Structural Integrity Associates, Inc.	File No.: 0800368.301
CALCULATION PACKAGE	**Project No.:** 0800368 Quality Program: ☒ Nuclear ☐ Commercial

PROJECT NAME:

Davis Besse Phase 2 Alloy 600

CONTRACT NO.:

49151, Rev.1

CLIENT:	**PLANT:**
Welding Service Inc (WSI)	Davis-Besse Nuclear Power Station, Unit 1

CALCULATION TITLE:

Material Properties for Davis-Besse Unit 1, RCP Suction, RCP Discharge, Cold Leg Drain and Core Flood Nozzles Preemptive Weld Overlay Repairs

Document Revision	Affected Pages	Revision Description	Project Manager Approval Signature & Date	Co-Preparer(s) & Checker(s) Signatures & Date
0	1 – 23 A1 – A27 Computer Files	Initial Issue	Rich Bax 04/21/09	Preparers: Aparna Chintapalli 04/21/09 Steve White 04/21/09 Checker: Vikram Marthandam 04/21/09

Table of Contents

1.0 OBJECTIVE 3
2.0 METHODOLOGY 3
3.0 ASSUMPTIONS 3
4.0 DESIGN INPUTS 4
5.0 CONCLUSIONS 4
6.0 REFERENCES 5
APPENDIX A MATERIAL PROPERTY INPUT FILES A1

List of Tables

Table 1: Material Designation 6
Table 2: Elastic Properties for SA-508, Class 2 (3/4Ni-1/2Mo-1/3Cr-V) 8
Table 3: Elastic-Plastic Properties for SA-508, Class 2 (3/4Ni-1/2Mo-1/3Cr-V) 9
Table 4: Elastic Properties for Alloy 82/182 10
Table 5: Elastic-Plastic Properties for Alloy 82/182 11
Table 6: Elastic Properties for Alloy 52M/152 12
Table 7: Elastic-Plastic Properties for Alloy 52M/152 13
Table 8: Elastic Properties for SA-240-304L, SA-371 ER308L and ER308L (18Cr-8Ni) 14
Table 9: Elastic-Plastic Properties for SA-240-304L, SA-371 ER308L and ER308L (18Cr-8Ni) 15
Table 10: Elastic Properties for A-376, Type 316, A-351 Grade CF8M, A-336 Grade F8M, SA-403 WP 316 (16Cr-12Ni-2Mo) 16
Table 11: Elastic-Plastic Properties for A-376, Type 316, A-351 Grade CF8M, A-336 Grade F8M, SA-403 WP 316 (16Cr-12Ni-2Mo) 17
Table 12: Elastic Properties for SA-105, Grade 2 (C>0.3%) 18
Table 13: Elastic-Plastic Properties for SA-105, Grade 2 19
Table 14: Elastic Properties for A-106 Grade C (C>0.3%) 20
Table 15: Elastic-Plastic Properties for A-106 Grade C 21
Table 16: Elastic Properties for SA-516 Grade 70 (<4" thick, C<0.3%) 22
Table 17: Elastic-Plastic Properties for SA-516 Grade 70 (<4" thick, C<0.3%) 23

1.0 OBJECTIVE

The purpose of this calculation is to identify the materials of the Reactor Coolant Pump (RCP) Suction, RCP Discharge, Cold Leg Drain and Core Flood Nozzle components to be analyzed for preemptive weld overlay repair for Davis-Besse, Unit 1. Material property data values are obtained for use in subsequent finite element analyses using the commercial software package ANSYS [1].

2.0 METHODOLOGY

The material component information for the nozzles of interest are obtained from References 6 through 9. The material property data values are obtained from the ASME Code, Section II, Part D, 2001 Edition with Addenda through 2003 [2] and ASME Code, Section II, Part A, Ferrous Material Specification [4].

Two input files are developed containing the material property data for use within ANSYS for specific analyses. Material property data values are defined for linear and nonlinear type analyses, which will be temperature dependent. Linear material property data values will be used for thermal-mechanical analyses (MProp_Linear_DB.INP). Nonlinear material property data values will be used for weld residual analyses (MProp_MISO_NLinear_DB.INP).

3.0 ASSUMPTIONS

The following assumptions are made with respect to the analyses (i.e., linear, nonlinear):

- The nozzle-to-safe end weld for the RCP Discharge and the safe end-to-pipe weld for the Core Flood Nozzle are identified as SS Type 316. SS Type 316 is assumed to have similar properties to SA-376, Type 316.
- The cladding for the Core Flood Nozzle is listed in Reference 6 as Stainless Steel and is assumed to have similar properties to SA-240-304L.
- Any ID weld repairs are assumed to be Alloy 82/182.
- The weld overlay material is assumed to be Alloy 52M, which has similar material properties to Alloy 690. Alloy 52M is assumed for the overlay weld filler metal based on Reference 3.
- A buffer layer of ER308L is assumed to be applied over the stainless steel components prior to the application of the Alloy 52M overlay material.
- Poisson's ratio and density are assumed temperature independent.

- Linear interpolation is used obtain material properties that are not provided in the ASME Code.
- The Reactor Vessel is assumed to be clad with the equivalent of SA-240-304L.
- High Temperature material properties (above ASME Code values) are based on values and assumptions from Reference 5.
- The RCP cold leg drain nozzle-to-cold leg weld is not modeled. Instead, the materials transition instantly. Stress from this transition will be local to the transition and remote from the weld overlay repair. Therefore, those stresses are insignificant to the weld overlay repair.
- The Spray Nozzle-to-RCP Discharge Safe End weld and Pressure Tap-to-RCP Discharge Safe End weld are assumed to be SS Type 316. SS Type 316 is assumed to have similar properties to SA-376, Type 316.

4.0 DESIGN INPUTS

Material designations for the various components are shown in Table 1. The thermal and structural properties (E, α, k, c_p) are obtained from Reference 2. Non-linear material properties required for residual stress analysis based on multi-linear isotropic hardening (MISO) principles are obtained from Reference 5. Linear and non-linear (elastic and elastic-plastic) properties at high temperatures are necessary for simulating the molten metal for the residual stress analysis. Elastic and elastic-plastic properties for these materials are shown in Tables 2 through 17. For the ASME Code, Section III stress evaluation, only temperatures up to design temperature are necessary.

5.0 CONCLUSIONS

Two input files have been developed in this calculation for use in the subsequent finite element analyses. They are included in Appendix A and the computer files.

6.0 REFERENCES

1. ANSYS/Mechanical, Release 8.1 (w/Service Pack 1), ANSYS, Inc., June 2004.

2. ASME Boiler and Pressure Vessel Code, Section II, Part D, Material Properties, 2001 Edition with Addenda through 2003.

3. *Materials Reliability Program Technical Basis for Preemption Weld Overlays for Alloy 82/182 Butt Welds in PWRs (MRP-169)*, EPRI, Palo Alto, CA and Structural Integrity Associates, Inc., San Jose, CA : 2005. 1012843.

4. ASME Boiler and Pressure Vessel Code, Section II, Part A, Ferrous Material Specifications, 2001 Edition with Addenda through 2003.

5. SI Calculation No. 0800777.302, Rev. 2, "Material Properties for Residual Stress Analyses, Including MISO Properties."

6. "Input List – Design Data," Rev.1, Design Input Information Supplied by FirstEnergy Nuclear Operating Company on 9/12/08, SI File No. 0800368.241.

[redacted]

10. ASME Boiler and Pressure Vessel Code, Section III, Appendices, 1974 Edition.

11. ASME Boiler and Pressure Vessel Code, Section II, Material Specifications, 1974 Edition.

Table 1: Material Designation

Component	Nozzle Forging	Safe -End	Clad	Nozzle-to-SE Butter and Weld	SE-to-Pipe Weld	Nozzle-to-pipe butter and weld	Attached Pipe/Elbow
RCP Inlet/Suction	A-351, Grade CF8M[10]	N/A	SA240-304L	N/A	N/A	Alloy 82/182[1]	A-516, Grade 70
RCP Discharge	A-351, Grade CF8M[10]	A-376, Type 316	SA240-304L	SS Type 316 (Assumed)[6]	Alloy 82/182[1]	N/A	A-516, Grade 70
RCP Cold Leg Drain	SA-105 Grade 2[8]	N/A	SA-371 ER308L[3]	N/A	N/A	Alloy 82/182[1]	SA-403 WP316
Core Flood Nozzle	SA-508 Class 2[5]	SA-336, Grade F8M[7]	Stainless Steel (Assumed)[3]	Alloy 82/182[1]	SS Type 316 (Assumed)[6]	N/A	SA-376, Type 316
Core Flood Vessel Shell	[redacted]						
Core Flood Vessel Clad	SS Clad[3] (Assumed)						
ID Weld Repair	Alloy 82/182[1] (Assumed)						
Weld Overlay	Alloy 52M[2] (Assumed)						
Cold Leg Straight Pipe	[redacted]						
Cold Leg Clad	SA-240-304L						
Spray Nozzle on Discharge Nozzle	[redacted]						
Pressure Tap on Discharge Nozzle	[redacted]						
Spray Nozzle and Pressure Tap welds to the RCP Discharge Safe End	SS Type 316 (Assumed)[6]						
Buffer Layer	ER308L[3] (Assumed)						

Notes:

1. Alloy 82/182 elastic properties are equivalent to Alloy 600.
2. Alloy 52M properties will be treated as equivalent to Alloy 690.
3. SA-371 ER308L, ER308L, the stainless steel clad for Core Flood Nozzle and Vessel Shell will be treated as SA-240-304L.
4. All materials in this table are obtained from Reference 6 unless otherwise specified.
5. SA-508 Grade 2, Class 1 was formerly known as SA-508 Class 2 in Reference 4.
6. SS Type 316 will be treated as SA-376 Type 316.
7. SA-336, Grade F8M is not mentioned in Reference 4. Going back to the 1974 Edition of the ASME Code [10, 11], A-336, Grade F8M has similar chemical composition as well as allowables for Design Stress Intensity, Sm, Yield Strength, Sy, and Ultimate Strength when compared to SA-430 FP316. Therefore, material properties of SA-430 FP316 from the 2001 Edition of the ASME Code [2, 4] will be used in substitution for A-336, Grade F8M.
8. SA-105 Grade 2 is now defined in Reference 4 as SA-105.
9. A-182 F316 has similar composition and material properties as SA-376 Type 316.
10. SI's past experience has shown that when using available thermally aged cast austenitic stainless steel (CASS) toughness data, thermal aging of the CASS does not significantly affect the results of the weld overlay residual

stress analysis. Thermal aging affects the mechanical properties of the CASS, increasing the yield and ultimate strengths, and reducing the elongation and reduction of area. SI performed a search of published data, investigating the effects of thermal aging at temperatures ranging from 300 to 400°C (572 to 752°F) for from 10000 to 50000 hours on mechanical properties of CASS. The result of that search indicated that one could reasonably represent the thermal aging effects on yield strength and ultimate tensile strength by increasing these by approximately 15% and correspondingly decrease the elongation and reduction of area by 15-20% to see the effect on residual stress following a weld overlay application. Taking our investigation one step further, a two-dimensional finite element analysis was performed where we compared the ID and through wall residual stresses of a 30-inch diameter weld overlay repaired CASS component in the unaged condition to one in the aged condition where the properties were adjusted as described in the paragraph above. The investigation revealed that the change in properties had very minimal effect on the as-welded residual stresses, when comparing the unaged to the aged condition. The change was of the order of a few ksi, well within any anticipated scatter in the raw data. There is also no effect on the applied loads, or the physical properties, such as modulus of elasticity, thermal conductivity, thermal diffusivity, thermal expansion, and specific heat. Consequently, the effects on the above properties need not be adjusted for thermal aging.

