THRUST = 60500. LBF TURBINE EFFICIENCY = 85.7 % PUMP EFFICIENCY = 64.8 %
TC = 4254. DEGREES R SSCV POSITION = 26.0 DEGREES ISP = 823.0 SEC BYPASS FRACTION = 39.5 % PUMP SPEED = 26527. RPM
CRUM POSITION = 58.5 DEGREES NPSP = 8.8 PSI FEEDBACK REACTIVITY = 0.73 \$
PDCV POSITION = 90.0 DEGREES

NETAP RESTART TAPE 21234 AT 278. SECONDS PLOTTED AT 278. SECONDS

	FLOW RATE (LBS/SEC)			PRESSURE (PSIA)			TEMPERATURE (DEGREES R)		
	NOMINAL	MIN	MAX	NOMINAL	MIN	MAX	NOMINAL	MIN	MAX
27 - TURBINE BYPASS BLOCK VALVE INLET	14.5	12.1	15.9	1066	1042	1106	290	279	303
28 - TURBINE BYPASS BLOCK VALVE OUTLET	14.5	12.1	15.9	1063	1039	1102	290	279	303
29 - TURBINE BYPASS CONTROL VALVE OUTLET	14.5	12.1	15.9	747	732	763	290	276	305
30 - TURBINE BLOCK VALVE INLET	44.4	41.2	49.9	1076	1052	1116	290	277	305
31 - TURBINE BLOCK VALVE OUTLET	44.4	41.2	49.9	1073	1050	1113	290	277	305
32 - TURBINE INLET	44.4	41.2	49.9	1064	1040	1103	290	277	305
33 - TURBINE OUTLET	44.9	41.7	50.4	605	590	620	257	244	270
34 - TURBINE DISCHARGE BLOCK VALVE INLET	44.9	41.7	50.4	604	590	619	257	244	270
35 - TURBINE DISCHARGE BLOCK VALVE OUTLET	44.9	41.7	50.4	601	586	616	257	244	270
36 - STACK PRESSURANT LINE INLET	0.40	0.34	0.46	574	560	588	271	258	284
37 - CORE INLET LINE OUTLET	73.6	72.0	75.2	563	551	576	271	258	284
38 - THRUST CHAMBER	73.6	72.0	75.2	361	356	365	4254	4212	4297
39 - PROPELLANT TANK OUTLET	0.0	0.0	0.0	24.0	23.2	24.8	36.5	36.2	36.8
40 - COOLDOWN SHUTOFF VALVE INLET	0.0	0.0	0.0	24.0	23.2	24.8	36.5	36.2	36.8
41 - COOLDOWN SHUTOFF VALVE OUTLET	0.0	0.0	0.0	0.0	0.0	0.0	46.5	45.7	47.7
42 - COOLDOWN SUPPLY CONTROL VALVE OUTLET	0.0	0.0	0.0	1135	1110	1178	56.5	55.2	58.7

Reactivity (\$)

	Pos	Neg
	+	-
Total Feedback	0.73	
Stem Hydrogen Worth	1.72	--
Core Hydrogen Worth	0.86	--
Reflector Hydrogen Worth	0.39	--
Core Temperature	--	2.24
	2.97	2.24
Drum Worth	--	0.73
	2.97	2.97

STATE POINT CONDITIONS AND SPECIFICATION EXTREMES
75K FULL FLOW NERVA ENGINE - DRAWING NUMBER 1137400E

REFER TO DRAWING NUMBER 1137456 FOR STATE POINT LOCATIONS

1137400E REFERENCE ENGINE - START OF LIFE - 1 TPA 80% THRUST

PC = 361. PSIA TPCV POSITION = 63.9 DEGREES THRUST = 60500. LBF TURBINE EFFICIENCY = 85.7 % PUMP EFFICIENCY = 64.8 %
TC = 4254. DEGREES R SSCV POSITION = 26.0 DEGREES ISP = 823.0 SEC BYPASS FRACTION = 39.5 % PUMP SPEED = 26527. RPM
CRUM POSITION = 59.5 DEGREES NPSP = 8.8 PSI FEEDBACK REACTIVITY = 0.73 %
PDCV POSITION = 90.0 DEGREES

NETAP RESTART TAPE 21234 AT 278. SECONDS PLOTTED AT 278. SECONDS

	FLOW RATE (LBS/SEC)			PRESSURE (PSIA)			TEMPERATURE (DEGREES R)		
	NOMINAL	MIN	MAX	NOMINAL	MIN	MAX	NOMINAL	MIN	MAX
9.1 - PUMP DISCHARGE JUNCTION INLET	73.4	71.8	75.0	1323	1292	1376	54.7	53.4	56.9
9.2 - PUMP DISCHARGE LINE JUNCTION OUTLET	73.4	71.8	75.0	1319	1288	1371	54.7	53.4	56.9
9.3 - STRUCTURAL SUPPORT COOLANT LINE INLET	6.36	6.30	6.42	1282	1252	1333	55.2	53.9	57.4
9.4 - PUMP DISCHARGE VALVE MODULE INLET	67.0	65.3	68.7	1280	1250	1331	55.2	53.9	57.4
9.5 - STRUCTURAL SUPPORT MODULE INLET	6.36	6.30	6.42	1281	1251	1332	55.2	53.9	57.4
12.1 - MIDDLE PUMP DISCHARGE LINE INLET	67.0	65.3	68.7	1267	1236	1317	55.3	54.0	57.5
15.1 - STRUCTURAL SUPPORT MODULE OUTLET	6.36	6.30	6.42	1135	1110	1178	56.5	55.2	58.7
15.2 - COOLDOWN SUPPLY LINE OUTLET	6.36	6.30	6.42	1134	1109	1177	56.5	55.2	58.7
16.1 - STRUCTURAL SUPPORT BYPASS LINE INLET	2.49	2.43	2.55	1264	1235	1314	55.3	54.0	57.5
19.1 - STEM OUTLET IN CORE SUPPORT PLATE	6.36	6.30	6.42	1096	1072	1138	842	711	972
22.1 - REFLECTOR PRESSURE VESSEL ANALLS - MIDPOINT	5.51	5.31	5.71	1134	1108	1178	232	220	246
23.1 - REFLECTOR OUTLET	59.0	57.5	60.5	1095	1071	1136	251	238	264
23.2 - STRUCTURAL SUPPORT OUTLET	8.85	8.79	8.91	1095	1071	1136	592	533	651
23.3 - PERIPHERAL SHIELD INLET	53.2	52.0	54.4	1095	1071	1136	290	276	305
26.1 - TURBINE BYPASS LINE INLET	29.0	24.2	31.8	1080	1057	1121	290	277	305
26.2 - TURBINE BYPASS MODULE INLET	29.0	24.2	31.8	1070	1046	1111	290	279	303
29.1 - TURBINE BYPASS MODULE OUTLET	29.0	24.2	31.8	724	709	738	290	276	305
29.2 - TURBINE BYPASS LINE OUTLET	29.0	24.2	31.8	589	574	603	291	278	304
29.3 - TURBINE LINE JUNCTION INLET	44.4	41.2	49.9	1080	1057	1121	291	277	306
29.4 - TURBINE LINE DUAL LEG INLET	44.4	41.2	49.9	1076	1052	1116	290	277	305
35.1 - TURBINE DISCHARGE LINE JUNCTION INLET	44.9	41.7	50.4	601	586	615	257	244	270
35.2 - TURBINE DISCHARGE LINE SINGLE LEG INLET	74.0	72.4	75.6	596	582	611	271	258	284
37.1 - CENTRAL SHIELD INLET	73.6	72.0	75.2	521	510	533	271	258	284
37.2 - CORE SUPPORT PLATE INLET	73.6	72.0	75.2	514	503	526	272	258	285
37.3 - CORE INLET	73.6	72.0	75.2	504	493	515	275	262	288

STATE POINT CONDITIONS AND SPECIFICATION EXTREMES

75K FULL FLOW NERVA ENGINE - DRAWING NUMBER 1137400E

REFER TO DRAWING NUMBER 1137456 FOR STATE POINT LOCATIONS

1137400E REFERENCE ENGINE - END OF LIFE - 1 TPA 80% THRUST

PC = 360. PSIA TRCV POSITION = 63.8 DEGREES THRUST = 60500. LBF TURBINE EFFICIENCY = 85.7 % PUMP EFFICIENCY = 64.5 %
TC = 4251. DEGREES R SSCV POSITION = 38.5 DEGREES ISP = 822.7 SEC BYPASS FRACTION = 39.6 % PUMP SPEED = 27261. RPM
CPUM POSITION = 58.5 DEGREES NPSP = 1.7 PSI FEEDBACK REACTIVITY = 0.73 %
PDCV POSITION = 46.2 DEGREES

NETAP RESTART TAPE 21239 AT 278. SECONDS PLOTTED AT 260. SECONDS

	FLOW RATE (LBS/SEC)			PRESSURE (PSIA)			TEMPERATURE (DEGREES R)		
	NOMINAL	MIN	MAX	NOMINAL	MIN	MAX	NOMINAL	MIN	MAX
1 - PROPELLANT TANK OUTLET	73.9	72.3	75.5	30.0	29.2	30.8	40.6	40.3	40.9
2 - PROPELLANT SHUTOFF VALVE INLET	73.9	72.3	75.5	30.0	29.2	30.8	40.6	40.3	40.9
3 - PROPELLANT SHUTOFF VALVE OUTLET	73.9	72.3	75.5	30.0	29.2	30.8	40.6	40.3	40.9
4 - PUMP INLET	73.9	72.3	75.5	29.5	26.7	30.3	40.6	40.3	40.9
5 - PUMP OUTLET	73.4	71.8	75.0	1340	1309	1394	60.1	58.8	62.3
6 - PUMP DISCHARGE CHECK VALVE ACTUATOR INLET	73.4	71.8	75.0	1340	1309	1394	60.0	58.7	62.2
7 - PUMP DISCHARGE CHECK VALVE ACTUATOR OUTLET	73.4	71.8	75.0	1337	1306	1390	60.0	58.7	62.2
8 - PUMP DISCHARGE CHECK VALVE INLET	73.4	71.8	75.0	1337	1306	1390	60.0	58.7	62.2
9 - PUMP DISCHARGE CHECK VALVE OUTLET	73.4	71.8	75.0	1333	1302	1386	60.0	58.7	62.2
10 - PUMP DISCHARGE BLOCK VALVE INLET	31.6	30.7	32.4	1285	1255	1335	60.5	59.2	62.7
11 - PUMP DISCHARGE BLOCK VALVE OUTLET	31.6	30.7	32.4	1282	1253	1333	60.5	59.2	62.7
12 - PUMP DISCHARGE CONTROL VALVE OUTLET	31.6	30.7	32.4	1279	1250	1329	60.5	59.2	62.7
13 - STRUCTURAL SUPPORT BLOCK VALVE INLET	5.08	5.05	5.11	1285	1255	1335	60.5	59.2	62.7
14 - STRUCTURAL SUPPORT BLOCK VALVE OUTLET	5.08	5.05	5.11	1285	1255	1335	60.5	59.2	62.7
15 - STRUCTURAL SUPPORT CONTROL VALVE OUTLET	5.08	5.05	5.11	1174	1148	1218	61.3	60.0	63.5
16 - STRUCTURAL SUPPORT COOLANT LINE OUTLET (PV DOME)	10.2	10.1	10.2	1171	1145	1215	61.3	60.0	63.5
17 - STRUCTURAL SUPPORT BYPASS ORIFICE INLET	2.36	2.30	2.42	1262	1233	1311	60.6	59.3	62.8
18 - STRUCTURAL SUPPORT BYPASS ORIFICE OUTLET	2.36	2.30	2.42	1137	1112	1179	60.6	59.3	62.8
19 - STRUCTURAL SUPPORT BYPASS LINE OUTLET (PV DOME)	2.36	2.30	2.42	1125	1101	1167	60.7	59.4	62.9
20 - LOWER PUMP DISCHARGE LINE OUTLET	60.8	59.1	62.5	1269	1240	1318	60.6	59.3	62.8
22 - NOZZLE TUBES OUTLET	60.8	59.1	62.5	1149	1123	1192	207	156	220
23 - REFLECTOR PRESSURE VESSEL ANNULUS OUTLET	5.20	5.00	5.40	1112	1088	1154	283	270	297
24 - PERIPHERAL SHIELD PRESSURE VESSEL ANNULUS OUTLET	20.2	19.8	20.6	1105	1081	1146	303	289	318
25 - PERIPHERAL SHIELD OUTLET	53.2	52.0	54.4	1105	1081	1147	303	289	318
26 - DOME TURBINE LINE INLET	73.4	71.8	75.0	1102	1078	1143	303	289	318

9.3

STATE POINT CONDITIONS AND SPECIFICATION EXTREMES
75K FULL FLOW NERVA ENGINE - DRAWING NUMBER 1137400E

REFER TO DRAWING NUMBER 1137456 FOR STATE POINT LOCATIONS

1137400F REFERENCE ENGINE - END OF LIFE - 1 TPA 80% THRUST

C = 360. PSIA TBCV POSITION = 63.5 DEGREES THRUST = 60500. LBF TURBINE EFFICIENCY = 85.7 % PUMP EFFICIENCY = 64.5 %
C = 4251. DEGREES R SSCV POSITION = 38.5 DEGREES ISP = 822.7 SEC BYPASS FRACTION = 39.6 % PUMP SPEED = 27261. RPM
DRUM POSITION = 58.5 DEGREES NPSP = 1.7 PSI FEEDBACK REACTIVITY = 0.73 \$
PDCV POSITION = 46.2 DEGREES

NETAP RESTART TAPE 21239 AT 278. SECONDS PLOTTED AT 280. SECONDS

	FLOW RATE (LBS/SEC)			PRESSURE (PSIA)			TEMPERATURE (DEGREES R)		
	NOMINAL	MIN	MAX	NOMINAL	MIN	MAX	NOMINAL	MIN	MAX
7 - TURBINE BYPASS BLOCK VALVE INLET	14.5	12.1	15.9	1082	1058	1122	303	291	315
8 - TURBINE BYPASS BLOCK VALVE OUTLET	14.5	12.1	15.9	1079	1055	1119	303	291	315
9 - TURBINE BYPASS CONTROL VALVE OUTLET	14.5	12.1	15.9	755	740	771	303	289	318
10 - TURBINE BLOCK VALVE INLET	44.3	41.1	49.8	1092	1069	1132	303	289	318
11 - TURBINE BLOCK VALVE OUTLET	44.3	41.1	49.8	1090	1066	1130	303	289	318
12 - TURBINE INLET	44.3	41.1	49.8	1080	1057	1119	303	289	318
13 - TURBINE OUTLET	44.8	41.6	50.3	610	595	625	267	254	280
14 - TURBINE DISCHARGE BLOCK VALVE INLET	44.8	41.6	50.3	610	595	625	267	254	280
15 - TURBINE DISCHARGE BLOCK VALVE OUTLET	44.8	41.6	50.3	606	591	621	267	254	280
16 - STAGE PRESSURANT LINE INLET	0.40	0.34	0.46	577	564	591	282	268	295
17 - COME INLET LINE OUTLET	73.5	71.9	75.1	567	554	579	282	268	295
18 - THRUST CHAMBER	73.5	71.9	75.1	360	356	365	4251	4209	4294
19 - PROPELLANT TANK OUTLET	0.0	0.0	0.0	30.0	29.2	30.8	40.6	40.3	40.9
20 - COOLDOWN SHUTOFF VALVE INLET	0.0	0.0	0.0	30.0	29.2	30.8	40.6	40.3	40.9
21 - COOLDOWN SHUTOFF VALVE OUTLET	0.0	0.0	0.0	0.0	0.0	0.0	51.0	50.2	52.2
22 - COOLDOWN SUPPLY CONTROL VALVE OUTLET	0.0	0.0	0.0	1173	1147	1217	61.3	60.0	63.5

Reactivity (\$)

	Pos	Neg
	+	-
Total Feedback	0.73	
Stem Hydrogen Worth	2.75	--
Core Hydrogen Worth	0.86	--
Reflector Hydrogen Worth	0.33	--
Core Temperature + Corrosion	--	3.26
	3.99	
Drum Worth	--	0.73
	3.99	3.99

STATE POINT CONDITIONS AND SPECIFICATION EXTREMES
75K FULL FLOW NERVA ENGINE - DRAWING NUMBER 1137400E

REFER TO DRAWING NUMBER 1137456 FOR STATE POINT LOCATIONS

1137400E REFERENCE ENGINE - END OF LIFE - 1 TPA 80% THRUST

PC = 360. PSIA TRCV POSITION = 63.9 DEGREES THRUST = 60500. LBF TURBINE EFFICIENCY = 85.7 % PUMP EFFICIENCY = 64.5 %
TC = 4251. DEGREES P SSCV POSITION = 38.5 DEGREES ISP = 822.7 SEC BYPASS FRACTION = 39.6 % PUMP SPEED = 27261. RPM
CRUM POSITION = 58.5 DEGREES NPSP = 1.7 PSI FEEDBACK REACTIVITY = 0.73 %
PDCV POSITION = 46.2 DEGREES

NETAP RESTART TAPE 21239 AT 278. SECONDS PLOTTED AT 280. SECONDS

	FLOW RATE (LBS/SEC)			PRESSURE (PSIA)			TEMPERATURE (DEGREES R)		
	NOMINAL	MIN	MAX	NOMINAL	MIN	MAX	NOMINAL	MIN	MAX
9.1 - PUMP DISCHARGE JUNCTION INLET	73.4	71.8	75.0	1330	1299	1383	60.0	58.7	62.2
9.2 - PUMP DISCHARGE LINE JUNCTION OUTLET	73.4	71.8	75.0	1326	1295	1378	60.0	58.7	62.2
9.3 - STRUCTURAL SUPPORT COOLANT LINE INLET	10.2	10.1	10.2	1288	1258	1338	60.4	59.1	62.6
9.4 - PUMP DISCHARGE VALVE MODULE INLET	63.2	61.5	64.9	1286	1257	1337	60.4	59.1	62.6
9.5 - STRUCTURAL SUPPORT MODULE INLET	10.2	10.1	10.2	1285	1255	1336	60.5	59.2	62.7
12.1 - MIDDLE PUMP DISCHARGE LINE INLET	63.2	61.5	64.9	1274	1245	1324	60.5	59.2	62.7
15.1 - STRUCTURAL SUPPORT MODULE OUTLET	10.2	10.1	10.2	1173	1147	1217	61.3	60.0	63.5
15.2 - COOLDOWN SUPPLY LINE OUTLET	10.2	10.1	10.2	1171	1145	1215	61.3	60.0	63.5
16.1 - STRUCTURAL SUPPORT BYPASS LINE INLET	2.36	2.30	2.42	1271	1242	1321	60.6	59.3	62.8
19.1 - STEM OUTLET IN CORE SUPPORT PLATE	10.2	10.1	10.2	1115	1090	1156	579	449	709
22.1 - REFLECTOR PRESSURE VESSEL ANNULUS - MIDPOINT	5.20	5.00	5.40	1149	1123	1192	246	234	260
23.1 - REFLECTOR OUTLET	55.6	54.1	57.1	1112	1088	1153	270	257	284
23.2 - STRUCTURAL SUPPORT OUTLET	12.5	12.5	12.6	1112	1088	1154	469	410	528
23.3 - PERIPHERAL SHIELD INLET	53.2	52.0	54.4	1112	1088	1154	303	289	318
26.1 - TURBINE BYPASS LINE INLET	29.0	24.2	31.8	1097	1073	1138	303	289	318
26.2 - TURBINE BYPASS MODULE INLET	29.0	24.2	31.8	1087	1063	1127	303	291	315
29.1 - TURBINE BYPASS MODULE OUTLET	29.0	24.2	31.8	731	717	745	303	289	318
29.2 - TURBINE BYPASS LINE OUTLET	29.0	24.2	31.8	592	577	606	303	290	316
29.3 - TURBINE LINE JUNCTION INLET	44.3	41.1	49.8	1097	1073	1138	303	289	318
29.4 - TURBINE LINE DUAL LEG INLET	44.3	41.1	49.8	1092	1069	1133	303	289	318
35.1 - TURBINE DISCHARGE LINE JUNCTION INLET	44.8	41.6	50.3	606	591	620	267	254	280
35.2 - TURBINE DISCHARGE LINE SINGLE LEG INLET	73.9	72.3	75.5	601	587	616	282	268	295
37.1 - CENTRAL SHIELD INLET	73.5	71.9	75.1	523	511	534	282	268	295
37.2 - CORE SUPPORT PLATE INLET	73.5	71.9	75.1	516	504	527	282	269	295
37.3 - CORE INLET	73.5	71.9	75.1	505	494	516	285	272	299

STATE POINT CONDITIONS AND SPECIFICATION EXTREMES

75K FULL FLOW NERVA ENGINE - DRAWING NUMBER 1137400E

REFER TO DRAWING NUMBER 1137456 FOR STATE POINT LOCATIONS

1137400E REFERENCE ENGINE - START OF LIFE - NORMAL - 60% THRUST

NTSOL
ThrustLine

PC = 270. PSIA TRCV POSITION = 61.8 DEGREES THRUST = 45400. LRF TURBINE EFFICIENCY = 84.8 % PUMP EFFICIENCY = 61.0 %
 TC = 4254. DEGREES R SSCV POSITION = 24.9 DEGREES ISP = 823.5 SEC BYPASS FRACTION = 21.1 % PUMP SPEED = 19463. RPM
 CRUM POSITION = 70.0 DEGREES NPSP = 7.2 PSI FEEDBACK REACTIVITY = 0.35 %
 PDCV POSITION = 46.2 DEGREES

NETAP RESTART TAPE 21350 AT 277. SECONDS PLOTTED AT 277. SECONDS

	FLOW RATE (LBS/SEC)			PRESSURE (PSIA)			TEMPERATURE (DEGREES R)		
	NOMINAL	MIN	MAX	NOMINAL	MIN	MAX	NOMINAL	MIN	MAX
1 - PROPELLANT TANK OUTLET	27.7	26.9	28.5	22.0	21.2	22.8	36.5	36.2	36.8
2 - PROPELLANT SHUTOFF VALVE INLET	27.7	26.9	28.5	22.0	21.2	22.8	36.4	36.1	36.7
3 - PROPELLANT SHUTOFF VALVE OUTLET	27.7	26.9	28.5	22.0	21.2	22.8	36.4	36.1	36.7
4 - PUMP INLET	27.7	26.9	28.5	21.9	21.1	22.7	36.4	36.1	36.7
5 - PUMP OUTLET	27.5	26.7	28.3	992	967	1035	51.8	51.3	52.7
6 - PUMP DISCHARGE CHECK VALVE ACTUATOR INLET	27.5	26.7	28.3	992	967	1035	51.7	51.2	52.6
7 - PUMP DISCHARGE CHECK VALVE ACTUATOR OUTLET	27.5	26.7	28.3	990	965	1033	51.7	51.2	52.6
8 - PUMP DISCHARGE CHECK VALVE INLET	27.5	26.7	28.3	990	965	1033	51.7	51.2	52.6
9 - PUMP DISCHARGE CHECK VALVE OUTLET	27.5	26.7	28.3	988	963	1031	51.7	51.2	52.6
10 - PUMP DISCHARGE FLOCK VALVE INLET	23.4	22.6	24.3	981	956	1024	51.8	51.3	52.7
11 - PUMP DISCHARGE FLOCK VALVE OUTLET	23.4	22.6	24.3	980	955	1023	51.8	51.3	52.7
12 - PUMP DISCHARGE CONTROL VALVE OUTLET	23.4	22.6	24.3	978	953	1021	51.8	51.3	52.7
13 - STRUCTURAL SUPPORT FLOCK VALVE INLET	4.07	4.04	4.10	981	956	1024	51.8	51.3	52.7
14 - STRUCTURAL SUPPORT FLOCK VALVE OUTLET	4.07	4.04	4.10	981	956	1024	51.8	51.3	52.7
15 - STRUCTURAL SUPPORT CONTROL VALVE OUTLET	4.07	4.04	4.10	725	706	759	53.8	53.3	54.7
16 - STRUCTURAL SUPPORT COOLANT LINE OUTLET (PV DOME)	8.15	8.09	8.21	723	703	756	53.8	53.3	54.7
17 - STRUCTURAL SUPPORT BYPASS ORIFICE INLET	2.13	2.07	2.19	778	757	813	53.3	52.8	54.2
18 - STRUCTURAL SUPPORT BYPASS ORIFICE OUTLET	2.13	2.07	2.19	675	657	707	53.3	52.8	54.2
19 - STRUCTURAL SUPPORT BYPASS LINE OUTLET (PV DOME)	2.13	2.07	2.19	666	647	697	53.5	53.0	54.4
20 - LOWER PUMP DISCHARGE LINE OUTLET	44.7	43.0	46.4	784	763	820	53.4	52.9	54.3
22 - NOZZLE TUBES OUTLET	44.7	43.0	46.4	687	667	720	210	200	220
23 - REFLECTOR PRESSURE VESSEL ANNULUS OUTLET	3.84	3.64	4.04	654	625	685	288	278	298
24 - PERIPHERAL SHIELD PRESSURE VESSEL ANNULUS OUTLET	15.2	14.8	15.6	647	629	678	313	303	323
25 - PERIPHERAL SHIELD OUTLET	39.8	38.6	41.0	647	629	678	313	303	323
26 - DOME TURBINE LINE INLET	55.0	53.4	56.6	644	626	675	313	303	323

5.05

STATE POINT CONDITIONS AND SPECIFICATION EXTREMES

75K FULL FLOW NERVA ENGINE - DRAWING NUMBER 1137400E

REFER TO DRAWING NUMBER 1137456 FOR STATE POINT LOCATIONS

1137400E REFERENCE ENGINE - START OF LIFE - NORMAL - 60% THRUST

PC = 270. PSIA TBCV POSITION = 61.8 DEGREES THRUST = 45400. LBF TURBINE EFFICIENCY = 84.8 % PUMP EFFICIENCY = 61.0 %
TC = 4254. DEGREES R SSCV POSITION = 24.9 DEGREES ISP = 823.5 SEC BYPASS FRACTION = 21.1 % PUMP SPEED = 19463. RPM
DRUM POSITION = 70.0 DEGREES NPSP = 7.2 PSI FEEDBACK REACTIVITY = 0.35 %
PDCV POSITION = 46.2 DEGREES

NETAP RESTART TAPE 21350 AT 277. SECONDS PLOTTED AT 277. SECONDS

	FLOW RATE (LBS/SEC)			PRESSURE (PSIA)			TEMPERATURE (DEGREES R)		
	NOMINAL	MIN	MAX	NOMINAL	MIN	MAX	NOMINAL	MIN	MAX
27 - TURBINE BYPASS BLOCK VALVE INLET	5.79	4.69	6.44	635	617	665	313	303	323
28 - TURBINE BYPASS BLOCK VALVE OUTLET	5.79	4.69	6.44	634	616	664	313	303	323
29 - TURBINE BYPASS CONTROL VALVE OUTLET	5.79	4.69	6.44	516	505	528	313	303	323
30 - TURBINE BLOCK VALVE INLET	21.7	20.3	23.2	631	613	661	313	303	323
31 - TURBINE BLOCK VALVE OUTLET	21.7	20.3	23.2	627	609	657	313	303	323
32 - TURBINE INLET	21.7	20.3	23.2	627	609	657	313	303	323
33 - TURBINE OUTLET	21.9	21.0	23.5	457	446	469	292	282	302
34 - TURBINE DISCHARGE BLOCK VALVE INLET	21.9	21.0	23.5	457	445	468	292	282	302
35 - TURBINE DISCHARGE BLOCK VALVE OUTLET	21.9	21.0	23.5	452	440	463	292	282	302
36 - STAGE PRESSURANT LINE INLET	0.31	0.25	0.37	441	430	452	296	286	306
37 - COMB INLET LINE OUTLET	55.1	53.5	56.7	432	431	452	296	286	306
38 - THRUST CHAMBER	55.1	53.5	56.7	270	265	275	4254	4211	4297
39 - PROPELLANT TANK OUTLET	0.0	0.0	0.0	22.0	21.2	22.8	36.5	36.2	36.8
40 - COOLDOWN SHUTOFF VALVE INLET	0.0	0.0	0.0	22.0	21.2	22.8	36.5	36.2	36.8
41 - COOLDOWN SHUTOFF VALVE OUTLET	0.0	0.0	0.0	0.0	0.0	0.0	45.2	44.8	45.8
42 - COOLDOWN SUPPLY CONTROL VALVE OUTLET	0.0	0.0	0.0	724	705	758	53.8	53.3	54.7

Reactivity (\$)

	Pos +	Neg -
Total Feedback	0.35	
Stem Hydrogen Worth	1.71	--
Core Hydrogen Worth	0.64	--
Reflector Hydrogen Worth	0.22	--
Core Temperature	--	2.22
	2.57	
Drum Worth	--	0.35
	2.57	2.57

STATE POINT CONDITIONS AND SIGNIFICATION EXTREMES

75K FULL FLOW NERVA ENGINE - DRAWING NUMBER 1137400E

REFER TO DRAWING NUMBER 1137456 FOR STATE POINT LOCATIONS

1137400E REFERENCE ENGINE - START OF LIFE - NORMAL - 60% THRUST *Throttling*

DC = 270. PSIA TPCV POSITION = 61.8 DEGREES THRUST = 45400. LBF TURBINE EFFICIENCY = 84.8 % PUMP EFFICIENCY = 61.0 %
TC = 4254. DEGREES R SSCV POSITION = 24.9 DEGREES ISP = 823.5 SFC BYPASS FRACTION = 21.1 % PUMP SPEED = 19463. RPM
DRUM POSITION = 70.0 DEGREES NPSP = 7.2 PSI FEEDBACK REACTIVITY = 0.35 %
PDCV POSITION = 46.2 DEGREES

NETAP RESTART TAPE 21350 AT 277. SECONDS PLOTTED AT 277. SECONDS

	FLOW RATE (LBS/SEC)			PRESSURE (PSIA)			TEMPERATURE (DEGREES R)		
	NOMINAL	MIN	MAX	NOMINAL	MIN	MAX	NOMINAL	MIN	MAX
9.1 - PUMP DISCHARGE JUNCTION INLET	27.5	26.7	28.3	987	962	1030	51.7	51.2	52.6
9.2 - PUMP DISCHARGE LINE JUNCTION OUTLET	55.0	53.4	56.6	984	959	1027	51.7	51.2	52.6
9.3 - STRUCTURAL SUPPORT COOLANT LINE INLET	8.15	8.09	8.21	983	958	1026	51.8	51.3	52.7
9.4 - PUMP DISCHARGE VALVE MODULE INLET	46.8	45.1	48.5	982	957	1025	51.8	51.3	52.7
9.5 - STRUCTURAL SUPPORT MODULE INLET	8.15	8.09	8.21	981	956	1024	51.8	51.3	52.7
12.1 - MIDDLE PUMP DISCHARGE LINE INLET	46.8	45.1	48.5	788	766	824	53.3	52.8	54.2
15.1 - STRUCTURAL SUPPORT MODULE OUTLET	8.15	8.09	8.21	724	705	758	53.8	53.3	54.7
15.2 - COOLDOWN SUPPLY LINE OUTLET	8.15	8.09	8.21	723	703	756	53.8	53.3	54.7
16.1 - STRUCTURAL SUPPORT BYPASS LINE INLET	2.13	2.07	2.19	786	764	822	53.3	52.8	54.2
19.1 - STEM OUTLET IN CORE SUPPORT PLATE	8.15	8.09	8.21	657	638	688	633	502	763
22.1 - REFLECTOR PRESSURE VESSEL ANNULUS - MIDPOINT	3.84	3.64	4.04	687	667	720	251	242	262
23.1 - REFLECTOR OUTLET	40.8	39.3	42.3	654	635	685	272	263	283
23.2 - STRUCTURAL SUPPORT OUTLET	10.3	10.2	10.3	654	635	685	496	437	555
23.3 - PERIPHERAL SHIELD INLET	39.8	38.6	41.0	654	635	685	313	303	323
26.1 - TURBINE BYPASS LINE INLET	11.6	9.38	12.9	639	621	670	313	303	323
26.2 - TURBINE BYPASS MODULE INLET	11.6	9.38	12.9	636	618	667	313	303	323
29.1 - TURBINE BYPASS MODULE OUTLET	11.6	9.38	12.9	511	499	522	313	303	323
29.2 - TURBINE BYPASS LINE OUTLET	11.6	9.38	12.9	451	440	462	313	303	323
29.3 - TURBINE LINE JUNCTION INLET	43.4	41.6	46.5	639	621	670	313	303	323
29.4 - TURBINE LINE DUAL LEG INLET	21.7	20.9	23.2	631	614	661	313	303	323
35.1 - TURBINE DISCHARGE LINE JUNCTION INLET	21.9	21.0	23.5	451	440	462	292	282	302
35.2 - TURBINE DISCHARGE LINE SINGLE LEG INLET	55.4	53.8	57.0	445	434	456	296	286	306
37.1 - CENTRAL SHIELD INLET	55.1	53.5	56.7	399	389	409	296	286	306
37.2 - CORE SUPPORT PLATE INLET	55.1	53.5	56.7	393	383	403	297	287	307
37.3 - CORE INLET	55.1	53.5	56.7	385	375	394	300	290	310

STATE POINT CONDITIONS AND SPECIFICATION EXTREMES

75K FULL FLOW NERVA ENGINE - DRAWING NUMBER 1137400E

REFER TO DRAWING NUMBER 1137456 FOR STATE POINT LOCATIONS

1137400E REFERENCE ENGINE - END OF LIFE - NORMAL - 60% THRUST

NTROL
Throttling

FC = 270. PSIA TBCV POSITION = 64.4 DEGREES THRUST = 45300. LBF TURBINE EFFICIENCY = 84.7 % PUMP EFFICIENCY = 62.0 %
TC = 4248. DEGREES R SSCV POSITION = 37.8 DEGREES ISP = 822.8 SEC BYPASS FRACTION = 23.0 % PUMP SPEED = 19521. RPM
PCUM POSITION = 70.0 DEGREES NPSP = 0.0 PSI FEEDBACK REACTIVITY = 0.36 %
PDCV POSITION = 46.2 DEGREES