Table 2: Elastic Properties for SA-508, Class 2 (3/4Ni-1/2Mo-1/3Cr-V)

Temperature (°F)	Young's Modulus ($x10^6$ psi)	Mean Thermal Expansion ($x10^{-6}$ in/in/°F)	Thermal Conductivity ($x10^{-4}$ Btu/sec-in-°F)	Specific Heat[2] (Btu/lb-°F)
70	27.8	6.4	5.44	0.105
100	27.6[1]	6.5	5.46	0.107
150	27.4[1]	6.6	5.46	0.110
200	27.1	6.7	5.46	0.114
250	26.9[1]	6.8	5.44	0.116
300	26.7	6.9	5.42	0.119
350	26.4[1]	7.0	5.39	0.122
400	26.1	7.1	5.35	0.125
450	25.9[1]	7.2	5.30	0.128
500	25.7	7.3	5.25	0.130
550	25.5[1]	7.3	5.21	0.133
600	25.2	7.4	5.14	0.135
650	24.9[1]	7.5	5.07	0.137
700	24.6	7.6	5.00	0.140
1100	21.5	8.2	4.40	0.173
1500[3]	16	8.6	3.50	0.154
2500[3]	0.1	9.5	1.16	0.204

Density (ρ) = 0.283 lb/in^3, assumed temperature independent.
Poisson's Ratio (υ) = 0.3, assumed temperature independent.

Notes:
1. Interpolated.
2. Specific Heat values are derived from the equation shown in General Note (a) of Table TCD [2], Specific Heat = TC / (TD x density).
3. Values per Reference 5.

Table 3: Elastic-Plastic Properties for SA-508, Class 2 (3/4Ni-1/2Mo-1/3Cr-V)

Temperature (°F)	True Strain (in/in)	True Stress (psi)
70	0.0017986	50000
	0.0065369	60250
	0.0183386	70500
	0.0508884	80750
	0.1308399	91000
500	0.0016809	43200
	0.0042582	55150
	0.0131226	67100
	0.0432616	79050
	0.1306929	91000
700	0.0016545	40700
	0.0037548	53275
	0.0116755	65850
	0.0407883	78425
	0.1306539	91000
1100	0.0011163	24000
	0.0129052	36000
	0.0430001	48000
	0.1136083	60000
	0.2542214	72000
1500	0.0004375	7000
	0.0289125	17750
	0.1012202	28500
	0.2377615	39250
	0.4545419	50000
2500	0.0100000	1000
	0.2543666	2000
	0.4621339	3000
	0.7070397	4000
	0.9840915	5000

Table 4: Elastic Properties for Alloy 82/182

Temperature (°F)	Young's Modulus ($x10^6$ psi)	Mean Thermal Expansion ($x10^{-6}$ in/in/°F)	Thermal Conductivity ($x10^{-4}$ Btu/sec-in-°F)	Specific Heat[2] (Btu/lb-°F)
70	31.0	6.8	1.99	0.108
100	30.8[1]	6.9	2.01	0.109
150	30.5[1]	7.0	2.06	0.111
200	30.2	7.1	2.11	0.113
250	30.0[1]	7.2	2.15	0.114
300	29.8	7.3	2.22	0.116
350	29.7[1]	7.4	2.27	0.116
400	29.5	7.5	2.34	0.118
450	29.3[1]	7.6	2.38	0.118
500	29.0	7.6	2.45	0.120
550	28.9[1]	7.7	2.50	0.121
600	28.7	7.8	2.57	0.123
650	28.5[1]	7.8	2.62	0.123
700	28.2	7.9	2.69	0.125
1100	25.9	8.4	3.19	0.139
1500[3]	23.1	9.0	3.70	0.148
2500[3]	0.1	10.0	5.09	0.177

Density (ρ) = 0.300 lb/in^3, assumed temperature independent.
Poisson's Ratio (υ) = 0.29, assumed temperature independent.

Notes:
1. Interpolated.
2. Specific Heat values are derived from the equation shown in General Note (a) of Table TCD [2], Specific Heat = TC / (TD x density).
3. Values per Reference 5.

Table 5: Elastic-Plastic Properties for Alloy 82/182

Temperature (°F)	True Strain (in/in)	True Stress (psi)
70	0.0017581	54500
	0.0626142	77125
	0.1323668	99750
	0.2410555	122375
	0.3972410	145000
500	0.0016379	47500
	0.0608769	67625
	0.1300082	87750
	0.2382802	107875
	0.3943945	128000
700	0.0016596	46800
	0.0622784	66350
	0.1321471	85900
	0.2412033	105450
	0.3980922	125000
1100	0.0017375	45000
	0.0688026	62250
	0.1404333	79500
	0.2499634	96750
	0.4053648	114000
1500	0.0012900	29800
	0.1814980	41100
	0.2996116	52400
	0.4484683	63700
	0.6285114	75000
2500	0.0100000	1000
	0.2543666	2000
	0.4621339	3000
	0.7070397	4000
	0.9840915	5000

Table 6: Elastic Properties for Alloy 52M/152

Temperature (°F)	Young's Modulus ($x10^6$ psi)	Mean Thermal Expansion ($x10^{-6}$ in/in/°F)	Thermal Conductivity ($x10^{-4}$ Btu/sec-in-°F)	Specific Heat[2] (Btu/lb-°F)
70	30.3	7.7	1.57	0.107
100	30.1 [1]	7.8	1.62	0.108
150	29.8 [1]	7.8	1.69	0.110
200	29.5	7.9	1.76	0.112
250	29.3 [1]	7.9	1.83	0.114
300	29.1	7.9	1.90	0.116
350	29.0 [1]	8.0	1.97	0.117
400	28.8	8.0	2.04	0.118
450	28.6 [1]	8.1	2.11	0.119
500	28.3	8.1	2.18	0.121
550	28.2[1]	8.1	2.25	0.122
600	28.1	8.2	2.31	0.123
650	27.9[1]	8.2	2.38	0.124
700	27.6	8.3	2.45	0.125
1100	25.3	8.5	3.03	0.135
1500[3]	22.6	8.8	3.59	0.147
2500[3]	0.1	9.5	5.09	0.167

Density (ρ) = 0.293 lb/in^3, assumed temperature independent.
Poisson's Ratio (υ) = 0.29, assumed temperature independent.

Notes:
1. Interpolated.
2. Specific Heat values are derived from the equation shown in General Note (a) of Table TCD [2], Specific Heat = TC / (TD x density).
3. Values per Reference 5.

Table 7: Elastic-Plastic Properties for Alloy 52M/152

Temperature (°F)	True Strain (in/in)	True Stress (psi)
70	0.0016073	48700
	0.0630592	75275
	0.1421644	101850
	0.2663752	128425
	0.4441853	155000
500	0.0012898	36500
	0.0396551	59125
	0.1033755	81750
	0.2147115	104375
	0.3873830	127000
700	0.0012500	34500
	0.0354049	57125
	0.0968184	79750
	0.2076735	102375
	0.3836597	125000
1100	0.0012530	31700
	0.0493023	50775
	0.1202071	69850
	0.2373289	88925
	0.4112380	108000
1500	0.0012434	28100
	0.2618302	44075
	0.4304344	60050
	0.6289623	76025
	0.8547593	92000
2500	0.0100000	1000
	0.2543666	2000
	0.4621339	3000
	0.7070397	4000
	0.9840915	5000

Table 8: Elastic Properties for SA-240-304L, SA-371 ER308L and ER308L (18Cr-8Ni)

Temperature (°F)	Young's Modulus ($x10^6$ psi)	Mean Thermal Expansion ($x10^{-6}$ in/in/°F)	Thermal Conductivity ($x10^{-4}$ Btu/sec-in-°F)	Specific Heat[2] (Btu/lb-°F)
70	28.3	8.5	1.99	0.116
100	28.1[1]	8.6	2.01	0.117
150	27.9[1]	8.8	2.08	0.120
200	27.6	8.9	2.15	0.122
250	27.3[1]	9.1	2.22	0.124
300	27.0	9.2	2.27	0.125
350	26.8[1]	9.3	2.34	0.127
400	26.5	9.5	2.41	0.129
450	26.2[1]	9.6	2.45	0.130
500	25.8	9.7	2.52	0.131
550	25.6[1]	9.8	2.57	0.132
600	25.3	9.8	2.62	0.133
650	25.1[1]	9.9	2.69	0.134
700	24.8	10.0	2.73	0.135
1100	22.1	10.5	3.15	0.140
1500[3]	18.1	10.8	3.54	0.145
2500[3]	0.1	11.5	4.86	0.159

Density (ρ) = 0.283 lb/in^3, assumed temperature independent.
Poisson's Ratio (υ) = 0.3, assumed temperature independent.

Notes:
1. Interpolated.
2. Specific Heat values are derived from the equation shown in General Note (a) of Table TCD [2], Specific Heat = TC / (TD x density).
3. Values per Reference 5.