NETAP RESTART TAPE 21348 AT 2P0. SECONDS PLOTTED AT 280. SECONDS

	FLOW RATE (LBS/SEC)			PRESSURE (PSIA)			TEMPERATURE (DEGREES R)		
	NOMINAL	MIN	MAX	NOMINAL	MIN	MAX	NOMINAL	MIN	MAX
1 - PROPELLANT TANK OUTLET	27.7	26.9	28.5	28.0	27.2	28.8	40.6	40.3	40.9
2 - PROPELLANT SHUTOFF VALVE INLET	27.7	26.9	28.5	28.0	27.2	28.8	40.7	40.4	41.0
3 - PROPELLANT SHUTOFF VALVE OUTLET	27.7	26.9	28.5	28.0	27.2	28.8	40.7	40.4	41.0
4 - PUMP INLET	27.7	26.9	28.5	27.9	27.1	28.7	40.6	40.3	40.9
5 - PUMP OUTLET	27.5	26.7	28.3	955	929	998	55.5	55.0	56.4
6 - PUMP DISCHARGE CHECK VALVE ACTUATOR INLET	27.5	26.7	28.3	955	929	998	55.5	55.0	56.4
7 - PUMP DISCHARGE CHECK VALVE ACTUATOR OUTLET	27.5	26.7	28.3	953	927	996	55.5	55.0	56.4
8 - PUMP DISCHARGE CHECK VALVE INLET	27.5	26.7	28.3	953	927	996	55.5	55.0	56.4
9 - PUMP DISCHARGE CHECK VALVE OUTLET	27.5	26.7	28.3	951	925	993	55.5	55.0	56.4
10 - PUMP DISCHARGE BLOCK VALVE INLET	21.3	20.5	22.2	943	918	986	55.6	55.1	56.5
11 - PUMP DISCHARGE BLOCK VALVE OUTLET	21.3	20.5	22.2	942	917	985	55.6	55.1	56.5
12 - PUMP DISCHARGE CONTROL VALVE OUTLET	21.3	20.5	22.2	941	916	983	55.6	55.1	56.5
13 - STRUCTURAL SUPPORT BLOCK VALVE INLET	6.14	6.11	6.17	940	915	983	55.6	55.1	56.5
14 - STRUCTURAL SUPPORT BLOCK VALVE OUTLET	6.14	6.11	6.17	940	915	983	55.6	55.1	56.5
15 - STRUCTURAL SUPPORT CONTROL VALVE OUTLET	6.14	6.11	6.17	755	734	790	56.7	56.2	57.6
16 - STRUCTURAL SUPPORT COOLANT LINE OUTLET (PV DCMF)	12.3	12.2	12.3	750	729	785	56.8	56.3	57.7
17 - STRUCTURAL SUPPORT BYPASS ORIFICE INLET	2.00	1.94	2.06	767	747	803	56.6	56.1	57.5
18 - STRUCTURAL SUPPORT BYPASS ORIFICE OUTLET	2.00	1.94	2.06	674	656	706	56.6	56.1	57.5
19 - STRUCTURAL SUPPORT BYPASS LINE OUTLET (PV DCMF)	2.00	1.94	2.06	666	647	697	56.7	56.2	57.6
20 - LOWER PUMP DISCHARGE LINE OUTLET	27.3 40.7	39.0	42.4	773	752	809	56.7	56.2	57.6
22 - NOZZLE TUBES OUTLET	40.7	39.0	42.4	683	664	716	226	217	236
23 - REFLECTOR PRESSURE VESSEL ANNULUS OUTLET	3.51	3.31	3.71	653	635	685	309	300	320
24 - PERIPHERAL SHIELD PRESSURE VESSEL ANNULUS OUTLET	15.2	14.8	15.6	647	628	678	323	313	333
25 - PERIPHERAL SHIELD OUTLET	39.8	38.6	41.0	647	628	678	323	313	333
26 - DCMF TURBINE LINE INLET	55.0	53.4	56.6	644	625	675	323	313	333

4.34

does not include the elbow loss

Down at 70°

STATE POINT CONDITIONS AND SPECIFICATION EXTREMES

75K FULL FLOW NERVA ENGINE - DRAWING NUMBER 1137400E

REFER TO DRAWING NUMBER 1137456 FOR STATE POINT LOCATIONS

1137400E REFERENCE ENGINE - END OF LIFE - NORMAL - 60% THRUST

PC = 270. PSIA TPCV POSITION = 64.4 DEGREES THRUST = 45300. LBF TURBINE EFFICIENCY = 84.7 % PUMP EFFICIENCY = 62.0 %
 TC = 4248. DEGREES R SSCV POSITION = 37.8 DEGREES ISP = 822.8 SFC BYPASS FRACTION = 23.0 % PUMP SPEED = 19521. RPM
 DRUM POSITION = 70.0 DEGREES NPSP = 0.0 PSI FEEDBACK REACTIVITY = 0.36 %
 PDCV POSITION = 46.2 DEGREES

NETAP RESTART TAPE 21348 AT 280. SECONDS PLOTTED AT 280. SECONDS

	FLOW RATE (LBS/SEC)			PRESSURE (PSIA)			TEMPERATURE (DEGREES R)		
	NOMINAL	MIN	MAX	NOMINAL	MIN	MAX	NOMINAL	MIN	MAX
27 - TURBINE BYPASS BLOCK VALVE INLET	6.33	5.23	6.98	633	615	664	323	313	332
28 - TURBINE BYPASS BLOCK VALVE OUTLET	6.33	5.23	6.98	632	614	662	323	313	332
29 - TURBINE BYPASS CONTROL VALVE OUTLET	6.33	5.23	6.98	532	520	544	322	313	333
30 - TURBINE BLOCK VALVE INLET	21.2	20.3	22.7	630	612	660	323	313	333
31 - TURBINE BLOCK VALVE OUTLET	21.2	20.3	22.7	626	609	656	323	313	333
32 - TURBINE INLET	21.2	20.3	22.7	626	609	656	323	313	333
33 - TURBINE OUTLET	21.4	20.5	22.9	460	448	471	300	290	310
34 - TURBINE DISCHARGE BLOCK VALVE INLET	21.4	20.5	22.9	459	448	471	300	290	310
35 - TURBINE DISCHARGE BLOCK VALVE OUTLET	21.4	20.5	22.9	454	443	466	300	290	310
36 - STAGE PRESSURANT LINE INLET	0.31	0.25	0.37	443	432	454	305	295	315
37 - CORE INLET LINE OUTLET	55.1	53.5	56.7	434	424	445	305	295	315
38 - THRUST CHAMBER	55.1	53.5	56.7	270	265	275	4248	4206	4291
39 - PROPELLANT TANK OUTLET	0.0	0.0	0.0	28.0	27.2	28.8	40.6	40.3	40.9
40 - COOLDOWN SHUTOFF VALVE INLET	0.0	0.0	0.0	28.0	27.2	28.8	40.6	40.3	40.9
41 - COOLDOWN SHUTOFF VALVE OUTLET	0.0	0.0	0.0	0.0	0.0	0.0	48.7	48.3	49.3
42 - COOLDOWN SUPPLY CONTROL VALVE OUTLET	0.0	0.0	0.0	753	732	788	56.8	56.3	57.7

Reactivity (\$)

	Pos +	Neg -
Total Feedback	0.36	
Stem Hydrogen Worth	2.73	--
Core Hydrogen Worth	0.64	--
Reflector Hydrogen Worth	0.20	--
Core Temperature + Corrosion	--	3.21
	3.57	
Drum Worth	--	0.36

STATE POINT CONDITIONS AND SPECIFICATION EXTREMES

75K FULL FLOW NEVA ENGINE - DRAWING NUMBER 1137400E

REFER TO DRAWING NUMBER 1137456 FOR STATE POINT LOCATIONS

1137400E REFERENCE ENGINE - END OF LIFE - NORMAL - 60% THRUST

PC = 270. PSIA TBCV POSITION = 64.4 DEGREES THRUST = 45300. LBF TURBINE EFFICIENCY = 84.7 % PUMP EFFICIENCY = 62.0 %
TC = 4248. DEGREES R SSCV POSITION = 27.8 DEGREES ISP = 822.9 SEC BYPASS FRACTION = 23.0 % PUMP SPEED = 19521. RPM
CRUM POSITION = 70.0 DEGREES NRSP = 0.0 PSI FEEDBACK REACTIVITY = 0.36 %
PDCV POSITION = 46.2 DEGREES

NETAP RESTART TAPE 21348 AT 280. SECONDS PLOTTED AT 280. SECONDS

	FLOW RATE (LBS/SEC)			PRESSURE (PSIA)			TEMPERATURE (DEGREES R)		
	NOMINAL	MIN	MAX	NOMINAL	MIN	MAX	NOMINAL	MIN	MAX
9.1 - PUMP DISCHARGE JUNCTION INLET	27.5	26.7	28.3	949	924	992	55.5	55.0	56.4
9.2 - PUMP DISCHARGE LINE JUNCTION OUTLET	55.0	53.4	56.6	946	921	989	55.5	55.0	56.4
9.3 - STRUCTURAL SUPPORT COOLANT LINE INLET	12.3	12.2	12.3	945	920	988	55.6	55.1	56.5
9.4 - PUMP DISCHARGE VALVE MODULE INLET	42.7	41.0	44.4	944	919	987	55.6	55.1	56.5
9.5 - STRUCTURAL SUPPORT MODULE INLET	12.3	12.2	12.3	941	916	983	55.6	55.1	56.5
12.1 - MIDDLE PUMP DISCHARGE LINE INLET	42.7	41.0	44.4	776	754	812	56.6	56.1	57.5
15.1 - STRUCTURAL SUPPORT MODULE OUTLET	12.3	12.2	12.3	753	732	788	56.7	56.2	57.6
15.2 - COOLANT SUPPLY LINE OUTLET	12.3	12.2	12.3	750	729	785	56.8	56.3	57.7
16.1 - STRUCTURAL SUPPORT BYPASS LINE INLET	2.00	1.94	2.06	775	753	811	56.6	56.1	57.5
19.1 - STEM OUTLET IN CORE SUPPORT PLATE	12.3	12.2	12.3	657	639	689	450	320	580
22.1 - REFLECTOR PRESSURE VESSEL ANNULUS - MIDPOINT	3.51	3.31	3.71	683	664	716	270	260	280
23.1 - REFLECTOR OUTLET	37.2	35.7	38.7	653	635	685	298	288	308
23.2 - STRUCTURAL SUPPORT OUTLET	14.3	14.2	14.3	653	635	685	392	333	451
27.3 - PERIPHERAL SHIELD INLET	39.8	38.6	41.0	653	635	685	323	313	333
26.1 - TURBINE BYPASS LINE INLET	12.7	10.5	14.0	639	620	669	323	313	333
26.2 - TURBINE BYPASS MODULE INLET	12.7	10.5	14.0	635	617	665	323	313	332
29.1 - TURBINE BYPASS MODULE OUTLET	12.7	10.5	14.0	525	514	536	322	313	333
29.2 - TURBINE BYPASS LINE OUTLET	12.7	10.5	14.0	454	442	465	322	312	332
29.3 - TURBINE LINE JUNCTION INLET	42.3	40.5	45.4	638	620	669	322	313	333
29.4 - TURBINE LINE DUAL LEG INLET	21.2	20.3	22.7	630	613	661	323	313	333
35.1 - TURBINE DISCHARGE LINE JUNCTION INLET	21.4	20.5	22.9	454	442	465	300	290	310
35.2 - TURBINE DISCHARGE LINE SINGLE LEG INLET	55.4	53.8	57.0	448	436	459	305	295	315
37.1 - CENTRAL SHIELD INLET	55.1	53.5	56.7	400	390	410	305	295	315
37.2 - CORE SUPPORT PLATE INLET	55.1	53.5	56.7	394	384	404	306	296	316
37.3 - CORE INLET	55.1	53.5	56.7	386	376	395	309	299	319

STATE POINT CONDITIONS AND SPECIFICATION EXTREMES
75K FULL FLOW NERVA ENGINE - DRAWING NUMBER 1137400E

REFER TO DRAWING NUMBER 1137456 FOR STATE POINT LOCATIONS

1137400E REFERENCE ENGINE - START OF LIFE - 1 TPA 60% THRUST

MT SOL

THROTLING

PC = 270. PSIA TRCV POSITION = 71.3 DEGREES THRUST = 45300. LBF TURBINE EFFICIENCY = 84.0 % PUMP EFFICIENCY = 66.9 %
TC = 4253. DEGREES R SSCV POSITION = 28.5 DEGREES ISP = 823.4 S/C BYPASS FRACTION = 48.3 % PUMP SPEED = 22012. RPM
CRUM POSITION = 70.0 DEGREES NPSP = 9.0 PSI FEEDBACK REACTIVITY = 0.35 %
PDCV POSITION = 56.5 DEGREES

NETAP RESTART TAPE 21223 AT 282. SECONDS PLOTTED AT 282. SECONDS

	FLOW RATE (LBS/SFC)			PRESSURE (PSIA)			TEMPERATURE (DEGREES R)		
	NOMINAL	MIN	MAX	NOMINAL	MIN	MAX	NOMINAL	MIN	MAX
1 - PROPELLANT TANK OUTLET	55.4	53.8	57.0	24.0	23.2	24.8	36.5	36.2	36.8
2 - PROPELLANT SHUTOFF VALVE INLET	55.4	53.8	57.0	24.0	23.2	24.8	36.4	36.1	36.7
3 - PROPELLANT SHUTOFF VALVE OUTLET	55.4	53.8	57.0	24.0	23.2	24.8	36.4	36.1	36.7
4 - PUMP INLET	55.4	53.8	57.0	23.8	23.0	24.6	36.4	36.1	36.7
5 - PUMP OUTLET	54.9	53.3	56.5	998	973	1041	49.7	49.2	50.6
6 - PUMP DISCHARGE CHECK VALVE ACTUATOR INLET	54.9	53.3	56.5	998	973	1041	49.7	49.2	50.6
7 - PUMP DISCHARGE CHECK VALVE ACTUATOR OUTLET	54.9	53.3	56.5	997	971	1039	49.7	49.2	50.6
8 - PUMP DISCHARGE CHECK VALVE INLET	54.9	53.3	56.5	997	971	1039	49.7	49.2	50.6
9 - PUMP DISCHARGE CHECK VALVE OUTLET	54.9	53.3	56.5	995	969	1037	49.7	49.2	50.6
10 - PUMP DISCHARGE BLOCK VALVE INLET	23.8	23.0	24.7	969	944	1010	50.0	49.5	50.9
11 - PUMP DISCHARGE BLOCK VALVE OUTLET	23.8	23.0	24.7	967	943	1009	50.0	49.5	50.9
12 - PUMP DISCHARGE CONTROL VALVE OUTLET	23.8	23.0	24.7	966	941	1007	50.0	49.5	50.9
13 - STRUCTURAL SUPPORT BLOCK VALVE INLET	3.61	3.58	3.64	969	944	1010	50.0	49.5	50.9
14 - STRUCTURAL SUPPORT BLOCK VALVE OUTLET	3.61	3.58	3.64	969	944	1010	50.0	49.5	50.9
15 - STRUCTURAL SUPPORT CONTROL VALVE OUTLET	3.61	3.58	3.64	809	789	843	51.4	50.9	52.3
16 - STRUCTURAL SUPPORT COOLANT LINE OUTLET (PV DCME)	7.22	7.16	7.28	808	788	841	51.4	50.9	52.3
17 - STRUCTURAL SUPPORT BYPASS ORIFICE INLET	2.08	2.02	2.14	866	845	902	50.8	50.3	51.7
18 - STRUCTURAL SUPPORT BYPASS ORIFICE OUTLET	2.08	2.02	2.14	771	753	803	50.8	50.3	51.7
19 - STRUCTURAL SUPPORT BYPASS LINE OUTLET (PV DCME)	2.08	2.02	2.14	763	745	794	51.0	50.5	51.9
20 - LOWER PUMP DISCHARGE LINE OUTLET	45.6	43.9	47.3	862	840	899	50.9	50.4	51.8
22 - NOZZLE TUBES OUTLET	45.6	43.9	47.3	782	763	815	205	196	215
23 - REFLECTOR PRESSURE VESSEL ANNULUS OUTLET	3.92	3.72	4.12	752	734	783	282	272	292
24 - PERIPHERAL SHIELD PRESSURE VESSEL ANNULUS OUTLET	15.2	14.8	15.6	747	728	778	311	301	321
25 - PERIPHERAL SHIELD OUTLET	39.7	38.5	40.9	747	728	778	310	300	320
26 - DCME TURBINE LINE INLET	54.9	53.3	56.5	744	725	775	310	300	320

6.0

PER R.J. GULLEY
6-30-71

STATE POINT CONDITIONS AND SPECIFICATION EXTREMES

75K FULL FLOW NPVA ENGINE - DRAWING NUMBER 1137400E

REFER TO DRAWING NUMBER 1137456 FOR STATE POINT LOCATIONS

1137400E REFERENCE ENGINE - START OF LIFE - 1 TPA 60% THRUST

FC = 270.0 PSIA TPCV POSITION = 71.3 DEGREES THRUST = 45300.0 LBF TURBINE EFFICIENCY = 84.0 % PUMP EFFICIENCY = 66.5 %
TC = 4253.0 DEGREES R SSCV POSITION = 28.5 DEGREES ISF = 823.4 SFC BYPASS FRACTION = 48.3 % PUMP SPEED = 22012.0 RPM
DRUM POSITION = 70.0 DEGREES NPSP = 9.0 PSI FEEDBACK REACTIVITY = 0.35 %
PDCV POSITION = 56.5 DEGREES

NETAP RESTART TAPE 21223 AT 282.0 SECONDS PLOTTED AT 282.0 SECONDS

	FLOW RATE (LES/SEC)			PRESSURE (PSIA)			TEMPERATURE (DEGREES R)		
	NOMINAL	MIN	MAX	NOMINAL	MIN	MAX	NOMINAL	MIN	MAX
27 - TURBINE BYPASS BLOCK VALVE INLET	13.3	12.2	13.9	721	703	751	310	301	320
28 - TURBINE BYPASS BLOCK VALVE OUTLET	13.3	12.2	13.9	717	699	746	310	301	320
29 - TURBINE BYPASS CONTROL VALVE OUTLET	13.3	12.2	13.9	620	608	635	310	300	320
30 - TURBINE BLOCK VALVE INLET	28.4	26.6	31.5	737	719	767	310	300	320
31 - TURBINE BLOCK VALVE OUTLET	28.4	26.6	31.5	735	717	766	310	300	320
32 - TURBINE INLET	28.4	26.6	31.5	729	711	759	310	300	320
33 - TURBINE OUTLET	28.9	27.1	32.0	462	450	473	280	270	290
34 - TURBINE DISCHARGE BLOCK VALVE INLET	28.9	27.1	32.0	461	450	473	280	270	290
35 - TURBINE DISCHARGE BLOCK VALVE OUTLET	28.9	27.1	32.0	459	448	471	280	270	290
36 - STAGE PRESSURANT LINE INLET	0.31	0.25	0.37	440	429	451	295	285	305
37 - CORE INLET LINE OUTLET	55.1	53.5	56.7	431	421	441	295	285	305
38 - THRUST CHAMBER	55.1	53.5	56.7	270	265	275	4253	4210	4296
39 - PROPELLANT TANK OUTLET	0.0	0.0	0.0	24.0	23.2	24.8	36.5	36.2	36.8
40 - COOLDOWN SHUTOFF VALVE INLET	0.0	0.0	0.0	24.0	23.2	24.8	36.5	36.2	36.8
41 - COOLDOWN SHUTOFF VALVE OUTLET	0.0	0.0	0.0	0.0	0.0	0.0	43.9	43.5	44.5
42 - COOLDOWN SUPPLY CONTROL VALVE OUTLET	0.0	0.0	0.0	809	789	842	51.4	50.9	52.3

Reactivity (\$)

	Pos +	Neg -
Total Feedback	0.35	
Stem Hydrogen Worth	1.67	--
Core Hydrogen Worth	0.64	--
Reflector Hydrogen Worth	0.26	--
Core Temperature	--	2.22
	2.57	
Drum Worth		0.35
	2.57	2.57

STATE POINT CONDITIONS AND SPECIFICATION EXTREMES
75K FULL FLOW NERVA ENGINE - DRAWING NUMBER 1137400E

REFER TO DRAWING NUMBER 1137456 FOR STATE POINT LOCATIONS

1137400E REFERENCE ENGINE - START OF LIFE - 1 TPA 60% THRUST

PC = 270. PSIA TPCV POSITION = 71.3 DEGREES THRUST = 45100. LBF TURBINE EFFICIENCY = 84.0 % PUMP EFFICIENCY = 66.9 %
TC = 425.7. DEGREES R SSCV POSITION = 28.5 DEGREES ISP = 823.4 SEC BYPASS FRACTION = 48.3 % PUMP SPEED = 22012. RPM
CRUM POSITION = 70.0 DEGREES NPSP = 9.0 PSI FEEDBACK REACTIVITY = 0.35 %
PDCV POSITION = 56.5 DEGREES

NETAF RESTART TAPE 21223 AT 282. SECONDS PLOTTED AT 282. SECONDS

	FLOW RATE (LBS/SEC)			PRESSURE (PSIA)			TEMPERATURE (DEGREES R)		
	NOMINAL	MIN	MAX	NOMINAL	MIN	MAX	NOMINAL	MIN	MAX
9.1 - PUMP DISCHARGE JUNCTION INLET	54.0	53.3	56.5	993	968	1036	49.7	49.2	50.6
9.2 - PUMP DISCHARGE LINE JUNCTION OUTLET	54.0	53.3	56.5	991	965	1033	49.7	49.2	50.6
9.3 - STRUCTURAL SUPPORT COOLANT LINE INLET	7.22	7.16	7.28	970	946	1012	50.0	49.5	50.9
9.4 - PUMP DISCHARGE VALVE MODULE INLET	47.7	46.0	49.4	969	945	1011	50.0	49.5	50.9
9.5 - STRUCTURAL SUPPORT MODULE INLET	7.22	7.16	7.28	969	944	1010	50.0	49.5	50.9
12.1 - MIDDLE PUMP DISCHARGE LINE INLET	47.7	46.0	49.4	875	853	912	50.8	50.3	51.7
15.1 - STRUCTURAL SUPPORT MODULE OUTLET	7.22	7.16	7.28	809	789	842	51.4	50.9	52.3
15.2 - COOLDOWN SUPPLY LINE OUTLET	7.22	7.16	7.28	808	788	841	51.4	50.9	52.3
16.1 - STRUCTURAL SUPPORT BYPASS LINE INLET	2.08	2.02	2.14	873	851	910	50.8	50.3	51.7
19.1 - STEM OUTLET IN CORE SUPPORT PLATE	7.22	7.16	7.28	755	736	786	697	566	827
22.1 - REFLECTOR PRESSURE VESSEL ANNULUS - MIDPOINT	3.92	3.72	4.12	782	763	815	245	235	255
23.1 - REFLECTOR OUTLET	41.7	40.2	43.2	752	734	783	267	258	278
23.2 - STRUCTURAL SUPPORT OUTLET	9.30	9.24	9.36	752	734	783	531	472	590
23.3 - PERIPHERAL SHIELD INLET	39.7	38.5	40.9	752	734	783	310	301	321
26.1 - TURBINE BYPASS LINE INLET	26.5	24.3	27.8	740	722	770	310	300	320
26.2 - TURBINE BYPASS MODULE INLET	26.5	24.3	27.8	727	709	757	310	301	320
29.1 - TURBINE BYPASS MODULE OUTLET	26.5	24.3	27.8	595	584	607	310	300	320
29.2 - TURBINE BYPASS LINE OUTLET	26.5	24.3	27.8	451	440	462	310	300	320
29.3 - TURBINE LINE JUNCTION INLET	28.4	26.6	31.5	740	722	770	310	300	321
29.4 - TURBINE LINE DUAL LEG INLET	28.4	26.6	31.5	737	719	767	310	300	320
35.1 - TURBINE DISCHARGE LINE JUNCTION INLET	28.9	27.1	32.0	459	448	470	280	270	290
35.2 - TURBINE DISCHARGE LINE SINGLE LEG INLET	55.4	53.8	57.0	456	445	468	295	285	305
37.1 - CENTRAL SHIELD INLET	55.1	53.5	56.7	398	388	394	295	285	305
37.2 - CORE SUPPORT PLATE INLET	55.1	53.5	56.7	392	382	402	295	285	305
37.3 - CORE INLET	55.1	53.5	56.7	384	374	394	298	288	308

STATE POINT CONDITIONS AND SPECIFICATION EXTREMES

75K FULL FLOW NPVA ENGINE - DRAWING NUMBER 1137400E

REFER TO DRAWING NUMBER 1137456 FOR STATE POINT LOCATIONS

1137400E REFERENCE ENGINE - END OF LIFE - 1 TPA 60% THRUST

PC = 270. PSIA TRCV POSITION = 71.7 DEGREES THRUST = 45400. LBF TURBINE EFFICIENCY = 84.0 % PUMP EFFICIENCY = 66.5 %
 TC = 4247. DEGREES R SSCV POSITION = 39.0 DEGREES ISP = 222.7 SEC BYPASS FRACTION = 48.8 % PUMP SPEED = 22429. RPM
 CRUM POSITION = 70.0 DEGREES NPSP = 1.9 PSI FEEDBACK REACTIVITY = 0.34 %
 PDCV POSITION = 56.5 DEGREES

NETAP RESTART TAP 21214 AT 278. SECONDS PLOTTED AT 278. SECONDS

	FLOW RATE (LBS/SEC)			PRESSURE (PSIA)			TEMPERATURE (DEGREES R)		
	NOMINAL	MIN	MAX	NOMINAL	MIN	MAX	NOMINAL	MIN	MAX
1 - PROPELLANT TANK OUTLET	55.5	53.9	57.1	30.0	29.2	30.8	40.6	40.3	40.9
2 - PROPELLANT SHUTOFF VALVE INLET	55.5	53.9	57.1	30.0	29.2	30.8	40.6	40.3	40.9
3 - PROPELLANT SHUTOFF VALVE OUTLET	55.5	53.9	57.1	30.0	29.2	30.8	40.6	40.3	40.9
4 - PUMP INLET	55.5	53.9	57.1	29.7	28.9	30.5	40.6	40.3	40.9
5 - PUMP OUTLET	55.0	53.4	56.6	987	962	1030	54.4	53.9	55.3
6 - PUMP DISCHARGE CHECK VALVE ACTUATOR INLET	55.0	53.4	56.6	987	962	1030	54.4	53.9	55.3
7 - PUMP DISCHARGE CHECK VALVE ACTUATOR OUTLET	55.0	53.4	56.6	985	960	1028	54.4	53.9	55.3
8 - PUMP DISCHARGE CHECK VALVE INLET	55.0	53.4	56.6	985	960	1028	54.4	53.9	55.3
9 - PUMP DISCHARGE CHECK VALVE OUTLET	55.0	53.4	56.6	983	958	1026	54.4	53.9	55.3
10 - PUMP DISCHARGE BLOCK VALVE INLET	22.0	21.2	22.9	956	932	998	54.6	54.1	55.5
11 - PUMP DISCHARGE BLOCK VALVE OUTLET	22.0	21.2	22.9	955	931	996	54.6	54.1	55.5
12 - PUMP DISCHARGE CONTROL VALVE OUTLET	22.0	21.2	22.9	953	929	995	54.6	54.1	55.5
13 - STRUCTURAL SUPPORT BLOCK VALVE INLET	5.48	5.45	5.51	954	929	995	54.6	54.1	55.5
14 - STRUCTURAL SUPPORT BLOCK VALVE OUTLET	5.48	5.45	5.51	954	929	995	54.6	54.1	55.5
15 - STRUCTURAL SUPPORT CONTROL VALVE OUTLET	5.48	5.45	5.51	841	820	876	55.3	54.8	56.2
16 - STRUCTURAL SUPPORT COOLANT LINE OUTLET (PV DCME)	11.0	10.9	11.0	837	816	872	55.3	54.8	56.2
17 - STRUCTURAL SUPPORT BYPASS ORIFICE INLET	1.96	1.90	2.02	865	843	902	55.1	54.6	56.0
18 - STRUCTURAL SUPPORT BYPASS ORIFICE OUTLET	1.96	1.90	2.02	778	759	810	55.1	54.6	56.0
19 - STRUCTURAL SUPPORT BYPASS LINE OUTLET (PV DCME)	1.96	1.90	2.02	770	752	802	55.2	54.7	56.1
20 - LOWER PUMP DISCHARGE LINE OUTLET	42.1	40.4	43.8	870	848	907	55.2	54.7	56.1
22 - NOZZLE TUFFS OUTLET	42.1	40.4	43.8	787	767	820	220	211	230
23 - REFLECTOR PRESSURE VESSEL ANNULUS OUTLET	3.63	3.43	3.83	759	741	791	301	292	312
24 - PERIPHERAL SHIELD PRESSURE VESSEL ANNULUS OUTLET	15.2	14.8	15.6	754	735	785	321	311	332
25 - PERIPHERAL SHIELD OUTLET	39.9	38.7	41.1	753	735	785	321	312	332
26 - DCME TURBINE LINE INLET	55.0	53.4	56.6	751	732	782	321	311	332

4.5

STATE POINT CONDITIONS AND SIFICATION EXTREMES
75K FULL FLOW NERVA ENGINE - DRAWING NUMBER 1137400E

REFER TO DRAWING NUMBER 1137456 FOR STATE POINT LOCATIONS

1137400E REFERENCE ENGINE - END OF LIFE - 1 TPA 60% THRUST

FC = 270. PSIA TBCV POSITION = 71.7 DEGREES THRUST = 45400. LBF TURBINE EFFICIENCY = 84.0 % PUMP EFFICIENCY = 66.5 %
TC = 4247. DEGREES R SSCV POSITION = 70.0 DEGREES ISP = 822.7 SEC BYPASS FRACTION = 48.8 % PUMP SPEED = 22429. RPM
DRUM POSITION = 70.0 DEGREES NPSP = 1.9 PSI FEEDBACK REACTIVITY = 0.34 %
PDCV Position = 56.5 DEGREES

NETAP RESTART TAPE 21214 AT 278. SECONDS PLOTTED AT 278. SECONDS

	FLOW RATE (LBS/SEC)			PRESSURE (PSIA)			TEMPERATURE (DEGREES R)		
	NOMINAL	MIN	MAX	NOMINAL	MIN	MAX	NOMINAL	MIN	MAX
27 - TURBINE BYPASS BLOCK VALVE INLET	13.4	12.3	14.1	727	709	756	321	312	331
28 - TURBINE BYPASS BLOCK VALVE OUTLET	13.4	12.3	14.1	722	705	751	321	312	331
29 - TURBINE BYPASS CONTROL VALVE OUTLET	13.4	12.3	14.1	632	619	647	321	311	332
30 - TURBINE BLOCK VALVE INLET	28.2	26.4	31.3	742	725	774	321	311	332
31 - TURBINE BLOCK VALVE OUTLET	28.2	26.4	31.3	742	724	772	321	311	332
32 - TURBINE INLET	28.2	26.4	31.3	736	718	766	321	311	332
33 - TURBINE OUTLET	28.6	26.8	31.7	465	454	477	290	280	300
34 - TURBINE DISCHARGE BLOCK VALVE INLET	28.6	26.8	31.7	465	454	477	290	280	300
35 - TURBINE DISCHARGE BLOCK VALVE OUTLET	28.6	26.8	31.7	463	452	474	290	280	300
36 - STAGE PRESSURANT LINE INLET	0.31	0.25	0.37	442	432	454	305	295	315
37 - DCME INLET LINE OUTLET	55.1	53.5	56.7	435	424	445	305	295	315
38 - THRUST CHAMBER	55.1	53.5	56.7	270	266	275	4247	4204	4290
39 - PROPELLANT TANK OUTLET	0.0	0.0	0.0	30.0	29.2	30.8	40.6	40.3	40.9
40 - COOLDOWN SHUTOFF VALVE INLET	0.0	0.0	0.0	30.0	29.2	30.8	40.6	40.3	40.9
41 - COOLDOWN SHUTOFF VALVE OUTLET	0.0	0.0	0.0	0.0	0.0	0.0	48.0	47.6	48.6
42 - COOLDOWN SUPPLY CONTROL VALVE OUTLET	0.0	0.0	0.0	839	819	874	55.3	54.8	56.2

Reactivity (\$)

	Pos +	Neg -
Total Feedback	0.34	
Stem Hydrogen Worth	2.66	--
Core Hydrogen Worth	0.64	--
Reflector Hydrogen Worth	0.24	--
Core Temperature + Corrosion	--	3.20
	3.54	
Drum Worth		0.34
	3.54	3.54

STATE POINT CONDITIONS AND SIGNIFICATION EXTREMES

75K FULL FLOW NERVA ENGINE - DRAWING NUMBER 1137400E

REFER TO DRAWING NUMBER 1137456 FOR STATE POINT LOCATIONS

1137400E REFERENCE ENGINE - END OF LIFE - 1 TPA 60% THRUST

FC = 270. FSIA TRCV POSITION = 71.7 DEGREES THRUST = 45400. LRF TURBINE EFFICIENCY = 84.0 % PUMP EFFICIENCY = 66.5 %
 TC = 4247. DEGREES R SSCV POSITION = 39.0 DEGREES ISP = 222.7 SFC BYPASS FRACTION = 48.8 % PUMP SPEED = 22429. RPM
 CRUM POSITION = 70.0 DEGREES NPSP = 1.9 PSI FEEDBACK REACTIVITY = 0.34 %
 PDCV POSITION = 56.5 DEGREES

NETAP RESTART TAPE 21214 AT 278. SECONDS PLOTTED AT 278. SECONDS

	FLOW RATE (LBS/SEC)			PRESSURE (PSIA)			TEMPERATURE (DEGREES R)		
	NOMINAL	MIN	MAX	NOMINAL	MIN	MAX	NOMINAL	MIN	MAX
9.1 - PUMP DISCHARGE JUNCTION INLET	55.0	53.4	56.6	981	956	1024	54.4	53.9	55.3
9.2 - PUMP DISCHARGE LINE JUNCTION OUTLET	55.0	53.4	56.6	979	954	1021	54.4	53.9	55.3
9.3 - STRUCTURAL SUPPORT COOLANT LINE INLET	11.0	10.9	11.0	958	933	999	54.6	54.1	55.5
9.4 - PUMP DISCHARGE VALVE MODULE INLET	44.0	42.3	45.7	957	932	998	54.6	54.1	55.5
9.5 - STRUCTURAL SUPPORT MODULE INLET	11.0	10.9	11.0	954	930	996	54.6	54.1	55.5
12.1 - MIDDLE PUMP DISCHARGE LINE INLET	44.0	42.3	45.7	873	849	914	55.1	54.6	56.0
15.1 - STRUCTURAL SUPPORT MODULE OUTLET	11.0	10.9	11.0	839	816	875	55.3	54.8	56.2
15.2 - COOLDOWN SUPPLY LINE OUTLET	11.0	10.9	11.0	837	816	872	55.3	54.8	56.2
16.1 - STRUCTURAL SUPPORT BYPASS LINE INLET	1.96	1.90	2.02	872	850	909	55.1	54.6	56.0
19.1 - STEM OUTLET IN CORE SUPPORT PLATE	11.0	10.9	11.0	762	744	794	495	365	625
22.1 - REFLECTOR PRESSURE VESSEL ANNULUS - MIDPOINT	3.63	3.43	3.83	787	767	820	262	252	272
23.1 - REFLECTOR OUTLET	38.5	37.0	40.0	759	741	791	290	281	300
23.2 - STRUCTURAL SUPPORT OUTLET	12.9	12.9	13.0	759	741	791	423	364	482
23.3 - PERIPHERAL SHIELD INLET	39.9	38.7	41.1	759	741	791	321	311	331
26.1 - TURBINE BYPASS LINE INLET	26.8	24.6	28.1	746	728	777	321	311	332
26.2 - TURBINE BYPASS MODULE INLET	26.8	24.6	28.1	733	715	763	321	312	331
29.1 - TURBINE BYPASS MODULE OUTLET	26.8	24.6	28.1	606	596	617	321	311	332
29.2 - TURBINE BYPASS LINE OUTLET	26.8	24.6	28.1	455	444	466	321	311	331
29.3 - TURBINE LINE JUNCTION INLET	28.2	26.4	31.3	746	728	777	321	311	331
29.4 - TURBINE LINE DUAL LEG INLET	28.2	26.4	31.3	743	726	774	321	311	332
35.1 - TURBINE DISCHARGE LINE JUNCTION INLET	28.6	26.8	31.7	463	451	474	290	280	300
35.2 - TURBINE DISCHARGE LINE SINGLE LEG INLET	55.4	53.8	57.0	460	449	471	305	295	315
37.1 - CENTRAL SHIELD INLET	55.1	53.5	56.7	400	390	410	305	295	315
37.2 - CORE SUPPORT PLATE INLET	55.1	53.5	56.7	394	384	404	305	295	315
37.3 - CORE INLET	55.1	53.5	56.7	386	376	396	309	299	319