Table 9: Elastic-Plastic Properties for SA-240-304L, SA-371 ER308L and ER308L (18Cr-8Ni)

Temperature (°F)	True Strain (in/in)	True Stress (psi)
70	0.0012367	35000
	0.0777489	64750
	0.1821409	94500
	0.3382732	124250
	0.5503345	154000
500	0.0008527	22000
	0.0358911	42750
	0.1059492	63500
	0.2314091	84250
	0.4262954	105000
700	0.0008065	20000
	0.0281096	40000
	0.0908367	60000
	0.2111270	80000
	0.4075613	100000
1100	0.0007421	16400
	0.0138355	30050
	0.0519078	43700
	0.1392265	57350
	0.3044729	71000
1500	0.0007182	13000
	0.0652982	18250
	0.1354897	23500
	0.2429079	28750
	0.3950595	34000
2500	0.0100000	1000
	0.2543666	2000
	0.4621339	3000
	0.7070397	4000
	0.9840915	5000

Table 10: Elastic Properties for A-376, Type 316, A-351 Grade CF8M, A-336 Grade F8M, SA-403 WP 316 (16Cr-12Ni-2Mo)

Temperature (°F)	Young's Modulus ($x10^6$ psi)	Mean Thermal Expansion ($x10^{-6}$ in/in/°F)	Thermal Conductivity ($x10^{-4}$ Btu/sec-in-°F)	Specific Heat[2] (Btu/lb-°F)
70	28.3	8.5	1.90	0.121
100	28.1[1]	8.6	1.92	0.121
150	27.9[1]	8.8	1.99	0.124
200	27.6	8.9	2.04	0.124
250	27.3[1]	9.1	2.11	0.127
300	27.0	9.2	2.15	0.127
350	26.8[1]	9.3	2.20	0.128
400	26.5	9.5	2.27	0.129
450	26.2[1]	9.6	2.31	0.130
500	25.8	9.7	2.36	0.130
550	25.6[1]	9.8	2.43	0.133
600	25.3	9.8	2.48	0.133
650	25.1[1]	9.9	2.52	0.133
700	24.8	10.0	2.59	0.135
1100	22.1	10.5	3.01	0.141
1500[3]	18.1	10.8	3.40	0.145
2500[3]	0.1	11.5	4.40	0.155

Density (ρ) = 0.283 lb/in^3, assumed temperature independent.
Poisson's Ratio (υ) = 0.3, assumed temperature independent.

Notes:
1. Interpolated.
2. Specific Heat values are derived from the equation shown in General Note (a) of Table TCD [2], Specific Heat = TC / (TD x density).
3. Values per Reference 5.

Table 11: Elastic-Plastic Properties for A-376, Type 316, A-351 Grade CF8M, A-336 Grade F8M, SA-403 WP 316 (16Cr-12Ni-2Mo)

Temperature (°F)	True Strain (in/in)	True Stress (psi)
70	0.0014982	42400
	0.1300043	69800
	0.2546138	97200
	0.4219726	124600
	0.6325849	152000
500	0.0012791	33000
	0.0616081	52500
	0.1421800	72000
	0.2692310	91500
	0.4511647	111000
700	0.0011573	28700
	0.0471341	48775
	0.1211840	68850
	0.2457186	88925
	0.4321680	109000
1100	0.0010407	23000
	0.0262971	38000
	0.0768737	53000
	0.1739465	68000
	0.3357481	83000
1500	0.0006630	12000
	0.0301352	17250
	0.0772324	22500
	0.1632721	27750
	0.3037215	33000
2500	0.0100000	1000
	0.2543666	2000
	0.4621339	3000
	0.7070397	4000
	0.9840915	5000

Table 12: Elastic Properties for SA-105, Grade 2 (C>0.3%)

Temperature (°F)	Young's Modulus ($x10^6$ psi)	Mean Thermal Expansion ($x10^{-6}$ in/in/°F)	Thermal Conductivity ($x10^{-4}$ Btu/sec-in-°F)	Specific Heat[2] (Btu/lb-°F)
70	29.3	6.4	8.13	0.103
100	29.1[1]	6.5	8.03	0.105
150	28.9[1]	6.6	7.89	0.108
200	28.6	6.7	7.78	0.112
250	28.4[1]	6.8	7.62	0.115
300	28.1	6.9	7.48	0.118
350	27.8[1]	7.0	7.31	0.121
400	27.5	7.1	7.15	0.123
450	27.3[1]	7.2	7.01	0.125
500	27.1	7.3	6.83	0.128
550	26.8[1]	7.3	6.67	0.130
600	26.5	7.4	6.48	0.132
650	25.9[1]	7.5	6.32	0.135
700	25.3	7.6	6.16	0.138
1100	17.9	8.2	4.84	0.171
1500[3]	8.0	8.6	3.63	0.198
2500[3]	0.1	9.5	2.31	0.204

Density (ρ) = 0.283 lb/in^3, assumed temperature independent.
Poisson's Ratio (υ) = 0.3, assumed temperature independent.

Notes:
1. Interpolated.
2. Specific Heat values are derived from the equation shown in General Note (a) of Table TCD [2], Specific Heat = TC / (TD x density).
3. Values per Reference 5.

Table 13: Elastic-Plastic Properties for SA-105, Grade 2

Temperature (°F)	True Strain (in/in)	True Stress (psi)
70	0.0012287	36000
	0.0189353	49500
	0.0529716	63000
	0.1239287	76500
	0.2543922	90000
500	0.0010812	29300
	0.0122960	44475
	0.0419116	59650
	0.1124188	74825
	0.2541804	90000
700	0.0010198	25800
	0.0097556	41850
	0.0369914	57900
	0.1068094	73950
	0.2540781	90000
1100	0.0010615	19000
	0.0917640	25750
	0.1708286	32500
	0.2830538	39250
	0.4330697	46000
1500	0.0015000	12000
	0.2466409	15000
	0.3545140	18000
	0.4818666	21000
	0.6286895	24000
2500	0.0100000	1000
	0.2543666	2000
	0.4621339	3000
	0.7070397	4000
	0.9840915	5000

Table 14: Elastic Properties for A-106 Grade C (C>0.3%)

Temperature (°F)	Young's Modulus ($x10^6$ psi)	Mean Thermal Expansion ($x10^{-6}$ in/in/°F)	Thermal Conductivity ($x10^{-4}$ Btu/sec-in-°F)	Specific Heat[2] (Btu/lb-°F)
70	29.3	6.4	8.13	0.103
100	29.1[1]	6.5	8.03	0.105
150	28.9[1]	6.6	7.89	0.108
200	28.6	6.7	7.78	0.112
250	28.4[1]	6.8	7.62	0.115
300	28.1	6.9	7.48	0.118
350	27.8[1]	7.0	7.31	0.121
400	27.5	7.1	7.15	0.123
450	27.3[1]	7.2	7.01	0.125
500	27.1	7.3	6.83	0.128
550	26.8[1]	7.3	6.67	0.130
600	26.5	7.4	6.48	0.132
650	25.9[1]	7.5	6.32	0.135
700	25.3	7.6	6.16	0.138
1100	17.9	8.2	4.84	0.171
1500[3]	8.0	8.6	3.63	0.198
2500[3]	0.1	9.5	2.31	0.204

Density (ρ) = 0.283 lb/in^3, assumed temperature independent.
Poisson's Ratio (υ) = 0.3, assumed temperature independent.

Notes:
1. Interpolated.
2. Specific Heat values are derived from the equation shown in General Note (a) of Table TCD [2], Specific Heat = TC / (TD x density).
3. Values per Reference 5.

Table 15: Elastic-Plastic Properties for A-106 Grade C

Temperature (°F)	True Strain (in/in)	True Stress (psi)
70	0.0013652	40000
	0.0242564	52500
	0.0607202	65000
	0.1313209	77500
	0.2545637	90000
500	0.0012030	32600
	0.0153223	46950
	0.0471649	61300
	0.1180426	75650
	0.2543331	90000
700	0.0011304	28600
	0.0118318	43950
	0.0409899	59300
	0.1113772	74650
	0.2542167	90000
1100	0.0012291	22000
	0.1147927	28000
	0.1928368	34000
	0.2979323	40000
	0.4333004	46000
1500	0.0002500	2000
	0.1694709	2875
	0.2879455	3750
	0.4375783	4625
	0.6183490	5500
2500	0.0100000	1000
	0.2543666	2000
	0.4621339	3000
	0.7070397	4000
	0.9840915	5000

Table 16: Elastic Properties for SA-516 Grade 70 (<4" thick, C<0.3%)

Temperature (°F)	Young's Modulus ($x10^6$ psi)	Mean Thermal Expansion ($x10^{-6}$ in/in/°F)	Thermal Conductivity ($x10^{-4}$ Btu/sec-in-°F)	Specific Heat[2] (Btu/lb-°F)
70	29.5	6.4	8.13	0.103
100	29.3[1]	6.5	8.03	0.105
150	29.1[1]	6.6	7.89	0.108
200	28.8	6.7	7.78	0.112
250	28.6[1]	6.8	7.62	0.115
300	28.3	6.9	7.48	0.118
350	28.0[1]	7.0	7.31	0.121
400	27.7	7.1	7.15	0.123
450	27.5[1]	7.2	7.01	0.125
500	27.3	7.3	6.83	0.128
550	27.0[1]	7.3	6.67	0.130
600	26.7	7.4	6.48	0.132
650	26.1[1]	7.5	6.32	0.135
700	25.5	7.6	6.16	0.138
1100	18.0	8.2	4.84	0.171
1500[3]	5.0	8.6	3.63	0.198
2500[3]	0.1	9.5	2.31	0.204

Density (ρ) = 0.283 lb/in^3, assumed temperature independent.
Poisson's Ratio (υ) = 0.3, assumed temperature independent.

Notes:
1. Interpolated.
2. Specific Heat values are derived from the equation shown in General Note (a) of Table TCD [2], Specific Heat = TC / (TD x density).
3. Values per Reference 5.