STATE POINT CONDITIONS AND SPECIFICATION EXTREMES
75K FULL FLOW NERVA ENGINE - DRAWING NUMBER 1137400E

REFER TO DRAWING NUMBER 1137456 FOR STATE POINT LOCATIONS

1137400E PRELIMINARY DESIGN REVIEW ENGINE EMERGENCY OPERATING POINT

PC = 200. PSIA TRCV POSITION = 86.3 DEGREES THRUST = 33300. LBF TURBINE EFFICIENCY = 82.8 % PUMP EFFICIENCY = 66.2 %
TC = 3342. DEGREES D SSCV POSITION = 73.7 DEGREES ISP = 717.1 SEC BYPASS FRACTION = 52.9 % PUMP SPEED = 17871. RPM
DRUM POSITION = 0.0 DEGREES NOSEP = 0.1 PSI FEEDBACK REACTIVITY = 1.65 %
PDCV POSITION 90.0 DEGREES

NETAP RESTART TIME 21046 AT 289. SECONDS PLOTTED AT 289. SECONDS

	FLOW RATE (LBS/SEC)			PRESSURE (PSIA)			TEMPERATURE (DEGREES R)		
	NOMINAL	MIN	MAX	NOMINAL	MIN	MAX	NOMINAL	MIN	MAX
1 - PROPELLANT TANK OUTLET	23.2	22.4	24.0	24.0	23.2	24.8	36.5	36.2	36.8
2 - PROPELLANT SHUTOFF VALVE INLET	23.2	22.4	24.0	24.0	23.2	24.8	36.4	36.1	36.7
3 - PROPELLANT SHUTOFF VALVE OUTLET	23.2	22.4	24.0	24.0	23.2	24.8	36.4	36.1	36.7
4 - PUMP INLET	23.2	22.4	24.0	23.8	23.0	24.6	36.4	36.1	36.7
5 - PUMP OUTLET	23.0	22.2	23.8	641	616	684	45.3	44.8	46.2
6 - PUMP DISCHARGE CHECK VALVE ACTUATOR INLET	23.0	22.2	23.8	641	616	684	45.3	44.8	46.2
7 - PUMP DISCHARGE CHECK VALVE ACTUATOR OUTLET	23.0	22.2	23.8	640	614	682	45.3	44.8	46.2
8 - PUMP DISCHARGE CHECK VALVE INLET	23.0	22.2	23.8	640	614	682	45.3	44.8	46.2
9 - PUMP DISCHARGE CHECK VALVE OUTLET	23.0	22.2	23.8	638	613	681	45.3	44.8	46.2
10 - PUMP DISCHARGE BLOCK VALVE INLET	18.8	18.0	19.7	620	596	660	45.5	45.0	46.4
11 - PUMP DISCHARGE BLOCK VALVE OUTLET	18.8	18.0	19.7	619	595	659	45.5	45.0	46.4
12 - PUMP DISCHARGE CONTROL VALVE OUTLET	18.8	18.0	19.7	618	594	658	45.5	45.0	46.4
13 - STRUCTURAL SUPPORT BLOCK VALVE INLET	4.23	4.20	4.26	619	595	659	45.6	45.1	46.5
14 - STRUCTURAL SUPPORT BLOCK VALVE OUTLET	4.23	4.20	4.26	617	593	657	45.6	45.1	46.5
15 - STRUCTURAL SUPPORT CONTROL VALVE OUTLET	4.23	4.20	4.26	599	576	637	45.8	45.3	46.7
16 - STRUCTURAL SUPPORT COOLANT LINE OUTLET (PV DOME)	8.47	8.41	8.53	596	574	634	45.8	45.3	46.7
17 - STRUCTURAL SUPPORT BYPASS ORIFICE INLET	1.67	1.61	1.73	611	587	650	45.6	45.1	46.5
18 - STRUCTURAL SUPPORT BYPASS ORIFICE OUTLET	1.67	1.61	1.73	551	532	583	45.6	45.1	46.5
19 - STRUCTURAL SUPPORT BYPASS LINE OUTLET (PV DOME)	1.67	1.61	1.73	545	527	577	45.7	45.2	46.6
20 - LOWER PUMP DISCHARGE LINE OUTLET	36.0	34.3	37.7	614	591	654	45.6	45.1	46.5
22 - NOZZLE TUBES OUTLET	36.0	34.3	37.7	557	537	590	165	155	175
23 - REFLECTOR PRESSURE VESSEL ANNULUS OUTLET	3.11	2.91	3.31	537	518	568	233	223	243
24 - PERIPHERAL SHIELD PRESSURE VESSEL ANNULUS OUTLET	12.8	12.4	13.2	532	514	563	258	248	268
25 - PERIPHERAL SHIELD OUTLET	33.3	32.1	34.5	532	514	563	257	247	268
26 - DOME TURBINE LINE INLET	46.1	44.5	47.7	530	512	561	257	248	268

STATE POINT CONDITIONS AND REACTIVITY EXTREMES

75K FULL FLOW NERVA ENGINE - DRAWING NUMBER 1137400F

REFER TO DRAWING NUMBER 1137456 FOR STATE POINT LOCATIONS

1137400E PRELIMINARY DESIGN REVIEW ENGINE EMERGENCY OPERATING POINT

PC = 200. PSIA TPCV POSITION = 86.3 DEGREES THRUST = 33700. LBF TURBINE EFFICIENCY = 82.8 % PUMP EFFICIENCY = 66.2 %
 TC = 3342. DEGREES R SSCV POSITION = 73.7 DEGREES ISP = 717.1 SEC BYPASS FRACTION = 52.9 % PUMP SPEED = 17871. RPM
 DRUM POSITION = 0.0 DEGREES NPSP = 9.1 PSI FEEDBACK REACTIVITY = 1.65 %

NETAP RESTART TAP 21046 AT 289. SECONDS PLOTTED AT 289. SECONDS

	FLOW RATE (LPS/SEC)			PRESSURE (PSIA)			TEMPERATURE (DEGREES R)		
	NOMINAL	MIN	MAX	NOMINAL	MIN	MAX	NOMINAL	MIN	MAX
27 - TURBINE BYPASS BLOCK VALVE INLET	12.2	11.1	12.8	508	491	537	258	248	268
28 - TURBINE BYPASS BLOCK VALVE OUTLET	12.2	11.1	12.9	505	488	531	258	248	268
29 - TURBINE BYPASS CONTROL VALVE OUTLET	12.2	11.1	12.8	488	473	508	258	248	268
30 - TURBINE BLOCK VALVE INLET	10.9	9.96	12.4	525	507	555	257	248	268
31 - TURBINE BLOCK VALVE OUTLET	10.9	9.96	12.4	524	506	554	257	248	268
32 - TURBINE INLET	10.9	9.96	12.4	520	502	550	258	248	268
33 - TURBINE OUTLET	11.0	10.1	12.6	346	335	357	233	223	243
34 - TURBINE DISCHARGE BLOCK VALVE INLET	11.0	10.1	12.6	346	334	357	233	223	243
35 - TURBINE DISCHARGE BLOCK VALVE OUTLET	11.0	10.1	12.6	344	333	356	233	223	243
36 - STAGE PRESSURANT LINE INLET	.20	.18	.22	730	719	741	248	239	258
37 - DOME INLET LINE OUTLET	46.4	44.8	48.0	324	313	335	248	238	258
38 - THRUST CHAMBER	46.4	44.8	48.0	200	195	205	3342	3299	3385
39 - PROPELLANT TANK OUTLET	0.0	0.0	0.0	24.0	23.2	24.8	36.5	36.2	36.8
40 - COOLDOWN SHUTOFF VALVE INLET	0.0	0.0	0.0	24.0	23.2	24.8	36.5	36.2	36.8
41 - COOLDOWN SHUTOFF VALVE OUTLET	0.0	0.0	0.0	0.0	0.0	0.0	41.1	40.7	41.7
42 - COOLDOWN SUPPLY CONTROL VALVE OUTLET	0.0	0.0	0.0	598	576	636	45.8	45.3	46.7

REACTIVITY (%)

		POS +	NEG -
TOTAL FEEDBACK	1.65		
STEM HYDROGEN WORTH		2.43	
CORE HYDROGEN WORTH		0.62	
REFLECTOR HYDROGEN WORTH		0.22	
CORE TEMPERATURE			-1.62
		3.27	
DRUM WORTH			-1.65
		3.27	-3.27

STATE POINT CONDITIONS AND SPECIFICATION EXTREMES
75K FULL FLOW NERVA ENGINE - DRAWING NUMBER 1137400E

REFER TO DRAWING NUMBER 1137456 FOR STATE POINT LOCATIONS

1137400E PRELIMINARY DESIGN REVIEW ENGINE EMERGENCY OPERATING POINT

PC = 200. PSIA TRCV POSITION = 86.3 DEGREES THRUST = 33300. LBF TURBINE EFFICIENCY = 82.8 % PUMP EFFICIENCY = 56.2 %
TC = 3342. DEGREES R SSCV POSITION = 73.7 DEGREES ISP = 717.1 SEC BYPASS FRACTION = 52.9 % PUMP SPEED = 17871. RPM
DRUM POSITION = 0.0 DEGREES MRSP = 0.1 PSI FEEDBACK REACTIVITY = 1.65 \$

NETAP RESTART TARE 21046 AT 289. SECONDS PLOTTED AT 289. SECONDS

	FLOW RATE (LBS/SEC)			PRESSURE (PSIA)			TEMPERATURE (DEGREES R)		
	NOMINAL	MIN	MAX	NOMINAL	MIN	MAX	NOMINAL	MIN	MAX
9.1 - PUMP DISCHARGE JUNCTION INLET	23.0	22.2	23.8	637	612	680	45.3	44.8	46.2
9.2 - PUMP DISCHARGE LINE JUNCTION OUTLET	46.1	44.5	47.7	635	610	678	45.3	44.8	46.2
9.3 - STRUCTURAL SUPPORT COOLANT LINE INLET	8.47	8.41	8.53	621	597	662	45.5	45.0	46.4
9.4 - PUMP DISCHARGE VALVE MODULE INLET	37.6	35.9	39.3	620	597	661	45.5	45.0	46.4
9.5 - STRUCTURAL SUPPORT MODULE INLET	8.47	8.41	8.53	619	595	660	45.6	45.1	46.5
12.1 - MIDDLE PUMP DISCHARGE LINE INLET	37.6	35.9	39.3	616	593	656	45.6	45.1	46.5
15.1 - STRUCTURAL SUPPORT MODULE OUTLET	8.47	8.41	8.53	598	576	636	45.8	45.3	46.7
15.2 - COOLDOWN SUPPLY LINE OUTLET	8.47	8.41	8.53	596	574	634	45.8	45.3	46.7
16.1 - STRUCTURAL SUPPORT BYPASS LINE INLET	1.67	1.61	1.73	615	592	655	45.6	45.1	46.5
12.1 - STEM OUTLET IN CORE SUPPORT PLATE	8.47	8.41	8.53	539	521	571	446	316	576
22.1 - REFLECTOR PRESSURE VESSEL ANNULUS - MIDPOINT	3.11	2.91	3.31	557	537	590	198	189	208
23.1 - REFLECTOR OUTLET	32.0	31.4	34.4	537	518	568	219	210	229
23.2 - STRUCTURAL SUPPORT OUTLET	10.1	10.1	10.2	537	518	568	374	315	433
23.3 - PERIPHERAL SHIELD INLET	33.3	32.1	34.5	537	518	568	258	248	268
26.1 - TURBINE BYPASS LINE INLET	24.4	22.2	25.7	527	509	557	257	248	268
26.2 - TURBINE BYPASS MODULE INLET	24.4	22.2	25.7	514	496	544	258	248	268
29.1 - TURBINE BYPASS MODULE OUTLET	24.4	22.2	25.7	466	454	477	258	248	268
29.2 - TURBINE BYPASS LINE OUTLET	24.4	22.2	25.7	330	328	350	260	250	270
29.3 - TURBINE LINE JUNCTION INLET	21.7	19.9	24.8	527	509	557	257	248	268
29.4 - TURBINE LINE DUAL LEG INLET	10.9	9.96	12.4	525	507	555	257	248	268
35.1 - TURBINE DISCHARGE LINE JUNCTION INLET	11.0	10.1	12.6	344	333	356	233	223	243
35.2 - TURBINE DISCHARGE LINE SINGLE LEG INLET	22.1	20.3	25.2	343	331	354	248	238	258
37.1 - CENTRAL SHIELD INLET	46.4	44.8	48.0	298	288	308	248	238	258
37.2 - CORE SUPPORT PLATE INLET	46.4	44.8	48.0	293	283	303	249	239	259
37.3 - CORE INLET	46.4	44.8	48.0	287	277	297	252	242	262

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GENERAL CORPORATION

FORM	DATE	DESCRIPTION	DATE	APPROVED
D		REPLACE KEY C WITH CHARTER		
E		CHANGE FOR RECORD ONLY		
F		CHANGE FOR RECORD ONLY		
G		CHANGE FOR RECORD ONLY		

- NOTES
1. INTERPRET DRAWING PER MIL-D-1000 FORM 1
 2. THIS DRAWING TO BE USED ON CONSTRUCTION WITH
ALL PLANNING ENGINE LAYOUT FOR LAYOUT & FLOW
DIAGRAM BY LAYOUT "C" CHANGE
 3. ALL LOW PRESS INDICATED ARE OUTSIDE DIAMETER

SYMBOL	DESCRIPTION
[Symbol]	1. PUMP
[Symbol]	2. VALVE
[Symbol]	3. ORIFICE
[Symbol]	4. CHECK VALVE
[Symbol]	5. FLOW CONTROL VALVE
[Symbol]	6. STOP VALVE
[Symbol]	7. BYPASS VALVE
[Symbol]	8. SHUT-OFF VALVE
[Symbol]	9. FLOW CONTROL VALVE
[Symbol]	10. STOP VALVE
[Symbol]	11. BYPASS VALVE
[Symbol]	12. SHUT-OFF VALVE
[Symbol]	13. FLOW CONTROL VALVE
[Symbol]	14. STOP VALVE
[Symbol]	15. BYPASS VALVE
[Symbol]	16. SHUT-OFF VALVE
[Symbol]	17. FLOW CONTROL VALVE
[Symbol]	18. STOP VALVE
[Symbol]	19. BYPASS VALVE
[Symbol]	20. SHUT-OFF VALVE
[Symbol]	21. FLOW CONTROL VALVE
[Symbol]	22. STOP VALVE
[Symbol]	23. BYPASS VALVE
[Symbol]	24. SHUT-OFF VALVE
[Symbol]	25. FLOW CONTROL VALVE
[Symbol]	26. STOP VALVE
[Symbol]	27. BYPASS VALVE
[Symbol]	28. SHUT-OFF VALVE
[Symbol]	29. FLOW CONTROL VALVE
[Symbol]	30. STOP VALVE
[Symbol]	31. BYPASS VALVE
[Symbol]	32. SHUT-OFF VALVE
[Symbol]	33. FLOW CONTROL VALVE
[Symbol]	34. STOP VALVE
[Symbol]	35. BYPASS VALVE
[Symbol]	36. SHUT-OFF VALVE
[Symbol]	37. FLOW CONTROL VALVE
[Symbol]	38. STOP VALVE
[Symbol]	39. BYPASS VALVE
[Symbol]	40. SHUT-OFF VALVE
[Symbol]	41. FLOW CONTROL VALVE
[Symbol]	42. STOP VALVE
[Symbol]	43. BYPASS VALVE
[Symbol]	44. SHUT-OFF VALVE
[Symbol]	45. FLOW CONTROL VALVE
[Symbol]	46. STOP VALVE
[Symbol]	47. BYPASS VALVE
[Symbol]	48. SHUT-OFF VALVE
[Symbol]	49. FLOW CONTROL VALVE
[Symbol]	50. STOP VALVE
[Symbol]	51. BYPASS VALVE
[Symbol]	52. SHUT-OFF VALVE
[Symbol]	53. FLOW CONTROL VALVE
[Symbol]	54. STOP VALVE
[Symbol]	55. BYPASS VALVE
[Symbol]	56. SHUT-OFF VALVE
[Symbol]	57. FLOW CONTROL VALVE
[Symbol]	58. STOP VALVE
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[Symbol]	60. SHUT-OFF VALVE
[Symbol]	61. FLOW CONTROL VALVE
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[Symbol]	65. FLOW CONTROL VALVE
[Symbol]	66. STOP VALVE
[Symbol]	67. BYPASS VALVE
[Symbol]	68. SHUT-OFF VALVE
[Symbol]	69. FLOW CONTROL VALVE
[Symbol]	70. STOP VALVE
[Symbol]	71. BYPASS VALVE
[Symbol]	72. SHUT-OFF VALVE
[Symbol]	73. FLOW CONTROL VALVE
[Symbol]	74. STOP VALVE
[Symbol]	75. BYPASS VALVE
[Symbol]	76. SHUT-OFF VALVE
[Symbol]	77. FLOW CONTROL VALVE
[Symbol]	78. STOP VALVE
[Symbol]	79. BYPASS VALVE
[Symbol]	80. SHUT-OFF VALVE
[Symbol]	81. FLOW CONTROL VALVE
[Symbol]	82. STOP VALVE
[Symbol]	83. BYPASS VALVE
[Symbol]	84. SHUT-OFF VALVE
[Symbol]	85. FLOW CONTROL VALVE
[Symbol]	86. STOP VALVE
[Symbol]	87. BYPASS VALVE
[Symbol]	88. SHUT-OFF VALVE
[Symbol]	89. FLOW CONTROL VALVE
[Symbol]	90. STOP VALVE
[Symbol]	91. BYPASS VALVE
[Symbol]	92. SHUT-OFF VALVE
[Symbol]	93. FLOW CONTROL VALVE
[Symbol]	94. STOP VALVE
[Symbol]	95. BYPASS VALVE
[Symbol]	96. SHUT-OFF VALVE
[Symbol]	97. FLOW CONTROL VALVE
[Symbol]	98. STOP VALVE
[Symbol]	99. BYPASS VALVE
[Symbol]	100. SHUT-OFF VALVE