Table 17: Elastic-Plastic Properties for SA-516 Grade 70 (<4" thick, C<0.3%)

Temperature (°F)	True Strain (in/in)	True Stress (psi)
70	0.0012881	38000
	0.0031809	48250
	0.0104401	58500
	0.0374803	68750
	0.1224852	79000
500	0.0011355	31000
	0.0021324	43000
	0.0069050	55000
	0.0303574	67000
	0.1222991	79000
700	0.0010667	27200
	0.0018781	40150
	0.0056595	53100
	0.0271289	66050
	0.1222079	79000
1100	0.0011667	21000
	0.0917411	27000
	0.1656717	33000
	0.2713432	39000
	0.4143524	45000
1500	0.0030000	15000
	0.2558446	18750
	0.3673114	22500
	0.4988409	26250
	0.6504237	30000
2500	0.0100000	1000
	0.2543666	2000
	0.4621339	3000
	0.7070397	4000
	0.9840915	5000

APPENDIX A

MATERIAL PROPERTY INPUT FILES

MProp_Linear_DB.INP

```
/COM,*****************************************************
/COM, MATERIAL PROPERTIES for Thermal-Mechanical Analyses
/COM,*****************************************************

! MAT 1:    Nozzle Forging – RCP Inlet/Suction, Discharge        A-351, Grade CF8M (16Cr-12Ni-2Mo)
! MAT 2:    Nozzle Forging – RCP Cold Leg Drain                  SA-105 Grade 2 (Carbon Steel, C>0.3%)
! MAT 3:    Nozzle Forging – Core Flood Nozzle                   SA-508 Class 2 (3/4Ni-1/2Mo-1/3Cr-V)
! MAT 4:    Nozzle-to-Safe End Weld - Core Flood                 Alloy 82/182
! MAT 5:    Safe End – RCP Discharge                             A-376, Type 316 (16Cr-12Ni-2Mo)
! MAT 6:    Safe End –Core Flood Nozzle                          A-336, Grade F8M (assumed similar to SA-430 FP316 (16Cr-12Ni-2Mo))
! MAT 7:    Pipe Internal Clad - RCP Inlet/Suction, Discharge, cold leg clad    SA-240-304L (18Cr-8Ni)
! MAT 8:    Nozzle Internal Clad - RCP Cold Leg Drain, Core Flood    SA-371 ER308L (assumed SA-240-304L (18Cr-8Ni))
! MAT 9:    ID Weld Repair                                       Alloy 82/182
! MAT 10:   Safe End-to-Pipe Weld - RCP Discharge                Alloy 82/182
! MAT 11:   Safe End-to-Pipe Weld - Core Flood                   SS Type 316 (assumed similar to SA-376 TP316 (16Cr-12Ni-2Mo))
! MAT 12:   Attached Pipe/Elbow - RCP Inlet/Suction, Discharge   A-516 Grade 70 (Carbon Steel, (<=4" C < 0.3%))
! MAT 13:   Attached Pipe/Elbow – RCP Cold Leg Drain             SA-403 WP316 (16Cr-12Ni-2Mo)
! MAT 14:   Attached Pipe/Elbow – Core Flood Nozzle              SA-376, Type 316 (16Cr-12Ni-2Mo)
! MAT 15:   Cold Leg Pipe - RCP Cold Leg Drain                   A-106 Grade C (C>0.3%)
! MAT 16:   Core Flood Vessel Shell                              A-508 Class 2 (3/4Ni-1/2Mo-1/3Cr-V)
! MAT 17:   Core Flood Vessel Clad                               SS Clad (assumed SA-240 304L (18Cr-8Ni))
! MAT 18:   Weld Overlay                                         Alloy 52M
! MAT 19:   Nozzle to Pipe Weld - RCP Inlet/Suction, RCP Cold Leg Drain Alloy 82/182
! MAT 20:   Butter material                                      Alloy 82/182
! MAT 21:   Buffer Layer                                         ER308L (assumed SA-240-304L (18Cr-8Ni))
! MAT 22:   RCP Discharge Nozzle-to-SE Weld, Spray Nozzle and Pressure Tap welds to RCP Discharge SE    SS Type 316 (assumed similar
to SA-376 TP316 (16Cr-12Ni-2Mo))
! MAT 23:   Pressure Tap - Discharge Nozzle                      A-336, Grade F8M (assumed similar to SA-430 FP316 (16Cr-12Ni-2Mo))
! MAT 24:   Spray Nozzle - Discharge Nozzle                      A-182 F 316 (16Cr-12Ni-2Mo)

MPTEMP, , 70, 100
MPTGEN, , 12, 150, 50

! MAT 1: A-351, Grade CF8M (16Cr-12Ni-2Mo)

MPDATA,EX , 1, , 28.3e6, 28.1e6, 27.9e6, 27.6e6, 27.3e6, 27e6
MPDATA,EX , 1, , 26.8e6, 26.5e6, 26.2e6, 25.8e6, 25.6e6, 25.3e6
MPDATA,EX , 1, , 25.1e6, 24.8e6

MPDATA,ALPX, 1, , 8.5E-6, 8.6E-6, 8.8E-6, 8.9E-6, 9.1E-6, 9.2E-6
MPDATA,ALPX, 1, , 9.3E-6, 9.5E-6, 9.6E-6, 9.7E-6, 9.8E-6, 9.8E-6
MPDATA,ALPX, 1, , 9.9E-6, 10E-6

MPDATA,KXX , 1, , 1.9E-4, 1.92E-4, 1.99E-4, 2.04E-4, 2.11E-4, 2.15E-4
MPDATA,KXX , 1, , 2.2E-4, 2.27E-4, 2.31E-4, 2.36E-4, 2.43E-4, 2.48E-4
MPDATA,KXX , 1, , 2.52E-4, 2.59E-4

MPDATA,C , 1, , 0.121, 0.121, 0.124, 0.124, 0.127, 0.127,
MPDATA,C , 1, , 0.128, 0.129, 0.13, 0.13, 0.133, 0.133,
MPDATA,C , 1, , 0.133, 0.135

MP, DENS, 1, 0.283
MP, NUXY, 1, 0.3

! MAT 2:  SA-105 Grade 2 (Hi Carbon)

MPDATA,EX , 2, , 29.3e6, 29.1e6, 28.9e6, 28.6e6, 28.4e6, 28.1e6
MPDATA,EX , 2, , 27.8e6, 27.5e6, 27.3e6, 27.1e6, 26.8e6, 26.5e6
MPDATA,EX , 2, , 25.9e6, 25.3e6

MPDATA,ALPX, 2, , 6.4E-6, 6.5E-6, 6.6E-6, 6.7E-6, 6.8E-6, 6.9E-6
MPDATA,ALPX, 2, , 7.0E-6, 7.1E-6, 7.2E-6, 7.3E-6, 7.3E-6, 7.4E-6
MPDATA,ALPX, 2, , 7.5E-6, 7.6E-6

MPDATA,KXX , 2, , 8.13E-4, 8.03E-4, 7.89E-4, 7.78E-4, 7.62E-4, 7.48E-4
MPDATA,KXX , 2, , 7.31E-4, 7.15E-4, 7.01E-4, 6.83E-4, 6.67E-4, 6.48E-4
```

```
MPDATA,KXX , 2, , 6.32E-4, 6.16E-4

MPDATA,C , 2, , 0.103, 0.105, 0.108, 0.112, 0.115, 0.118,
MPDATA,C , 2, , 0.121, 0.123, 0.125, 0.128, 0.130, 0.132,
MPDATA,C , 2, , 0.135, 0.138

MP, DENS, 2, 0.283
MP, NUXY, 2, 0.3

! MAT 3: SA-508 Class 2 (3/4Ni-1/2Mo-1/3Cr-V)

MPDATA,EX  , 3, , 27.8e6, 27.6e6, 27.4e6, 27.1e6, 26.9e6, 26.7e6
MPDATA,EX  , 3, , 26.4e6, 26.1e6, 25.9e6, 25.7e6, 25.5e6, 25.2e6
MPDATA,EX  , 3, , 24.9e6, 24.6e6

MPDATA,ALPX, 3, , 6.4E-6, 6.5E-6, 6.6E-6, 6.7E-6, 6.8E-6, 6.9E-6
MPDATA,ALPX, 3, , 7E-6, 7.1E-6, 7.2E-6, 7.3E-6, 7.3E-6, 7.4E-6
MPDATA,ALPX, 3, , 7.5E-6, 7.6E-6

MPDATA,KXX , 3, , 5.44E-4, 5.46E-4, 5.46E-4, 5.46E-4, 5.44E-4, 5.42E-4