FOR RECORD ONLY. DO NOT FABRICATE
TO THIS PRINT.
RETAIN ORIGINAL VELLUM.
DESTROY ORIGINAL VELLUM
AUTHORIZED CHECKER: [Signature]

DATE	10/1/67	BY	W. J. [Signature]
REVISION	1	DATE	10/1/67
DESCRIPTION	TX-1000 ROCKET ENGINE		
QUANTITY	1	DATE	10/1/67
APPROVAL	[Signature]		
DATE	10/1/67	BY	W. J. [Signature]
REVISION	1	DATE	10/1/67
DESCRIPTION	TX-1000 ROCKET ENGINE		
QUANTITY	1	DATE	10/1/67
APPROVAL	[Signature]		
DATE	10/1/67	BY	W. J. [Signature]

AEROJET NUCLEAR SYSTEMS COMPANY
SACRAMENTO, CALIFORNIA

N8510

WSH 9d
BACK UP

TO: R. H. Coppo 15 June 1971
FROM: J. J. Williams JJW:jm:N8110:M1709
Project No. 141, W.S. 9
SUBJECT: Thermal Analysis of Nozzle Coolant Channels (W.O. 1190-14-109)
DISTRIBUTION: O. J. Demuth, W. L. Garrett, L. A. Shurley, P. P. Ventura,
J. L. Watkins
REFERENCES: (a) Request from R. H. Coppo Dated 5-4-71, "Heat Transfer
Analysis - Coolant Channel Flow Area Reduction"
(b) Request from R. H. Coppo Dated 5-5-71, "Heat Transfer
Analysis"
(c) Request from R. H. Coppo Dated 6-3-71, "Heat Transfer
Analysis - Coolant Channel Flow Area Reduction"
(d) Request from R. H. Coppo Dated 6-10-71, "Heat Transfer
Analysis - Coolant Channel Flow Area Reduction -
Revised"
(e) Memorandum N8110:M1686, J. J. Williams to J. L. Watkins
Dated 30 April 1971, Subject: "Heat Transfer Analysis
of Nozzle Coolant Channels for Barrel Configuration
Shown on Drawing 1138000"
(f) Aerospace Fluid Component Designers' Handbook, Volume 1,
Revision D, RPL-TDR-64-25, February 1970
ENCLOSURE: (1) Tables 1 Through 7

I. SUMMARY

Results of steady state coolant channel heat transfer analyses are presented for the eleven cases requested in References (a) through (d). All computer model parameters shown in Table 3 of Reference (e) are unchanged for these analyses. The present results are for (1) the same state point data as in Reference (e) with changes in channel flow area (Runs 09SG003, 09SG012, and 09SG013), -

CLASSIFICATION CATEGORY

Unclassified

OJ Demuth 6-16-71
CLASSIFYING OFFICER DATE

and (2) new state point data with an increase of 0.4 in the tube exit pressure loss coefficient. Summary results of all the analyses are shown in the enclosed tables.

II. DISCUSSION

Steady state heat transfer analyses were made to determine coolant tube channel temperatures, heat fluxes and pressure drops for the engine operating conditions shown in Tables 1 and 3. Table 1 lists the engine operating conditions for the runs made to determine the effect of a flow area reduction on temperature and pressure drop. Run number 09SG001 is the reference run reported on in Reference (e). ^A

Run 09SG003 is the analysis requested in Reference (a). The flow areas used for this run are tabulated in Table 5. ^P

Run 09SG012 is the analysis requested in Reference (c). The flow areas used for this run are tabulated in Table 6. ^P

Run 09SG013 is the analysis requested in Reference (d). The flow areas used for this run are tabulated in Table 7. ^P

Computed results from Runs 09SG003, 09SG012 and 09SG013 are shown in Table 2. The results generally show that as flow areas are decreased, the maximum wall temperatures decrease and the pressure drops increase. It should be noted that the flow area distribution used for Run 09SG003 was somewhat irregular and this run was repeated as number 09SG013.

Runs 09SG004 through 09SG011 are the analyses requested in Reference (b). The flow areas are the nominal values used in Reference (e). Engine operating conditions used for these runs are shown on Table 3 and a summary of the computed results are shown on Table 4. The computer model for these runs was modified by changing the exit coolant pressure loss coefficient to account for a 15 degree increase in amount of channel turn at the exit. Evaluation of the nominal loss coefficients and friction factor multipliers has not been accomplished and therefore adequacy of these values has not been established. The increase in loss coefficient used for the present analyses, however, (0.40) is based on Figure 3.9.2.3b of Reference (f) and is considered to accurately model

the change in pressure drop associated with the increased turning angle.

J. J. Williams

J. J. Williams
Thermophysics
Engineering Staff Department

ENGINE OPERATING CONDITIONS, COMPUTER RESULTS
AND FLOW AREAS FOR COOLANT CHANNEL HEAT TRANSFER ANALYSES
(TABLES 1 THROUGH 7)

J. J. Williams

13 June 1971

TABLE 1 - ENGINE OPERATING CONDITIONS ASSUMED FOR FLOW AREA REDUCTION ANALYSIS

Run Number*	Stagnation Conditions		Nozzle Flow	Coolant Flow	Coolant Inlet Conditions		Comments
	Temperature (Deg R)	Pressure (Psia)	(lb/sec)	(lb/sec)	Temperature (Deg R)	Pressure (Psia)	
^A 09SG001	4295.	445.	90.2	76.1	59.4	1344.	Nominal flow area (A_F)
^P 09SG003	4295.	445.	90.2	76.1	59.4	1344.	.10 increase in leg height
^P 09SG012	4295.	445.	90.2	76.1	59.4	1344.	.05 increase in leg height
^P 09SG013	4295.	445.	90.2	76.1	59.4	1344.	Revised A_F /Run 09SG003 ^P

TABLE 2 - COMPUTER RESULTS FOR FLOW AREA REDUCTION ANALYSIS

Run Number	Maximum Coolant Heat Flux/ Station Number (Btu/in ² -sec)	Maximum Gas-Side Wall Temperature/ Station Number (Deg R)	Maximum Coolant Bulk Mach Number/ Station Number	Maximum Gas-Side Wall Temperature at Barrel Station 35 (Deg R)	Over-all Coolant Temperature Rise (Deg R)	Over-all Coolant Pressure Drop (Psia)
^A 09SG001	20.82/22	1933./22	.21/22	1520.	140.5	146.8
^P 09SG003	21.20/22	1896./22	.24/22	1518.	140.8	159.7
^P 09SG012	21.01/22	1914./22	.22/22	1519.	140.6	152.6
^P 09SG013	21.20/22	1896./22 & 23	.24/22	1518.	140.8	157.0

*All analyses run with land and groove configuration option where applicable

TABLE 3 - ENGINE OPERATING CONDITIONS ASSUMED FOR ANALYSIS OF "E" ENGINE NETAP

N8110:M1709

MEMO N4110:0067 STATE POINT DATA

Run Number*	Stagnation Conditions		Nozzle Flow (lb/sec)	Coolant Flow (lb/sec)	Coolant Inlet Conditions		Comments (All Runs)
	Temperature (Deg R)	Pressure (Psia)			Temperature (Deg R)	Pressure (Psia)	
09SG004	4295.	446.	90.2	80.0	54.5	1342.	Nominal flow areas
09SG005	4295.	445.	90.2	76.1	59.4	1344.	
09SG006	4297.	356.	72.0	62.9	54.1	1232.	
09SG007	4294.	356.	71.9	59.3	59.1	1240.	Exit coolant pressure loss coefficient in- creased by 0.4
09SG008	4297.	265.	53.5	43.0	52.9	763.	
09SG009	4291.	265.	53.5	39.0	56.2	752.	
09SG010	4296.	265.	53.5	43.9	50.4	840.	
09SG011	4290.	266.	53.5	40.4	54.7	848.	

TABLE 4 - COMPUTER RESULTS

Run Number	Maximum Coolant		Maximum Gas-Side		Over-all	
	Heat Flux/ Station Number (Btu/in ² -sec)	Wall Temperature/ Station Number (Deg R)	Bulk Mach Number/ Station Number	Wall Temperature at Barrel Station 35 (Deg R)	Coolant Temperature Rise (Deg R)	Coolant Pressure Drop (Psia)
09SG004	20.84/22	1930./22	.21/22	1508.	136.2	165.7
09SG005	20.83/22	1931./22	.22/22	1520.	140.5	159.2
09SG006	18.09/22	1858./22	.18/22	1466.	145.7	115.5
09SG007	17.99/22	1863./22	.18/22	1483.	153.0	109.0
09SG008	14.79/22	1786./22	.22/22	1459.	165.3	94.5
09SG009	14.63/22	1807./23	.22/22	1496.	178.3	85.4
09SG010	14.74/22	1793./22	.19/22	1451.	163.8	86.7
09SG011	14.64/22	1805./23	.19/22	1481.	174.6	78.9

*All analyses run with land and groove configuration option where applicable

TABLE 5

FLOW AREAS FOR 0.10 INCH LEG HEIGHT INCREASE

(Run 09SG003)

<u>ϵ</u>	<u>A_F</u>	<u>ϵ</u>	<u>A_F</u>
24	.2965	-1.04	.0332
22	.2851	-1.16	.0329
20	.3207	-1.37	.0395
18	.3050	-1.67	.0643
16	.2885	-2.41	.0820
14	.2708	-3.28	.0985
12	.2490	-4.28	.1136
10	.2270	-5.42	.1276
8	.2017	-6.69	.1325
7	.1870	-8.10	.1366
6	.1718	-9.64	.1305
5	.1561	-12.01	.1145
4	.1283	-13.14	.0995
3	.1103	-13.87	.0915
2	.0888	-14.12	.0906
1.9	.0864	-14.12
1.49	.0775	-14.12	
1.16	.0672	-14.12	
1.04	.0622	-14.12	
1.00	.0499	-14.12	

TABLE 6

FLOW AREAS FOR .050 INCH LEG HEIGHT INCREASE

(Run 09SG012)

<u>ϵ</u>	<u>A_F</u>	<u>ϵ</u>	<u>A_F</u>
24	.2965	-1.04	.0347
22	.2851	-1.16	.0344
20	.3203	-1.37	.0431
18	.3045	-1.67	.0657
16	.2880	-2.41	.0833
14	.2702	-3.28	.0985
12	.2493	-4.28	.1150
10	.2270	-5.42	.1286
8	.2017	-6.69	.1338
7	.1873	-8.10	.1379
6	.1722	-9.64	.1312
5	.1561	-12.01	.1152
4	.1294	-13.14	.0997
3	.1115	-13.87	.0917
2	.0898	-14.12	.0908
1.9	.0879	-14.12	.0908
1.49	.0781	-14.12	.0908
1.16	.0682	-14.12	.0908
1.04	.0639	-14.12	.0908
1.00	.0517	-14.12	.0908

TABLE 7

FLOW AREAS FOR .100 INCH LEG HEIGHT INCREASE

REVISED (Run 09SC013)

<u>ϵ</u>	<u>A_F</u>	<u>ϵ</u>	<u>A_F</u>
24	.2965	-1.04	.0332
22	.2851	-1.16	.0329
20	.3203	-1.37	.0437
18	.3045	-1.67	.0643
16	.2880	-2.41	.0818
14	.2702	-3.28	.0982
12	.2489	-4.28	.1136
10	.2263	-5.42	.1269
8	.2009	-6.69	.1323
7	.1858	-8.10	.1366
6	.1708	-9.64	.1305
5	.1541	-12.01	.1150
4	.1276	-13.14	.0995
3	.1098	-13.87	.0915
2	.0878	-14.12	.0906
1.9	.0862	-14.12	.0906
1.49	.0754	-14.12	.0906
1.16	.0658	-14.12	.0906
1.04	.0622	-14.12	.0906
1.00	.0499	-14.12	.0906

N4220

WSH 9d
BACK UP

AEROJET NUCLEAR SYSTEMS COMPANY
SACRAMENTO, CALIFORNIA

TO: J. L. Watkins 30 April 1971
JJW:jm:N8110:M1686

FROM: J. J. Williams

SUBJECT: Heat Transfer Analysis of Nozzle Coolant Channels for
Barrel Configuration Shown on Drawing 1138000 (W.O. 1190-14-109)

DISTRIBUTION: R. H. Coppo, O. J. Demuth, W. L. Garrett, L. A. Shurley,
P. P. Ventura (W/O Encl.)

REFERENCES: (a) Request from R. H. Coppo Dated 4-12-71, "Heat Transfer
Analysis"

(b) Memorandum N4110:0067, W. E. Stephens to A. D. Cornell,
Dated 26 February 1971, Subject: "State Points for the
1137400/Revision E Reference Engine"

(c) ANSC Drawing 1138000 - Nozzle Layout, Checker's
Signature on 4-17-70

(d) Computing Sciences Report on Program E25104, Dated
21 June 1968

(e) Memorandum N8110:M1679, J. J. Williams to J. L. Watkins,
Dated 19 April 1971, Subject: "Steady State Temperature
Distributions in the NERVA Nozzle Coolant Channels With
A 300 Degree Increase in Nominal Crown Temperature"

ENCLOSURE: (1) Tabulated Computer Printout From Code E25104 -
Runs 09SA001 and 09SA002

I. SUMMARY

Steady state coolant channel heat transfer analyses are presented for the two cases requested in Reference (a). These cases are for conditions selected from the EOL Normal Design Point and EOL Normal 60 percent thrust state point data presented in Reference (b) and were for the nozzle configuration shown in Reference (c). The analyses were completed and summary data are presented in the enclosed tables.

CLASSIFICATION CATEGORY	
<i>Unclassified</i>	
<i>OJ Demuth</i>	<i>7-30-71</i>
CLASSIFYING OFFICER	DATE

Enclosure (1) is a listing of the short form computer output for each case and has already been transmitted to R. H. Coppo. In addition, a more detailed and lengthy printout has been retained.

II. DISCUSSION

Steady state heat transfer analyses were made to determine coolant tube channel temperatures, heat fluxes and pressure drops for the engine operating conditions shown in Table 1. The run numbers assigned to these analyses were 09SA001 (corresponding to the NEOL run) and 09SA002 (corresponding to the NTEOL run). The analysis method used was essentially that described in Reference (d). The major difference was an addition to the computer code (E25104) to permit the modeling of longitudinal lands and grooves in the coolant tubes. This option was employed where shown applicable by the nozzle drawing of Reference (c).

A summary of computed results for both analyses showing selected heat fluxes, temperatures and over-all coolant pressure drop is presented in Table 2. A copy of the short printout from computer code E25104 for each run is contained in Enclosure (1). Run number identification is shown on the first sheet of each two page output.

The nozzle configuration analyzed for these cases (Reference (c)) had slightly different barrel dimensions from previous analyses. For this reason it was necessary to modify values of several of the computer model parameters used in the barrel region. Specifically, the values of the recovery temperature factor (BETA) and the factor used in the gas side heat transfer equation (CG) were modified to retain the same length dependent nature of these parameters near the reactor exit. The modifications were small and affected only a few stations near the reactor. Corrections to the radiation exchange factor (FEFV) were negligible and no change from previously used values was necessary. A complete list of the current values for these three factors is shown in Table 3. In addition, the station number, axial distance (from the 24:1 area ratio location), area ratio and radius of each station are also shown. The use of these factors in the heat transfer calculations is described in Reference (d). The correlations used to compute gas and coolant side heat transfer coefficients and coolant pressure drop are the same as those used in Reference (e).

J. Williams, Sr. Engr. Spec.
Thermophysics
Engineering Staff Department

ENCLOSURE (1) - TABULATED COMPUTER PRINTOUT
FROM CODE E25104 - RUNS 09SA001 AND 09SA002

28 April 1971

J. J. Williams

9
07SA001WLG SINGLE PASS FLOW 75K NOZZLE EOL NOM.

24/1 REF. 1137400/E-ENGINE 40

***** SUMMARY *****

COOLANT = PARA-HYDROGEN (FARMERS)

PIN = 1344.

TIN = 59.4

TC = 4295.

PC = 445.

WG = 90.2

WC = 76.1

MR = 0.0

NT = 216.