MPDATA,KXX , 3, , 5.39E-4, 5.35E-4, 5.3E-4, 5.25E-4, 5.21E-4, 5.14E-4
MPDATA,KXX , 3, , 5.07E-4, 5E-4

MPDATA,C   , 3, , 0.105, 0.107, 0.11, 0.114, 0.116, 0.119,
MPDATA,C   , 3, , 0.122, 0.125, 0.128, 0.13, 0.133, 0.135,
MPDATA,C   , 3, , 0.137, 0.14

MP, DENS, 3, 0.283
MP, NUXY, 3, 0.3

! MAT 4: Alloy 82/182

MPDATA,EX  ,4, , 31e6, 30.8e6, 30.5e6, 30.2e6, 30e6, 29.8e6
MPDATA,EX  ,4, , 29.7e6, 29.5e6, 29.3e6, 29e6, 28.9e6, 28.7e6
MPDATA,EX  ,4, , 28.5e6, 28.2e6

MPDATA,ALPX,4, , 6.8E-6, 6.9E-6, 7E-6, 7.1E-6, 7.2E-6, 7.3E-6
MPDATA,ALPX,4, , 7.4E-6, 7.5E-6, 7.6E-6, 7.6E-6, 7.7E-6, 7.8E-6
MPDATA,ALPX,4, , 7.8E-6, 7.9E-6

MPDATA,KXX ,4, , 1.99E-4, 2.01E-4, 2.06E-4, 2.11E-4, 2.15E-4, 2.22E-4
MPDATA,KXX ,4, , 2.27E-4, 2.34E-4, 2.38E-4, 2.45E-4, 2.5E-4, 2.57E-4
MPDATA,KXX ,4, , 2.62E-4, 2.69E-4

MPDATA,C   ,4, , 0.108, 0.109, 0.111, 0.113, 0.114, 0.116,
MPDATA,C   ,4, , 0.116, 0.118, 0.118, 0.120, 0.121, 0.123,
MPDATA,C   ,4, , 0.123, 0.125

MP, DENS,4, 0.300
MP, NUXY,4, 0.29

! MAT 5: A-376, Type 316 (16Cr-12Ni-2Mo)

MPDATA,EX , 5, , 28.3e6, 28.1e6, 27.9e6, 27.6e6, 27.3e6, 27e6
MPDATA,EX , 5, , 26.8e6, 26.5e6, 26.2e6, 25.8e6, 25.6e6, 25.3e6
MPDATA,EX , 5, , 25.1e6, 24.8e6

MPDATA,ALPX, 5, , 8.5E-6, 8.6E-6, 8.8E-6, 8.9E-6, 9.1E-6, 9.2E-6
MPDATA,ALPX, 5, , 9.3E-6, 9.5E-6, 9.6E-6, 9.7E-6, 9.8E-6, 9.8E-6
MPDATA,ALPX, 5, , 9.9E-6, 10E-6

MPDATA,KXX , 5, , 1.9E-4, 1.92E-4, 1.99E-4, 2.04E-4, 2.11E-4, 2.15E-4
MPDATA,KXX , 5, , 2.2E-4, 2.27E-4, 2.31E-4, 2.36E-4, 2.43E-4, 2.48E-4
MPDATA,KXX , 5, , 2.52E-4, 2.59E-4

MPDATA,C , 5, , 0.121, 0.121, 0.124, 0.124, 0.127, 0.127,
MPDATA,C , 5, , 0.128, 0.129, 0.13, 0.13, 0.133, 0.133,
MPDATA,C , 5, , 0.133, 0.135
```

```
MP, DENS, 5, 0.283
MP, NUXY, 5, 0.3

! MAT 6: A-336, Grade F8M (assumed similar to SA-430 FP316 (16Cr-12Ni-2Mo))

MPDATA,EX , 6, , 28.3e6, 28.1e6, 27.9e6, 27.6e6, 27.3e6, 27e6
MPDATA,EX , 6, , 26.8e6, 26.5e6, 26.2e6, 25.8e6, 25.6e6, 25.3e6
MPDATA,EX , 6, , 25.1e6, 24.8e6

MPDATA,ALPX, 6, , 8.5E-6, 8.6E-6, 8.8E-6, 8.9E-6, 9.1E-6, 9.2E-6
MPDATA,ALPX, 6, , 9.3E-6, 9.5E-6, 9.6E-6, 9.7E-6, 9.8E-6, 9.8E-6
MPDATA,ALPX, 6, , 9.9E-6, 10E-6

MPDATA,KXX , 6, , 1.9E-4, 1.92E-4, 1.99E-4, 2.04E-4, 2.11E-4, 2.15E-4
MPDATA,KXX , 6, , 2.2E-4, 2.27E-4, 2.31E-4, 2.36E-4, 2.43E-4, 2.48E-4
MPDATA,KXX , 6, , 2.52E-4, 2.59E-4

MPDATA,C , 6, , 0.121, 0.121, 0.124, 0.124, 0.127, 0.127,
MPDATA,C , 6, , 0.128, 0.129, 0.13, 0.13, 0.133, 0.133,
MPDATA,C , 6, , 0.133, 0.135

MP, DENS, 6, 0.283
MP, NUXY, 6, 0.3

! MAT 7: SA-240-304L (18Cr-8Ni)

MPDATA,EX  , 7, , 28.3e6, 28.1e6, 27.9e6, 27.6e6, 27.3e6, 27e6
MPDATA,EX  , 7, , 26.8e6, 26.5e6, 26.2e6, 25.8e6, 25.6e6, 25.3e6
MPDATA,EX  , 7, , 25.1e6, 24.8e6

MPDATA,ALPX, 7, , 8.5E-6, 8.6E-6, 8.8E-6, 8.9E-6, 9.1E-6, 9.2E-6
MPDATA,ALPX, 7, , 9.3E-6, 9.5E-6, 9.6E-6, 9.7E-6, 9.8E-6, 9.8E-6
MPDATA,ALPX, 7, , 9.9E-6, 10E-6

MPDATA,KXX , 7, , 1.99E-4, 2.01E-4, 2.08E-4, 2.15E-4, 2.22E-4, 2.27E-4
MPDATA,KXX , 7, , 2.34E-4, 2.41E-4, 2.45E-4, 2.52E-4, 2.57E-4, 2.62E-4
MPDATA,KXX , 7, , 2.69E-4, 2.73E-4

MPDATA,C   , 7, , 0.116, 0.117, 0.12, 0.122, 0.124, 0.125,
MPDATA,C   , 7, , 0.127, 0.129, 0.13, 0.131, 0.132, 0.133,
MPDATA,C   , 7, , 0.134, 0.135

MP, DENS, 7, 0.283
MP, NUXY, 7, 0.3

! MAT 8: SA-371 ER308L (assumed SA-240-304L (18Cr-8Ni))

MPDATA,EX  , 8, , 28.3e6, 28.1e6, 27.9e6, 27.6e6, 27.3e6, 27e6
MPDATA,EX  , 8, , 26.8e6, 26.5e6, 26.2e6, 25.8e6, 25.6e6, 25.3e6
MPDATA,EX  , 8, , 25.1e6, 24.8e6

MPDATA,ALPX, 8, , 8.5E-6, 8.6E-6, 8.8E-6, 8.9E-6, 9.1E-6, 9.2E-6
MPDATA,ALPX, 8, , 9.3E-6, 9.5E-6, 9.6E-6, 9.7E-6, 9.8E-6, 9.8E-6
MPDATA,ALPX, 8, , 9.9E-6, 10E-6

MPDATA,KXX , 8, , 1.99E-4, 2.01E-4, 2.08E-4, 2.15E-4, 2.22E-4, 2.27E-4
MPDATA,KXX , 8, , 2.34E-4, 2.41E-4, 2.45E-4, 2.52E-4, 2.57E-4, 2.62E-4
MPDATA,KXX , 8, , 2.69E-4, 2.73E-4

MPDATA,C   , 8, , 0.116, 0.117, 0.12, 0.122, 0.124, 0.125,
MPDATA,C   , 8, , 0.127, 0.129, 0.13, 0.131, 0.132, 0.133,
MPDATA,C   , 8, , 0.134, 0.135

MP, DENS, 8, 0.283
MP, NUXY, 8, 0.3

! MAT 9: Alloy 82/182

MPDATA,EX  ,9, , 31e6, 30.8e6, 30.5e6, 30.2e6, 30e6, 29.8e6
```

```
MPDATA,EX  ,9, , 29.7e6, 29.5e6, 29.3e6, 29e6, 28.9e6, 28.7e6
MPDATA,EX  ,9, , 28.5e6, 28.2e6

MPDATA,ALPX,9, , 6.8E-6, 6.9E-6, 7E-6, 7.1E-6, 7.2E-6, 7.3E-6
MPDATA,ALPX,9, , 7.4E-6, 7.5E-6, 7.6E-6, 7.6E-6, 7.7E-6, 7.8E-6
MPDATA,ALPX,9, , 7.8E-6, 7.9E-6

MPDATA,KXX ,9, , 1.99E-4, 2.01E-4, 2.06E-4, 2.11E-4, 2.15E-4, 2.22E-4
MPDATA,KXX ,9, , 2.27E-4, 2.34E-4, 2.38E-4, 2.45E-4, 2.5E-4, 2.57E-4
MPDATA,KXX ,9, , 2.62E-4, 2.69E-4

MPDATA,C   ,9, , 0.108, 0.109, 0.111, 0.113, 0.114, 0.116,
MPDATA,C   ,9, , 0.116, 0.118, 0.118, 0.120, 0.121, 0.123,
MPDATA,C   ,9, , 0.123, 0.125

MP, DENS,9, 0.300
MP, NUXY,9, 0.29

! MAT 10: Alloy 82/182

MPDATA,EX  , 10, , 31e6, 30.8e6, 30.5e6, 30.2e6, 30e6, 29.8e6
MPDATA,EX  , 10, , 29.7e6, 29.5e6, 29.3e6, 29e6, 28.9e6, 28.7e6
MPDATA,EX  , 10, , 28.5e6, 28.2e6

MPDATA,ALPX, 10, , 6.8E-6, 6.9E-6, 7E-6, 7.1E-6, 7.2E-6, 7.3E-6
MPDATA,ALPX, 10,, 7.4E-6, 7.5E-6, 7.6E-6, 7.6E-6, 7.7E-6, 7.8E-6
MPDATA,ALPX, 10, , 7.8E-6, 7.9E-6

MPDATA,KXX , 10, , 1.99E-4, 2.01E-4, 2.06E-4, 2.11E-4, 2.15E-4, 2.22E-4
MPDATA,KXX , 10, , 2.27E-4, 2.34E-4, 2.38E-4, 2.45E-4, 2.5E-4, 2.57E-4
MPDATA,KXX , 10, , 2.62E-4, 2.69E-4

MPDATA,C   , 10, , 0.108, 0.109, 0.111, 0.113, 0.114, 0.116,