STA	A/AT Z	CL CG	SUMQ VC	TM Q/AI	HL HG	R PRC	TR DE	RG L	AF NMB	TWL TWG	RE MUB	WDOT/A MACH
1	24.00 72.81	0.0177 0.0500	0. 474.	0.0280 0.8	0.00180 0.00024	27.46 1343.27	59.4 0.557	0.400 0.1058	0.2965 216.	524. 637.	0.3494E 06 0.6144E-06	1.2 0.0098
	TUBE TYPE = U-TUBE MATERIAL = STAINLESS STEEL											
2	22.00 69.68	0.0177 0.0499	614. 504.	0.0280 0.9	0.00182 0.00026	26.29 1343.08	62.2 0.550	0.383 0.1225	0.2851 216.	563. 683.	0.3301E 06 0.5779E-06	1.2 0.0106
3	20.00 66.53	0.0177 0.0498	1244. 459.	0.0280 1.0	0.00140 0.00029	25.07 1343.13	64.9 0.579	0.365 0.1401	0.3207 216.	746. 861.	0.2096E 06 0.5450E-06	1.1 0.0099
4	18.00 63.35	0.0177 0.0497	1896. 495.	0.0280 1.1	0.00146 0.00033	23.78 1342.94	67.6 0.565	0.346 0.1601	0.3050 216.	795. 920.	0.2006E 06 0.5177E-06	1.2 0.0109
5	16.00 60.12	0.0177 0.0496	2600. 537.	0.0270 1.2	0.00153 0.00038	22.42 1342.72	70.5 0.549	0.326 0.1799	0.2885 216.	854. 987.	0.1898E 06 0.4892E-06	1.2 0.0122
6	14.00 56.85	0.0177 0.0495	3364. 587.	0.0260 1.4	0.00162 0.00044	20.97 1342.44	73.4. 0.531	0.304 0.2013	0.2708 216.	916. 1057.	0.1803E 06 0.4595E-06	1.3 0.0136
7	12.00 57.50	0.0177 0.0475	4193. 656.	0.0250 1.6	0.00176 0.00050	19.42 1342.05	76.5 0.509	0.281 0.2241	0.2510 216.	958. 1109.	0.1799E 06 0.4362E-06	1.4 0.0157
8	10.00 50.04	0.0177 0.0447	5105. 748.	0.0240 1.8	0.00195 0.00059	17.73 1341.50	79.8 0.481	0.257 0.2483	0.2285 216.	1007. 1172.	0.1792E 06 0.4131E-06	1.5 0.0184
9	8.00 46.42	0.0177 0.0419	6131. 875.	0.0230 2.2	0.00222 0.00072	15.85 1340.69	83.4 0.447	0.229 0.2759	0.2033 216.	1060. 1245.	0.1794E 06 0.3881E-06	1.7 0.0222
10	7.00 44.53	0.0177 0.0400	6696. 962.	0.0220 2.4	0.00240 0.00081	14.83 1340.09	85.4 0.427	0.214 0.2898	0.1893 216.	1087. 1280.	0.1811E 06 0.3777E-06	1.9 0.0247
11	6.00 42.55	0.0177 0.0372	7310. 1073.	0.0210 2.7	0.00263 0.00091	13.73 1339.29	87.4 0.404	0.198 0.3058	0.1745 216.	1117. 1321.	0.1828E 06 0.3678E-06	2.0 0.0280
12	5.00 40.49	0.0177 0.0332	7975. 1219.	0.0200 3.0	0.00285 0.00101	12.53 1338.14	89.7 0.377	0.180 0.3231	0.1579 216.	1117. 1333.	0.1930E 06 0.3571E-06	2.2 0.0323
13	4.00 37.93	0.0177 0.0294	8709. 1522.	0.0190 3.6	0.00356 0.00118	11.21 1335.69	92.1 0.366	0.160 0.3444	0.1305 216.	1092. 1333.	0.2409E 06 0.3454E-06	2.7 0.0410
14	3.00 35.88	0.0177 0.0258	9559. 1825.	0.0180 4.4	0.00413 0.00146	9.71 1332.53	94.8 0.331	0.138 0.3666	0.1128 216.	1157. 1429.	0.2385E 06 0.3334E-06	3.1 0.0501
15	2.00 33.07	0.0177 0.0211	10615. 2374.	0.0170 5.9	0.00519 0.00197	7.93 1325.86	98.2 0.283	0.112 0.3925	0.0909 216.	1228. 1554.	0.2405E 06 0.3226E-06	3.9 0.0663
16	1.90 32.76	0.0177 0.0202	10731. 2426.	0.0160 6.0	0.00529 0.00202	7.73 1325.08	98.6 0.279	0.109 0.3955	0.0894 216.	1233. 1549.	0.2406E 06 0.3215E-06	3.9 0.0678
17	1.49 31.35	0.0177 0.0176	11279. 2825.	0.0150 7.1	0.00607 0.00239	6.84 1319.24	100.3 0.253	0.096 0.4079	0.0787 216.	1272. 1615.	0.2410E 06 0.3157E-06	4.5 0.0797
18	1.16 30.02	0.0177 0.0173	11835. 3295.	0.0140 9.4	0.00706 0.00333	6.04 1311.41	101.9 0.228	0.084 0.4207	0.0692 216.	1430. 1824.	0.2112E 06 0.3098E-06	5.1 0.0939
19	1.04 29.31	0.0270 0.0206	12186. 3526.	0.0130 13.3	0.01131 0.00463	5.72 1306.93	103.0 0.219	0.079 0.4239	0.0657 216.	1278. 1811.	0.2552E 06 0.3061E-06	5.4 0.1011
20	1.00 28.53	0.0287 0.0235	12622. 4447.	0.0130 16.1	0.01453 0.00554	5.61 1290.96	104.0 0.205	0.078 0.3485	0.0534 216.	1209. 1855.	0.3231E 06 0.2988E-06	6.6 0.1293
21	-1.04 27.44	0.0299 0.0306	13381. 6781.	0.0130 20.5	0.02158 0.00721	5.71 1238.20	104.7 0.186	0.079 0.2168	0.0363 216.	1053. 1893.	0.5272E 06 0.2915E-06	9.7 0.2012

	26.39	0.0344	7137.	0.0130	0.02134	6.03	107.4	0.084	0.0360	1083.	0.5344E-06	9.5
				20.8	0.00755	1221.33	0.190	0.1941	216.	1933.	0.2972E-06	0.213
23	-1	0.0263	15165.	0.0140	0.01535	6.55	11.1	0.092	0.0467	1202.	0.417E-06	7.5
	25	0.0310	5678.	16.7	0.00595	1247.49	0.213	0.2349	216.	1926.	0.2972E-06	0.1685
24	-1.67	0.0216	15913.	0.0140	0.00937	7.25	114.4	0.102	0.0672	1377.	0.2891E-06	5.2
	24.57	0.0258	4046.	11.8	0.00419	1270.62	0.251	0.3056	216.	1882.	0.2870E-06	0.1194
25	-2.41	0.0177	17093.	0.0150	0.00636	9.70	118.6	0.123	0.0847	1462.	0.2542E-06	4.2
	23.11	0.0255	3359.	9.5	0.00300	1276.13	0.291	0.3000	216.	1854.	0.2837E-06	0.0993
26	-3.28	0.0177	18184.	0.0150	0.00549	10.15	122.5	0.145	0.1010	1395.	0.2662E-06	3.5
	21.66	0.0262	2936.	7.0	0.00236	1278.59	0.326	0.2830	216.	1729.	0.2805E-06	0.0870
27	-4.28	0.0177	19252.	0.0160	0.00490	11.60	126.3	0.166	0.1164	1334.	0.2791E-06	3.0
	20.21	0.0271	2652.	5.9	0.00194	1279.81	0.355	0.2664	216.	1644.	0.2772E-06	0.0707
28	-5.42	0.0177	20332.	0.0160	0.00453	13.05	130.1	0.188	0.1297	1331.	0.2782E-06	2.7
	18.76	0.0306	2478.	5.4	0.00178	1280.22	0.378	0.2409	216.	1619.	0.2737E-06	0.0738
29	-6.69	0.0177	21485.	0.0170	0.00446	14.50	134.3	0.209	0.1351	1320.	0.2878E-06	2.6
	17.31	0.0359	2482.	5.3	0.00173	1279.43	0.388	0.1997	216.	1619.	0.2699E-06	0.0742
30	-8.10	0.0177	22782.	0.0170	0.00443	15.95	138.9	0.230	0.1393	1387.	0.2730E-06	2.5
	15.86	0.0460	2515.	5.5	0.00186	1278.50	0.393	0.1580	216.	1694.	0.2690E-06	0.0750
31	-9.64	0.0177	24259.	0.0170	0.00475	17.40	144.2	0.252	0.1320	1324.	0.3037E-06	2.7
	14.41	0.0527	2779.	5.6	0.00183	1275.92	0.373	0.0987	216.	1642.	0.2703E-06	0.0826
32	-12.01	0.0177	26601.	0.0180	0.00561	19.42	152.4	0.282	0.1160	1189.	0.3709E-06	3.0
	12.39	0.0644	3396.	5.8	0.00184	1269.82	0.324	0.0223	216.	1552.	0.2722E-06	0.1004
33	-13.14	0.0177	27996.	0.0180	0.00688	20.31	157.2	0.295	0.1000	1088.	0.3955E-06	3.5
	11.23	0.0756	4110.	6.4	0.00201	1262.43	0.255	0.0063	216.	1500.	0.2731E-06	0.1212
34	-13.87	0.0177	29556.	0.0180	0.00787	20.87	162.6	0.303	0.0920	1016.	0.4289E-06	3.8
	9.88	0.0630	4678.	6.7	0.00210	1254.84	0.223	-0.0016	216.	1459.	0.2742E-06	0.1376
35	-14.12	0.0177	31157.	0.0220	0.00794	21.07	168.6	0.306	0.0910	998.	0.4319E-06	3.7
	8.43	0.0847	4749.	6.6	0.00211	1253.41	0.218	0.0035	216.	1520.	0.2760E-06	0.1309
36	-14.12	0.0177	32972.	0.0220	0.00814	21.07	175.2	0.306	0.0910	983.	0.4561E-06	3.7
	6.74	0.0846	4978.	6.6	0.00211	1248.09	0.218	0.0035	216.	1508.	0.2793E-06	0.1446
37	-14.12	0.0177	34789.	0.0220	0.00833	21.07	181.8	0.306	0.0910	973.	0.4773E-06	3.7
	5.06	0.0861	5208.	6.6	0.00216	1242.60	0.218	0.0035	216.	1501.	0.2826E-06	0.1502
38	-14.12	0.0177	36602.	0.0220	0.00855	21.07	188.3	0.306	0.0910	954.	0.5051E-06	3.7
	3.37	0.0888	5440.	6.6	0.00226	1236.95	0.218	0.0035	216.	1482.	0.2859E-06	0.1558
39	-14.12	0.0177	38398.	0.0220	0.00880	21.07	194.7	0.306	0.0910	929.	0.5385E-06	3.7
	1.69	0.1000	5672.	6.5	0.00263	1231.14	0.218	0.0035	216.	1455.	0.2891E-06	0.1613
40	-14.12	0.0177	39897.	0.0220	0.01094	21.07	199.9	0.306	0.0910	602.	0.9429E-06	3.7
	0.0	0.5811	5870.	4.4	0.02455	1225.51	0.218	0.0035	216.	1021.	0.2918E-06	0.1661

FOR BOLT COOLANT OF 0.0 ABSORPING 0.0 OUTLET CONDITIONS ARE...
ENTHALPY 505.6 TEMPERATURE 199.9 PRESSURE 1197.2 RESULTING IN...
DELTA T 140.5, DELTA P 146.8

9
01SA002WLG SINGLE PASS FLOW 75K NOZZLE COL NOM. THRT 24/1 REF. 1137400/5-ENGINE 40

***** SUMMARY *****

COOLANT = PARA-HYDROGEN (FARMERS)

PIN = 752.

TIN = 56.2

TC = 4291.

PC = 265.

WG = 53.5

WC = 39.0

MR = 0.0

NT = 216.

STA	A/AT Z	CL CG	SUMQ VC	TH Q/AT	HL HG	R PRQ	TB DF	RG L	AF NMB	TWL TAG	RE MUB	WDOT/A MACH
1	24.00 72.81	0.0177 0.0500	6. 258.	0.0280 0.5	0.00041 0.00015	27.46 751.80	56.2 0.557	0.400 0.1058	0.2965 216.	858. 915.	0.5473E 05 0.5332E-06	0.6 0.0060
TURB TYPE = U-TURB MATERIAL = STAINLESS STEEL												
2	22.00 59.68	0.0177 0.0409	361. 277.	0.0280 0.5	0.00065 0.00017	26.29 751.74	59.1 0.550	0.383 0.1235	0.2851 216.	883. 945.	0.5531E 05 0.4938E-06	0.6 0.0067
3	20.00 66.53	0.0177 0.0409	736. 255.	0.0280 0.6	0.00060 0.00019	25.07 751.74	61.9 0.579	0.366 0.1401	0.3207 216.	1013. 1076.	0.4329E 05 0.4585E-06	0.6 0.0065
4	18.00 53.35	0.0177 0.0407	1128. 279.	0.0280 0.6	0.00066 0.00021	23.78 751.68	64.7 0.565	0.346 0.1601	0.3050 216.	1042. 1112.	0.4396E 05 0.4259E-06	0.6 0.0073
5	16.00 60.12	0.0177 0.0406	1557. 309.	0.0270 0.7	0.00072 0.00024	22.42 751.60	67.5 0.549	0.326 0.1799	0.2855 216.	1079. 1154.	0.4477E 05 0.3979E-06	0.6 0.0085
6	14.00 56.85	0.0177 0.0405	2027. 346.	0.0260 0.8	0.00080 0.00028	20.97 751.51	70.4 0.531	0.304 0.2013	0.2708 216.	1117. 1199.	0.4567E 05 0.3696E-06	0.7 0.0100
7	12.00 53.50	0.0177 0.0475	2641. 391.	0.0250 1.0	0.00081 0.00033	19.42 751.38	73.4 0.509	0.281 0.2241	0.2510 216.	1133. 1227.	0.4792E 05 0.3405E-06	0.7 0.0119
8	10.00 50.04	0.0177 0.0447	3114. 461.	0.0240 1.1	0.00105 0.00039	17.73 751.18	76.5 0.481	0.257 0.2483	0.2285 216.	1167. 1266.	0.5116E 05 0.3182E-06	0.8 0.0147
9	8.00 46.42	0.0177 0.0419	3768. 561.	0.0230 1.4	0.00124 0.00047	15.85 750.86	79.9 0.447	0.229 0.2759	0.2033 216.	1198. 1311.	0.5532E 05 0.2962E-06	0.9 0.0186
10	7.00 44.53	0.0177 0.0400	4128. 629.	0.0220 1.5	0.00137 0.00053	14.83 750.63	81.8 0.427	0.214 0.2898	0.1893 216.	1211. 1331.	0.5798E 05 0.2842E-06	1.0 0.0214
11	6.00 42.55	0.0177 0.0372	4524. 714.	0.0210 1.8	0.00154 0.00060	13.73 750.32	83.8 0.404	0.198 0.3058	0.1745 216.	1226. 1355.	0.6092E 05 0.2713E-06	1.0 0.0250
12	5.00 40.49	0.0177 0.0332	4957. 831.	0.0200 2.0	0.00174 0.00067	12.53 749.87	86.0 0.377	0.180 0.3231	0.1579 216.	1222. 1360.	0.6625E 05 0.2637E-06	1.1 0.0294
13	4.00 37.93	0.0177 0.0294	5435. 1067.	0.0190 2.3	0.00209 0.00078	11.21 748.90	88.4 0.366	0.160 0.3444	0.1305 216.	1199. 1353.	0.8479E 05 0.2559E-06	1.4 0.0381
14	3.00 35.88	0.0177 0.0258	5903. 1322.	0.0180 2.0	0.00251 0.00097	9.71 747.53	91.3 0.331	0.138 0.3666	0.1128 216.	1246. 1423.	0.8920E 05 0.2465E-06	1.6 0.0479
15	2.00 33.07	0.0177 0.0211	6696. 1785.	0.0170 3.9	0.00326 0.00130	7.93 744.75	95.1 0.283	0.112 0.3925	0.0909 216.	1300. 1518.	0.9577E 05 0.2365E-06	2.0 0.0654
16	1.90 32.76	0.0177 0.0202	6774. 1830.	0.0160 4.0	0.00332 0.00134	7.73 744.41	95.5 0.279	0.109 0.3956	0.0894 216.	1304. 1514.	0.9635E 05 0.2359E-06	2.0 0.0670
17	1.49 31.35	0.0177 0.0176	7142. 2176.	0.0150 4.8	0.00385 0.00158	6.84 741.90	97.5 0.253	0.096 0.4079	0.0787 216.	1341. 1570.	0.9878E 05 0.2331E-06	2.3 0.0794
18	1.16 30.02	0.0177 0.0173	7518. 2579.	0.0140 6.4	0.00459 0.00221	5.04 738.45	99.5 0.228	0.084 0.4207	0.0692 216.	1490. 1758.	0.8947E 05 0.2302E-06	2.6 0.0943
19	1.04 29.31	0.0270 0.0206	7758. 2794.	0.0170 9.1	0.00723 0.00308	5.72 736.39	100.9 0.219	0.079 0.4239	0.0657 216.	1361. 1727.	0.1062E 06 0.2283E-06	2.7 0.1022
20	1.00 28.53	0.0227 0.0235	8059. 3569.	0.0150 11.1	0.00822 0.00463	5.61 729.49	102.4 0.205	0.078 0.3485	0.0534 216.	1310. 1757.	0.1336E 06 0.2256E-06	3.4 0.1307
21	-1.04 27.44	0.0299 0.0306	8588. 5654.	0.0130 14.3	0.01338 0.00480	5.71 705.40	104.2 0.186	0.079 0.2169	0.0363 216.	1177. 1766.	0.2171E 06 0.2186E-06	5.0 0.2080
22	-1.16 26.39	0.0292 0.0344	9219. 6086.	0.0130 14.6	0.01335 0.00502	6.03 696.20	107.9 0.190	0.084 0.1941	0.0360 216.	1204. 1802.	0.2265E 06 0.2182E-06	5.0 0.2224