MPDATA,C   , 10, , 0.116, 0.118, 0.118, 0.120, 0.121, 0.123,
MPDATA,C   , 10, , 0.123, 0.125

MP, DENS, 10, 0.300
MP, NUXY, 10, 0.29

! MAT 11: SS Type 316 (assumed as SA-376, Type 316 (16Cr-12Ni-2Mo)

MPDATA,EX , 11, , 28.3e6, 28.1e6, 27.9e6, 27.6e6, 27.3e6, 27e6
MPDATA,EX , 11, , 26.8e6, 26.5e6, 26.2e6, 25.8e6, 25.6e6, 25.3e6
MPDATA,EX , 11, , 25.1e6, 24.8e6

MPDATA,ALPX, 11, , 8.5E-6, 8.6E-6, 8.8E-6, 8.9E-6, 9.1E-6, 9.2E-6
MPDATA,ALPX, 11, , 9.3E-6, 9.5E-6, 9.6E-6, 9.7E-6, 9.8E-6, 9.8E-6
MPDATA,ALPX, 11, , 9.9E-6, 10E-6

MPDATA,KXX , 11, , 1.9E-4, 1.92E-4, 1.99E-4, 2.04E-4, 2.11E-4, 2.15E-4
MPDATA,KXX , 11, , 2.2E-4, 2.27E-4, 2.31E-4, 2.36E-4, 2.43E-4, 2.48E-4
MPDATA,KXX , 11, , 2.52E-4, 2.59E-4

MPDATA,C , 11, , 0.121, 0.121, 0.124, 0.124, 0.127, 0.127,
MPDATA,C , 11, , 0.128, 0.129, 0.13, 0.13, 0.133, 0.133,
MPDATA,C , 11, , 0.133, 0.135

MP, DENS, 11, 0.283
MP, NUXY, 11, 0.3

! Mat 12: A-516 Grade 70 (Carbon Steel, (<=4" C<0.3%))

MPDATA,EX , 12, , 29.5E6, 29.3E6, 29.1E6, 28.8E6, 28.6E6, 28.3E6
MPDATA,EX , 12, , 28.0E6, 27.7E6, 27.5E6, 27.3E6, 27.0E6, 26.7E6
MPDATA,EX , 12, , 26.1E6, 25.5E6

MPDATA,ALPX, 12, , 6.4E-6, 6.5E-6, 6.6E-6, 6.7E-6, 6.8E-6, 6.9E-6
MPDATA,ALPX, 12, , 7.0E-6, 7.1E-6, 7.2E-6, 7.3E-6, 7.3E-6, 7.4E-6
MPDATA,ALPX, 12, , 7.5E-6, 7.6E-6
```

```
MPDATA,KXX , 12, , 8.13E-4, 8.03E-4, 7.89E-4, 7.78E-4, 7.62E-4, 7.48E-4
MPDATA,KXX , 12, , 7.31E-4, 7.15E-4, 7.01E-4, 6.83E-4, 6.67E-4, 6.48E-4
MPDATA,KXX , 12, , 6.32E-4, 6.16E-4

MPDATA,C , 12, , 0.103, 0.105, 0.108, 0.112, 0.115, 0.118,
MPDATA,C , 12, , 0.121, 0.123, 0.125, 0.128, 0.130, 0.132,
MPDATA,C , 12, , 0.135, 0.138

MP, DENS, 12, 0.283
MP, NUXY, 12, 0.3

! Mat 13: SA-403 WP 316 (16Cr-12Ni-2Mo)

MPDATA,EX , 13, , 28.3e6, 28.1e6, 27.9e6, 27.6e6, 27.3e6, 27e6
MPDATA,EX , 13, , 26.8e6, 26.5e6, 26.2e6, 25.8e6, 25.6e6, 25.3e6
MPDATA,EX , 13, , 25.1e6, 24.8e6

MPDATA,ALPX, 13, , 8.5E-6, 8.6E-6, 8.8E-6, 8.9E-6, 9.1E-6, 9.2E-6
MPDATA,ALPX, 13, , 9.3E-6, 9.5E-6, 9.6E-6, 9.7E-6, 9.8E-6, 9.8E-6
MPDATA,ALPX, 13, , 9.9E-6, 10E-6

MPDATA,KXX , 13, , 1.9E-4, 1.92E-4, 1.99E-4, 2.04E-4, 2.11E-4, 2.15E-4
MPDATA,KXX , 13, , 2.2E-4, 2.27E-4, 2.31E-4, 2.36E-4, 2.43E-4, 2.48E-4
MPDATA,KXX , 13, , 2.52E-4, 2.59E-4

MPDATA,C , 13, , 0.121, 0.121, 0.124, 0.124, 0.127, 0.127,
MPDATA,C , 13, , 0.128, 0.129, 0.13, 0.13, 0.133, 0.133,
MPDATA,C , 13, , 0.133, 0.135

MP, DENS, 13, 0.283
MP, NUXY, 13, 0.3

! Mat 14: SA-376, Type 316 (16Cr-12Ni-2Mo)

MPDATA,EX , 14, , 28.3e6, 28.1e6, 27.9e6, 27.6e6, 27.3e6, 27e6
MPDATA,EX , 14, , 26.8e6, 26.5e6, 26.2e6, 25.8e6, 25.6e6, 25.3e6
MPDATA,EX , 14, , 25.1e6, 24.8e6

MPDATA,ALPX, 14, , 8.5E-6, 8.6E-6, 8.8E-6, 8.9E-6, 9.1E-6, 9.2E-6
MPDATA,ALPX, 14, , 9.3E-6, 9.5E-6, 9.6E-6, 9.7E-6, 9.8E-6, 9.8E-6
MPDATA,ALPX, 14, , 9.9E-6, 10E-6

MPDATA,KXX , 14, , 1.9E-4, 1.92E-4, 1.99E-4, 2.04E-4, 2.11E-4, 2.15E-4
MPDATA,KXX , 14, , 2.2E-4, 2.27E-4, 2.31E-4, 2.36E-4, 2.43E-4, 2.48E-4
MPDATA,KXX , 14, , 2.52E-4, 2.59E-4

MPDATA,C , 14, , 0.121, 0.121, 0.124, 0.124, 0.127, 0.127,
MPDATA,C , 14, , 0.128, 0.129, 0.13, 0.13, 0.133, 0.133,
MPDATA,C , 14, , 0.133, 0.135

MP, DENS, 14, 0.283
MP, NUXY, 14, 0.3

! Mat 15: A-106 Grade C (C>0.3%)

MPDATA,EX  , 15, , 29.3e6, 29.1e6, 28.9e6, 28.6e6, 28.4e6, 28.1e6
MPDATA,EX  , 15, , 27.8e6, 27.5e6, 27.3e6, 27.1e6, 26.8e6, 26.5e6
MPDATA,EX  , 15, , 25.9e6, 25.3e6

MPDATA,ALPX, 15, , 6.4E-6, 6.5E-6, 6.6E-6, 6.7E-6, 6.8E-6, 6.9E-6
MPDATA,ALPX, 15, , 7.0E-6, 7.1E-6, 7.2E-6, 7.3E-6, 7.3E-6, 7.4E-6
MPDATA,ALPX, 15, , 7.5E-6, 7.6E-6

MPDATA,KXX , 15, , 8.13E-4, 8.03E-4, 7.89E-4, 7.78E-4, 7.62E-4, 7.48E-4
MPDATA,KXX , 15, , 7.31E-4, 7.15E-4, 7.01E-4, 6.83E-4, 6.67E-4, 6.48E-4
MPDATA,KXX , 15, , 6.32E-4, 6.16E-4

MPDATA,C  , 15, , 0.103, 0.105, 0.108, 0.112, 0.115, 0.118,
```

```
MPDATA,C  , 15, , 0.121, 0.123, 0.125, 0.128, 0.130, 0.132,
MPDATA,C  , 15, , 0.135, 0.138

MP, DENS, 15, 0.283
MP, NUXY, 15, 0.3

! Mat 16: A-508 Class 2 (3/4Ni-1/2Mo-1/3Cr-V)

MPDATA,EX  , 16, , 27.8e6, 27.6e6, 27.4e6, 27.1e6, 26.9e6, 26.7e6
MPDATA,EX  , 16, , 26.4e6, 26.1e6, 25.9e6, 25.7e6, 25.5e6, 25.2e6
MPDATA,EX  , 16, , 24.9e6, 24.6e6

MPDATA,ALPX, 16, , 6.4E-6, 6.5E-6, 6.6E-6, 6.7E-6, 6.8E-6, 6.9E-6
MPDATA,ALPX, 16, , 7E-6, 7.1E-6, 7.2E-6, 7.3E-6, 7.3E-6, 7.4E-6
MPDATA,ALPX, 16, , 7.5E-6, 7.6E-6

MPDATA,KXX , 16, , 5.44E-4, 5.46E-4, 5.46E-4, 5.46E-4, 5.44E-4, 5.42E-4
MPDATA,KXX , 16, , 5.39E-4, 5.35E-4, 5.3E-4, 5.25E-4, 5.21E-4, 5.14E-4
MPDATA,KXX , 16, , 5.07E-4, 5E-4

MPDATA,C  , 16, , 0.105, 0.107, 0.11, 0.114, 0.116, 0.119,
MPDATA,C  , 16, , 0.122, 0.125, 0.128, 0.13, 0.133, 0.135,
MPDATA,C  , 16, , 0.137, 0.14

MP, DENS, 16, 0.283
MP, NUXY, 16, 0.3

! Mat 17: SA-371 ER308L (assumed SA-240-304L (18Cr-8Ni))

MPDATA,EX  , 17, , 28.3e6, 28.1e6, 27.9e6, 27.6e6, 27.3e6, 27e6
MPDATA,EX  , 17, , 26.8e6, 26.5e6, 26.2e6, 25.8e6, 25.6e6, 25.3e6
MPDATA,EX  , 17, , 25.1e6, 24.8e6

MPDATA,ALPX, 17, , 8.5E-6, 8.6E-6, 8.8E-6, 8.9E-6, 9.1E-6, 9.2E-6
MPDATA,ALPX, 17, , 9.3E-6, 9.5E-6, 9.6E-6, 9.7E-6, 9.8E-6, 9.8E-6
MPDATA,ALPX, 17, , 9.9E-6, 10E-6

MPDATA,KXX , 17, , 1.99E-4, 2.01E-4, 2.08E-4, 2.15E-4, 2.22E-4, 2.27E-4
MPDATA,KXX , 17, , 2.34E-4, 2.41E-4, 2.45E-4, 2.52E-4, 2.57E-4, 2.62E-4
MPDATA,KXX , 17, , 2.69E-4, 2.73E-4

MPDATA,C  , 17, , 0.116, 0.117, 0.12, 0.122, 0.124, 0.125,
MPDATA,C  , 17, , 0.127, 0.129, 0.13, 0.131, 0.132, 0.133,
MPDATA,C  , 17, , 0.134, 0.135

MP, DENS, 17, 0.283
MP, NUXY, 17, 0.3

! Mat 18: Alloy 690 for Alloy 52M

MPDATA,EX  , 18, , 30.3e6, 30.1e6, 29.8e6, 29.5e6, 29.3e6, 29.1e6
MPDATA,EX  , 18, , 29e6, 28.8e6, 28.6e6, 28.3e6, 28.2e6, 28.1e6
MPDATA,EX  , 18, , 27.9e6, 27.6e6

MPDATA,ALPX, 18, , 7.7E-6, 7.8E-6, 7.8E-6, 7.9E-6, 7.9E-6, 7.9E-6
MPDATA,ALPX, 18, , 8E-6, 8E-6, 8.1E-6, 8.1E-6, 8.1E-6, 8.2E-6
MPDATA,ALPX, 18, , 8.2E-6, 8.3E-6

MPDATA,KXX , 18, , 1.57E-4, 1.62E-4, 1.69E-4, 1.76E-4, 1.83E-4, 1.9E-4
MPDATA,KXX , 18, , 1.97E-4, 2.04E-4, 2.11E-4, 2.18E-4, 2.25E-4, 2.31E-4
MPDATA,KXX , 18, , 2.38E-4, 2.45E-4

MPDATA,C  , 18, , 0.107, 0.108, 0.110, 0.112, 0.114, 0.116,
MPDATA,C  , 18, , 0.117, 0.118, 0.119, 0.121, 0.122, 0.123,
MPDATA,C  , 18, , 0.124, 0.125

MP, DENS, 18, 0.293
MP, NUXY, 18, 0.29
```

```
! Mat 19: Alloy 82/182

MPDATA,EX  ,19, , 31e6, 30.8e6, 30.5e6, 30.2e6, 30e6, 29.8e6
MPDATA,EX  ,19, , 29.7e6, 29.5e6, 29.3e6, 29e6, 28.9e6, 28.7e6
MPDATA,EX  ,19, , 28.5e6, 28.2e6

MPDATA,ALPX,19, , 6.8E-6, 6.9E-6, 7E-6, 7.1E-6, 7.2E-6, 7.3E-6
MPDATA,ALPX,19, , 7.4E-6, 7.5E-6, 7.6E-6, 7.6E-6, 7.7E-6, 7.8E-6
MPDATA,ALPX,19, , 7.8E-6, 7.9E-6

MPDATA,KXX ,19, , 1.99E-4, 2.01E-4, 2.06E-4, 2.11E-4, 2.15E-4, 2.22E-4
MPDATA,KXX ,19, , 2.27E-4, 2.34E-4, 2.38E-4, 2.45E-4, 2.5E-4, 2.57E-4
MPDATA,KXX ,19, , 2.62E-4, 2.69E-4

MPDATA,C   ,19, , 0.108, 0.109, 0.111, 0.113, 0.114, 0.116,
MPDATA,C   ,19, , 0.116, 0.118, 0.118, 0.120, 0.121, 0.123,
MPDATA,C   ,19, , 0.123, 0.125

MP, DENS,19, 0.300
MP, NUXY,19, 0.29

! Mat 20: Alloy 82/182

MPDATA,EX  ,20, , 31e6, 30.8e6, 30.5e6, 30.2e6, 30e6, 29.8e6
MPDATA,EX  ,20, , 29.7e6, 29.5e6, 29.3e6, 29e6, 28.9e6, 28.7e6
MPDATA,EX  ,20, , 28.5e6, 28.2e6

MPDATA,ALPX,20, , 6.8E-6, 6.9E-6, 7E-6, 7.1E-6, 7.2E-6, 7.3E-6
MPDATA,ALPX,20, , 7.4E-6, 7.5E-6, 7.6E-6, 7.6E-6, 7.7E-6, 7.8E-6
MPDATA,ALPX,20, , 7.8E-6, 7.9E-6

MPDATA,KXX ,20, , 1.99E-4, 2.01E-4, 2.06E-4, 2.11E-4, 2.15E-4, 2.22E-4
MPDATA,KXX ,20, , 2.27E-4, 2.34E-4, 2.38E-4, 2.45E-4, 2.5E-4, 2.57E-4
MPDATA,KXX ,20, , 2.62E-4, 2.69E-4

MPDATA,C   ,20, , 0.108, 0.109, 0.111, 0.113, 0.114, 0.116,
MPDATA,C   ,20, , 0.116, 0.118, 0.118, 0.120, 0.121, 0.123,
MPDATA,C   ,20, , 0.123, 0.125

MP, DENS,20, 0.300
MP, NUXY,20, 0.29

! Mat 21: ER308L (assumed SA-240-304L (18Cr-8Ni))

MPDATA,EX  , 21, , 28.3e6, 28.1e6, 27.9e6, 27.6e6, 27.3e6, 27e6
MPDATA,EX  , 21, , 26.8e6, 26.5e6, 26.2e6, 25.8e6, 25.6e6, 25.3e6
MPDATA,EX  , 21, , 25.1e6, 24.8e6

MPDATA,ALPX, 21, , 8.5E-6, 8.6E-6, 8.8E-6, 8.9E-6, 9.1E-6, 9.2E-6
MPDATA,ALPX, 21, , 9.3E-6, 9.5E-6, 9.6E-6, 9.7E-6, 9.8E-6, 9.8E-6
MPDATA,ALPX, 21, , 9.9E-6, 10E-6

MPDATA,KXX , 21, , 1.99E-4, 2.01E-4, 2.08E-4, 2.15E-4, 2.22E-4, 2.27E-4
MPDATA,KXX , 21, , 2.34E-4, 2.41E-4, 2.45E-4, 2.52E-4, 2.57E-4, 2.62E-4
MPDATA,KXX , 21, , 2.69E-4, 2.73E-4

MPDATA,C   , 21, , 0.116, 0.117, 0.12, 0.122, 0.124, 0.125,
MPDATA,C   , 21, , 0.127, 0.129, 0.13, 0.131, 0.132, 0.133,
MPDATA,C   , 21, , 0.134, 0.135

MP, DENS, 21, 0.283
MP, NUXY, 21, 0.3

! MAT 22: SS Type 316 (assumed as SA-376, Type 316 (16Cr-12Ni-2Mo)

MPDATA,EX , 22, , 28.3e6, 28.1e6, 27.9e6, 27.6e6, 27.3e6, 27e6
MPDATA,EX , 22, , 26.8e6, 26.5e6, 26.2e6, 25.8e6, 25.6e6, 25.3e6
MPDATA,EX , 22, , 25.1e6, 24.8e6
```

```
MPDATA,ALPX, 22, , 8.5E-6, 8.6E-6, 8.8E-6, 8.9E-6, 9.1E-6, 9.2E-6
MPDATA,ALPX, 22, , 9.3E-6, 9.5E-6, 9.6E-6, 9.7E-6, 9.8E-6, 9.8E-6
MPDATA,ALPX, 22, , 9.9E-6, 10E-6

MPDATA,KXX , 22, , 1.9E-4, 1.92E-4, 1.99E-4, 2.04E-4, 2.11E-4, 2.15E-4
MPDATA,KXX , 22, , 2.2E-4, 2.27E-4, 2.31E-4, 2.36E-4, 2.43E-4, 2.48E-4
MPDATA,KXX , 22, , 2.52E-4, 2.59E-4

MPDATA,C , 22, , 0.121, 0.121, 0.124, 0.124, 0.127, 0.127,
MPDATA,C , 22, , 0.128, 0.129, 0.13, 0.13, 0.133, 0.133,
MPDATA,C , 22, , 0.133, 0.135

MP, DENS, 22, 0.283
MP, NUXY, 22, 0.3

! MAT 23: A-336, Grade F8M (assumed similar to SA-430 FP316 (16Cr-12Ni-2Mo))

MPDATA,EX , 23, , 28.3e6, 28.1e6, 27.9e6, 27.6e6, 27.3e6, 27e6
MPDATA,EX , 23, , 26.8e6, 26.5e6, 26.2e6, 25.8e6, 25.6e6, 25.3e6
MPDATA,EX , 23, , 25.1e6, 24.8e6

MPDATA,ALPX, 23, , 8.5E-6, 8.6E-6, 8.8E-6, 8.9E-6, 9.1E-6, 9.2E-6
MPDATA,ALPX, 23, , 9.3E-6, 9.5E-6, 9.6E-6, 9.7E-6, 9.8E-6, 9.8E-6
MPDATA,ALPX, 23, , 9.9E-6, 10E-6

MPDATA,KXX , 23, , 1.9E-4, 1.92E-4, 1.99E-4, 2.04E-4, 2.11E-4, 2.15E-4
MPDATA,KXX , 23, , 2.2E-4, 2.27E-4, 2.31E-4, 2.36E-4, 2.43E-4, 2.48E-4
MPDATA,KXX , 23, , 2.52E-4, 2.59E-4

MPDATA,C , 23, , 0.121, 0.121, 0.124, 0.124, 0.127, 0.127,
MPDATA,C , 23, , 0.128, 0.129, 0.13, 0.13, 0.133, 0.133,
MPDATA,C , 23, , 0.133, 0.135

MP, DENS, 23, 0.283
MP, NUXY, 23, 0.3

! MAT 24: A-182 F 316 (16Cr-12Ni-2Mo)

MPDATA,EX , 24, , 28.3e6, 28.1e6, 27.9e6, 27.6e6, 27.3e6, 27e6
MPDATA,EX , 24, , 26.8e6, 26.5e6, 26.2e6, 25.8e6, 25.6e6, 25.3e6
MPDATA,EX , 24, , 25.1e6, 24.8e6

MPDATA,ALPX, 24, , 8.5E-6, 8.6E-6, 8.8E-6, 8.9E-6, 9.1E-6, 9.2E-6
MPDATA,ALPX, 24, , 9.3E-6, 9.5E-6, 9.6E-6, 9.7E-6, 9.8E-6, 9.8E-6
MPDATA,ALPX, 24, , 9.9E-6, 10E-6

MPDATA,KXX , 24, , 1.9E-4, 1.92E-4, 1.99E-4, 2.04E-4, 2.11E-4, 2.15E-4
MPDATA,KXX , 24, , 2.2E-4, 2.27E-4, 2.31E-4, 2.36E-4, 2.43E-4, 2.48E-4
MPDATA,KXX , 24, , 2.52E-4, 2.59E-4

MPDATA,C , 24, , 0.121, 0.121, 0.124, 0.124, 0.127, 0.127,
MPDATA,C , 24, , 0.128, 0.129, 0.13, 0.13, 0.133, 0.133,
MPDATA,C , 24, , 0.133, 0.135

MP, DENS, 24, 0.283
MP, NUXY, 24, 0.3
```