24	-1.67 4.57	0.0216 0.0258	10350. 3565.	0.0140 8.1	0.00610 0.00277	7.16 716.	116.8 0.251	0.102 0.3055	0.0672 216.	1450. 1799.	0.1350E 06 0.2225E-06	0.1263
25	-2.41 23.11	0.0177 0.0255	11168. 3035.	0.0150 5.2	0.00415 0.00198	8.70 718.15	122.6 0.291	0.123 0.3000	0.0847 216.	1531. 1708.	0.1223E 06 0.2238E-06	2.1 0.1058
26	-3.28 21.66	0.0177 0.0252	11912. 2713.	0.0150 4.7	0.00355 0.00156	10.15 718.92	128.0 0.326	0.145 0.2830	0.1010 216.	1466. 1691.	0.1303E 06 0.2248E-06	1.8 0.0933
27	-4.28 20.21	0.0177 0.0271	12637. 2506.	0.0160 4.0	0.00315 0.00128	11.60 719.22	133.5 0.355	0.166 0.2664	0.1164 216.	1407. 1616.	0.1387E 06 0.2258E-06	1.6 0.0851
28	-5.42 18.76	0.0177 0.0306	13369. 2376.	0.0160 3.7	0.00290 0.00118	13.05 719.25	139.0 0.378	0.188 0.2409	0.1297 216.	1408. 1601.	0.1393E 06 0.2284E-06	1.4 0.0797
29	-6.69 17.31	0.0177 0.0359	14148. 2399.	0.0170 3.6	0.00282 0.00114	14.50 718.76	144.9 0.388	0.209 0.1997	0.1351 216.	1411. 1610.	0.1428E 06 0.2327E-06	1.3 0.0795
30	-8.10 15.86	0.0177 0.0460	15025. 2457.	0.0170 3.7	0.00279 0.00122	15.95 718.18	151.5 0.393	0.230 0.1580	0.1393 216.	1491. 1695.	0.1354E 06 0.2374E-06	1.3 0.0803
31	-9.64 14.41	0.0177 0.0527	16026. 2752.	0.0170 3.8	0.00298 0.00120	17.40 716.72	158.9 0.373	0.252 0.0987	0.1320 216.	1438. 1650.	0.1504E 06 0.2427E-06	1.4 0.0887
32	-12.01 12.79	0.0177 0.0744	17620. 3424.	0.0180 4.0	0.00347 0.00122	19.42 713.31	170.5 0.424	0.282 0.0228	0.1160 216.	1310. 1552.	0.1831E 06 0.2510E-06	1.6 0.1079
33	-13.14 11.23	0.0177 0.0756	18572. 4170.	0.0180 4.4	0.00418 0.00132	20.31 709.31	177.3 0.255	0.295 0.0063	0.1000 216.	1280. 1495.	0.1914E 06 0.2561E-06	1.8 0.1300
34	-13.87 9.88	0.0177 0.0830	19633. 4770.	0.0180 4.6	0.00470 0.00139	20.87 705.13	184.7 0.223	0.303 -0.0016	0.0920 216.	1157. 1450.	0.2036E 06 0.2616E-06	2.0 0.1469
35	-14.12 8.43	0.0177 0.0847	20724. 4867.	0.0220 4.5	0.00470 0.00139	21.07 704.13	192.7 0.218	0.306 0.0035	0.0910 216.	1149. 1496.	0.2028E 06 0.2678E-06	1.9 0.1477
36	-14.12 6.74	0.0177 0.0846	21967. 5138.	0.0220 4.5	0.00481 0.00139	21.07 700.95	201.5 0.218	0.306 0.0035	0.0910 216.	1136. 1466.	0.2141E 06 0.2752E-06	1.9 0.1538
37	-14.12 5.06	0.0177 0.0861	23206. 5392.	0.0220 4.5	0.00490 0.00143	21.07 697.78	210.3 0.218	0.306 0.0035	0.0910 216.	1130. 1482.	0.2230E 06 0.2815E-06	1.9 0.1589
38	-14.12 3.37	0.0177 0.0888	24445. 5647.	0.0220 4.5	0.00501 0.00149	21.07 694.49	218.9 0.218	0.306 0.0035	0.0910 216.	1114. 1465.	0.2347E 06 0.2877E-06	1.9 0.1639
39	-14.12 1.69	0.0177 0.1000	25665. 5901.	0.0220 4.4	0.00513 0.00174	21.07 691.11	227.4 0.218	0.306 0.0035	0.0910 216.	1085. 1433.	0.2503E 06 0.2938E-06	1.9 0.1687
40	-14.12 0.0	0.0177 0.6811	26695. 6125.	0.0220 3.0	0.00514 0.01951	21.07 687.82	234.4 0.218	0.306 0.0035	0.0910 216.	731. 1014.	0.4268E 06 0.2990E-06	1.9 0.1729

FOR BOLT COOLANT OF C.O. ABSORBING C.O. OUTLET CONDITIONS ARE...
ENTHALPY 650.1 TEMPERATURE 234.4 PRESSURE 672.7 RESULTING IN...
DELTA T 178.2, DELTA P 79.3

TABLE 1 - ENGINE OPERATING CONDITIONS ASSUMED FOR ANALYSIS

Run Number*	Stagnation Conditions Temperature (Deg R)	Pressure (Psia)	Nozzle Flow (lb/sec)	Coolant Flow (lb/sec)	Coolant Inlet Conditions Temperature (Deg R)	Pressure (Psia)	Comments
09SA001	4295.	445.	90.2	76.1	59.4	1344.	NEOL Modified Contour Per Dwg. 1138000
09SA002	4291.	265.	53.5	39.0	56.2	752.	NTEOL Modified Contour Per Dwg. 1138000

*All analyses run with land and groove configuration option where applicable

TABLE 2 - COMPUTER RESULTS

Run Number	Maximum Coolant Heat Flux/ Station Number (Btu/in ² -sec)	Maximum Gas-Side Wall Temperature/ Station Number (Deg R)	Maximum Coolant Bulk Mach Number/ Station Number	Maximum Gas-Side Wall Temperature at Barrel Station 35 (Deg R)	Over-all Coolant Temperature Rise (Deg R)	Over-all Coolant Pressure Drop (Psia)
09SA001	20.82/22	1933./22	.21/22	1520.	140.5	146.8
09SA002	14.63/22	1807./23	.22/22	1496.	178.2	79.3

TABLE 3 - VALUES OF COMPUTER MODEL PARAMETERS

Station Number	Axial Distance From 24:1 Area Ratio Location (Z) inches	Area Ratio (A/A_t)	Radius R (inches)	Radiation Exchange Factor (FEFV)	Recovery Temperature Factor (BETA)	Factor In Gas-Side Heat Transfer Coefficient Equation (CG)
1.	72.813	24.00	27.459	.000	.9100	.0500
2.	69.678	22.00	26.290	.000	.9100	.0499
3.	66.528	20.00	25.066	.000	.9100	.0498
4.	63.353	18.00	23.780	.000	.9100	.0497
5.	60.123	16.00	22.420	.000	.9100	.0496
6.	56.846	14.00	20.972	.000	.9100	.0495
7.	53.503	12.00	19.416	.000	.9100	.0475
8.	50.040	10.00	17.725	.000	.9200	.0447
9.	46.418	8.00	15.853	.000	.9200	.0419
10.	44.528	7.00	14.829	.000	.9200	.0400
11.	42.552	6.00	13.729	.000	.9300	.0372
12.	40.488	5.00	12.533	.000	.9300	.0332
13.	37.933	4.00	11.210	.000	.9300	.0294
14.	35.878	3.00	9.708	.000	.9400	.0258
15.	33.066	2.00	7.927	.000	.9500	.0211
16.	32.758	1.90	7.726	.000	.9500	.0202
17.	31.345	1.49	6.842	.000	.9600	.0176
18.	30.023	1.16	6.037	.000	.9700	.0173
19.	29.306	1.04	5.715	.000	.9800	.0206
20. (Throat)	28.528	1.00	5.605	.090	.9900	.0235
21.	27.435	- 1.04	5.713	.090	.9900	.0306
22.	26.385	- 1.16	6.032	.090	.9900	.0344
23.	25.415	- 1.37	6.549	.090	1.00	.0310
24.	24.565	- 1.67	7.247	.090	1.00	.0258
25.	23.114	- 2.41	8.697	.173	1.00	.0255
26.	21.663	- 3.28	10.148	.180	1.00	.0262
27.	20.212	- 4.28	11.599	.180	1.00	.0271
28.	18.761	- 5.42	13.050	.180	1.00	.0306
29.	17.310	- 6.69	14.501	.201	1.00	.0359
30.	15.859	- 8.10	15.952	.260	1.00	.0460
31.	14.408	- 9.64	17.403	.343	1.00	.0527
32.	12.388	-12.01	19.423	.343	1.00	.0644

TABLE 3 - VALUES OF COMPUTER MODEL PARAMETERS (Cont.)

Station Number	Axial Distance From 24:1 Area Ratio Location (Z) inches	Area Ratio (A/A_t)	Radius R (inches)	Radiation Exchange Factor (FEFV)	Recovery Temperature Factor (BETA)	Factor In Gas-Side Heat Transfer Coefficient Equation (CG)
33.	11.227	-13.14	20.314	.365	1.00	.0756
34.	09.875	-13.87	20.874	.335	.9980	.0830
35.	08.425	-14.12	21.065	.300	.9940	.0847
36.	06.740	-14.12	21.065	.342	.9850	.0846
37.	05.055	-14.12	21.065	.388	.9680	.0861
38.	03.370	-14.12	21.065	.445	.9335	.0888
39.	01.685	-14.12	21.065	.445	.8480	.1000
40.	00.000	-14.12	21.065	.500	.2700	.6811

AEROJET NUCLEAR SYSTEMS COMPANY
SACRAMENTO, CALIFORNIA

WS # 9d

TO: L A Shurley

DATE: 18 August 1971
RHC:lm:N8500:M1353

FROM: R H Coppo

SUBJECT: Nozzle Parameters per "E" Engine NETAP Conditions

DISTRIBUTION: J L Watkins

REFERENCE: ✓ (a) Memo N4110:0067, W E Stephens to A D Cornell, dtd 26 Feb. 1971
Subj: "State Points for the 1137400/Revision E Reference Engine"

✓ (b) Memo N8110:M1709, J J Williams to R H Coppo, dtd 15 June 1971
Subj: "Thermal Analysis of Nozzle Coolant Channels"

ENCLOSURE: (1) Table I - ΔP and ΔT_B Comparison
(2) Table II - Coolant Tube Wall Temperatures
(3) Table III - Comparison of Nozzle Results "E" Engine & Previous Design Conditions
(4) Plot of ΔT_{NT} vs Pressure

Table I presents a tabulation of nozzle coolant pressure drops and bulk temperature rises predicted by Heat Transfer Program E25104, Reference (b), in comparison with limits predicted by "E" engine NETAP conditions per Reference (a). "E" engine NETAP conditions were used to determine the effect on the nozzle operating parameters using the current nozzle coolant tube geometry previously determined (Ref. Computer Run 71-003) Nozzle inlet conditions and chamber conditions were chosen (all minimum except chamber temperature is maximum) so that maximum nozzle ΔP and T_{wg} are obtained using Computer Run 71-003 coolant channel geometry. Examination of Table III indicates fair agreement between ΔT_B predicted by E25104 and the maximum limit of NETAP as was expected. However, ΔP values predicted by E25104 agree more with minimum limit of NETAP. This is probably due to the change in inlet condition from which the coolant tube geometry was originally sized.

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CLASSIFICATION CATEGORY

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It is important to note that pressure drop values listed in Table I as predicted by E25104 have been adjusted in comparison with values listed in Reference (b) to account for nozzle inlet entrance loss. Program E25104 will be changed to include this loss. It was also found that NETAP nozzle inlet pressure values, as presented in Reference (a) for life condition MTSOL, were in error (low by 10 psia). The correct ΔP values are noted in Table I. Values predicted by E25104 program for the case are based on the lower nozzle inlet pressures; however, resultant ΔP and ΔT_B values are felt to be representative. As additional information, coolant tube wall temperatures for each run at selected stations are presented in Table II.

Table III presents a comparison of the nozzle parameters using "E" engine NETAP conditions with that of conditions used in Computer Run 71-003. Examination of Table III indicates a decrease of 22°F for the maximum flux wall temperature, 2.5°R in ΔT_B , 82° in T_{wg} maximum barrel section and an increase in ΔP of almost 4 psia for life condition NEOL. These changes are due to the changes in inlet conditions. A change in coolant tube geometry (increase flow area) can be made to restore the maximum wall temperature back to 1500°F which would also reduce ΔP and increase ΔT_B back to about the previous values.

Enclosure (4) presents a curve provided by Engine Systems people of nozzle ΔT_B versus pressure. Examination of Enclosure (4) indicates that if nozzle coolant tube geometry is changed in the future then it is important to consider the effect on other components by a reduction of nozzle ΔT_B . For example, if nozzle ΔT_B is reduced from the present value of 140°R to 124°R; a reduction in pump discharge pressure and turbine outlet pressure of about 16 and 18 psi respectively is expected. However, this would reduce effective ΔP of the nozzle which is desirable. It may be possible to maintain approximately the same effective nozzle ΔP by redesign of the divergent section portion of the nozzle coolant channels (increase the flow area) to reduce bulk temperature rise since from an area ratio of 24:1 to 3:1 there is about 35°R increase in ΔT_B with an accompanying increase of only 10 psi in ΔP .

It is therefore recommended to maintain the current nozzle coolant tube geometry and not revise T_{wg} (maximum) back to 1500°F until information concerning growth at $T_c = 4500^\circ R$ and final metal creep and fatigue test data is available. As time permits a study will be conducted to investigate the nozzle effects of redesigning the aft coolant tube geometry to reduce ΔT_B to about 124°R with minimum change in ΔP and without jeopardizing the reliability of the coolant tubes.

R. H. Coppo

R. H. Coppo
Nozzle, Pressure Vessel Section

TABLE I

 ΔP AND ΔT_B COMPARISON

Computer Run No.	Life Condition	Predicted by E25104 Program		NETAP					
		$\Delta P^{(1)}$ (PSID)	ΔT_B (°R)	ΔP (PSID)			ΔT_B (°R)		
				MAX	NOM	MIN	MAX	NOM	MIN
09SG004	NSOL	181.7	136.2	190	184	180	141.0	131.2	121.5
09SG005	NEOL	174.2	140.5	183	177	173	145.1	136.3	126.6
09SG006	MSOL	125.6	145.7	133	127	124	150.4	139.6	129.9
09SG007	MEOL	118.3	153.0	126	120	117	157.2	146.4	136.7
09SG008	NTSOL	99.6	165.3	100	97	96	165.7	156.6	147.1
09SG009	NTEOL	89.7	178.3	93	90	88	178.4	169.3	160.8
09SG010	MTSOL	92.7	163.8	84 ⁽²⁾	80	77	163.2	154.1	145.6
09SG011	MTEOL	83.4	174.6	87	83	81	173.9	164.8	156.3

(1) Nozzle inlet entrance loss has been included to give these results. Current 25104 program does not include inlet entrance loss.

(2) NETAP memo Reference (a) in error. Values should be 94, 90 and 87 respectively.

TABLE II

COOLANT TUBE WALL TEMPERATURES

Computer Run No.	Life Condition	Twg (Max) $\epsilon = -1.16$ (°F)	Twg $\epsilon = 24:1$ (°F)	Twg Barrel Section	
				Max (°F)	Mean (°F)
09SG004	NSOL	1470	167	1048	784
09SG005	NEOL	1471	177	1060	798
09SG006	MSOL	1398	191	1006	779
09SG007	MEOL	1403	207	1023	799
09SG008	NTSOL	1326	426	999	819
09SG009	NTEOL	1347	455	1036	862
09SG010	MTSQL	1333	404	991	810
09SG011	MTEOL	1345	416	1021	845

TABLE III

COMPARISON OF NOZZLE RESULTS
"E" ENGINE AND PREVIOUS DESIGN CONDITIONSA. INLET CONDITIONS

Computer Run No.	Life Condition	Engine Designation	P _c (PSIA)	T _c (°R)	W _t (lb/s)	W _c (lb/s)	P _{in} (PSIA)	T _{in} (°R)
09SG005	NEOL	E	445	4295	90.2	76.1	1344	59.4
71-003	NEOL		442	4318	89.1	73.2	1287	56.6
09SG009	NTEOL	E	265	4291	53.5	39.0	752	56.2
71-005	NTEOL		285	4318	57.2	38.7	747	49.9

B. RESULTS

Computer Run No.	Life Condition	Engine Designation	ΔP (PSID)	ΔT _B (°R)	T _{wg} (max) ε=-1.16 (°F)	T _{wg} ε=24:1 (°F)	T _{wg} Barrel Section Max(°F)	T _{wg} Section Mean(°F)
09SG005	NEOL	E	*2 174.2	140.5	1471	177	1060	798
71-003	NEOL		*1,2 170.3	143.0	1493	221	1142	888
09SG009	NTEOL	E	*2 89.7	178.3	1347	455	1036	862
71-005	NTEOL		*1,2 89.9	185.5	1407	562	1160	984

*1 Adjusted to account for additional exit loss (K = 0.4).

*2 Adjusted to account for inlet loss not included in E25104 program.