MProp_MISO_NLinear_DB.INP

```
/COM,*****************************************************************
/COM, Material Properties for Residual Stress Analyses
/COM,*****************************************************************

! MAT 1:  Nozzle Forging – RCP Inlet/Suction, Discharge          A-351, Grade CF8M (16Cr-12Ni-2Mo)
! MAT 2:  Nozzle Forging – RCP Cold Leg Drain                    SA-105 Grade 2 (Carbon Steel, C>0.3%)
! MAT 3:  Nozzle Forging – Core Flood Nozzle                     SA-508 Class 2 (3/4Ni-1/2Mo-1/3Cr-V)
! MAT 4:  Nozzle-to-Safe End Weld - Core Flood                   Alloy 82/182
! MAT 5:  Safe End – RCP Discharge                               A-376, Type 316 (16Cr-12Ni-2Mo)
! MAT 6:  Safe End –Core Flood Nozzle                            A-336, Grade F8M (assumed similar to SA-430 FP316 (16Cr-12Ni-2Mo))
! MAT 7:  Pipe Internal Clad - RCP Inlet/Suction, Discharge, cold leg clad      SA-240-304L (18Cr-8Ni)
! MAT 8:  Nozzle Internal Clad - RCP Cold Leg Drain, Core Flood     SA-371 ER308L (assumed SA-240-304L (18Cr-8Ni))
! MAT 9:  ID Weld Repair                                         Alloy 82/182
! MAT 10: Safe End-to-Pipe Weld - RCP Discharge                  Alloy 82/182
! MAT 11: Safe End-to-Pipe Weld - Core Flood                     SS Type 316 (assumed similar to SA-376 TP316 (16Cr-12Ni-2Mo))
! MAT 12: Attached Pipe/Elbow - RCP Inlet/Suction, Discharge     A-516 Grade 70 (Carbon Steel, (<=4" C < 0.3%))
! MAT 13: Attached Pipe/Elbow – RCP Cold Leg Drain               SA-403 WP316 (16Cr-12Ni-2Mo)
! MAT 14: Attached Pipe/Elbow – Core Flood Nozzle                SA-376, Type 316 (16Cr-12Ni-2Mo)
! MAT 15: Cold Leg Pipe - RCP Cold Leg Drain                     A-106 Grade C (C>0.3%)
! MAT 16: Core Flood Vessel Shell                                A-508 Class 2 (3/4Ni-1/2Mo-1/3Cr-V)
! MAT 17: Core Flood Vessel Clad                                 SS Clad (assumed SA-240 304L (18Cr-8Ni))
! MAT 18: Weld Overlay                                           Alloy 52M
! MAT 19: Nozzle to Pipe Weld - RCP Inlet/Suction, RCP Cold Leg Drain Alloy 82/182
! MAT 20: Butter material                                        Alloy 82/182
! MAT 21: Buffer Layer                                           ER308L (assumed SA-240-304L (18Cr-8Ni))
! MAT 22: RCP Discharge Nozzle-to-SE Weld, Spray Nozzle and Pressure Tap welds to RCP Discharge SE     SS Type 316 (assumed similar to SA-376
TP316 (16Cr-12Ni-2Mo))
! MAT 23: Pressure Tap - Discharge Nozzle                        A-336, Grade F8M (assumed similar to SA-430 FP316 (16Cr-12Ni-2Mo))
! MAT 24: Spray Nozzle - Discharge Nozzle                        A-182 F 316 (16Cr-12Ni-2Mo)


MPTEMP, 1, 70,500,700,1100,1500,2500

cv = 60*12   ! Convert hour-foot to minute-inch

! MAT 1: A-351, Grade CF8M (16Cr-12Ni-2Mo)
MPDATA,EX,  1, , 28.3E6, 25.8E6, 24.8E6, 22.1E6, 18.1E6,  0.1E6
MPDATA,ALPX,1, , 8.5E-6, 9.7E-6,10.0E-6,10.5E-6,10.8E-6,11.5E-6
MPDATA,KXX, 1, , 8.2/cv,10.2/cv,11.2/cv,13.0/cv,14.7/cv,19.0/cv
MPDATA,C,   1, , 0.121, 0.130, 0.135, 0.141, 0.145, 0.155
MP,DENS,    1,0.283
MP,NUXY,    1,0.300


! MAT 2:  SA-105 Grade 2 (Hi Carbon)
MPDATA,EX,  2, , 29.3E6, 27.1E6, 25.3E6, 17.9E6,  8.0E6,  0.1E6
MPDATA,ALPX, 2, , 6.4E-6, 7.3E-6, 7.6E-6, 8.2E-6, 8.6E-6, 9.5E-6
MPDATA,KXX,  2, , 35.1/cv,29.5/cv,26.6/cv,20.9/cv,15.7/cv, 1.0/cv
MPDATA,C,   2, , 0.103, 0.128, 0.138, 0.171, 0.198, 0.204
MP,DENS,    2,0.283
MP,NUXY,    2,0.300

! MAT 3: SA-508 Class 2 (3/4Ni-1/2Mo-1/3Cr-V)
MPDATA,EX,  3, , 27.8E6, 25.7E6, 24.6E6, 21.5E6, 16.0E6,  0.1E6
MPDATA,ALPX, 3, , 6.4E-6, 7.3E-6, 7.6E-6, 8.2E-6, 8.6E-6, 9.5E-6
MPDATA,KXX,  3, , 23.5/cv,22.7/cv,21.6/cv,19.0/cv,15.1/cv, 5.0/cv
MPDATA,C,   3, , 0.105, 0.130, 0.140, 0.173, 0.154, 0.204
MP,DENS,    3,0.283
MP,NUXY,    3,0.300


! MAT 4: Alloy 82/182
MPDATA,EX,  4, , 31.0E6, 29.0E6, 28.2E6, 25.9E6, 23.1E6,  0.1E6
MPDATA,ALPX,4, , 6.8E-6, 7.6E-6, 7.9E-6, 8.4E-6, 9.0E-6,10.0E-6
```

```
MPDATA,KXX, 4, , 8.6/cv,10.6/cv,11.6/cv,13.8/cv,16.0/cv,22.0/cv
MPDATA,C,  4, , 0.108, 0.120, 0.125, 0.139, 0.148, 0.177
MP,DENS,  4,0.300
MP,NUXY,  4,0.290

! MAT 5: A-376, Type 316 (16Cr-12Ni-2Mo)
MPDATA,EX,  5, , 28.3E6, 25.8E6, 24.8E6, 22.1E6, 18.1E6, 0.1E6
MPDATA,ALPX,5, , 8.5E-6, 9.7E-6,10.0E-6,10.5E-6,10.8E-6,11.5E-6
MPDATA,KXX, 5, , 8.2/cv,10.2/cv,11.2/cv,13.0/cv,14.7/cv,19.0/cv
MPDATA,C,  5, , 0.121, 0.130, 0.135, 0.141, 0.145, 0.155
MP,DENS,  5,0.283
MP,NUXY,  5,0.300


! MAT 6: A-336, Grade F8M (assumed similar to SA-430 FP316 (16Cr-12Ni-2Mo))
MPDATA,EX,  6, , 28.3E6, 25.8E6, 24.8E6, 22.1E6, 18.1E6, 0.1E6
MPDATA,ALPX,6, , 8.5E-6, 9.7E-6,10.0E-6,10.5E-6,10.8E-6,11.5E-6
MPDATA,KXX, 6, , 8.2/cv,10.2/cv,11.2/cv,13.0/cv,14.7/cv,19.0/cv
MPDATA,C,  6, , 0.121, 0.130, 0.135, 0.141, 0.145, 0.155
MP,DENS,  6,0.283
MP,NUXY,  6,0.300


! MAT 7: SA-240-304L (18Cr-8Ni)
MPDATA,EX,  7, , 28.3E6, 25.8E6, 24.8E6, 22.1E6, 18.1E6, 0.1E6
MPDATA,ALPX,7, , 8.5E-6, 9.7E-6,10.0E-6,10.5E-6,10.8E-6,11.5E-6
MPDATA,KXX, 7, , 8.6/cv,10.9/cv,11.8/cv,13.6/cv,15.3/cv,21.0/cv
MPDATA,C,  7, , 0.116, 0.131, 0.135, 0.140, 0.145, 0.159
MP,DENS,  7,0.283
MP,NUXY,  7,0.300

! MAT 8: SA-371 ER308L (assumed SA-240-304L (18Cr-8Ni))
MPDATA,EX,  8, , 28.3E6, 25.8E6, 24.8E6, 22.1E6, 18.1E6, 0.1E6
MPDATA,ALPX,8, , 8.5E-6, 9.7E-6,10.0E-6,10.5E-6,10.8E-6,11.5E-6
MPDATA,KXX, 8, , 8.6/cv,10.9/cv,11.8/cv,13.6/cv,15.3/cv,21.0/cv
MPDATA,C,  8, , 0.116, 0.131, 0.135, 0.140, 0.145, 0.159
MP,DENS,  8,0.283
MP,NUXY,  8,0.300

! MAT 9: Alloy 82/182
MPDATA,EX,  9, , 31.0E6, 29.0E6, 28.2E6, 25.9E6, 23.1E6, 0.1E6
MPDATA,ALPX,9, , 6.8E-6, 7.6E-6, 7.9E-6, 8.4E-6, 9.0E-6,10.0E-6
MPDATA,KXX, 9, , 8.6/cv,10.6/cv,11.6/cv,13.8/cv,16.0/cv,22.0/cv
MPDATA,C,  9, , 0.108, 0.120, 0.125, 0.139, 0.148, 0.177
MP,DENS,  9,0.300
MP,NUXY,  9,0.290

! MAT 10: Alloy 82/182
MPDATA,EX,  10, , 31.0E6, 29.0E6, 28.2E6, 25.9E6, 23.1E6, 0.1E6
MPDATA,ALPX,10, , 6.8E-6, 7.6E-6, 7.9E-6, 8.4E-6, 9.0E-6,10.0E-6
MPDATA,KXX, 10, , 8.6/cv,10.6/cv,11.6/cv,13.8/cv,16.0/cv,22.0/cv
MPDATA,C,  10, , 0.108, 0.120, 0.125, 0.139, 0.148, 0.177
MP,DENS,  10,0.300
MP,NUXY,  10,0.290

! MAT 11: SS Type 316 (assumed as SA-376, Type 316 (16Cr-12Ni-2Mo)
MPDATA,EX,  11, , 28.3E6, 25.8E6, 24.8E6, 22.1E6, 18.1E6, 0.1E6
MPDATA,ALPX,11, , 8.5E-6, 9.7E-6,10.0E-6,10.5E-6,10.8E-6,11.5E-6
MPDATA,KXX, 11, , 8.2/cv,10.2/cv,11.2/cv,13.0/cv,14.7/cv,19.0/cv
MPDATA,C,  11, , 0.121, 0.130, 0.135, 0.141, 0.145, 0.155
MP,DENS,  11,0.283
MP,NUXY,  11,0.300

! Mat 12: A-516 Grade 70 (Carbon Steel, (<=4" C<0.3%))
MPDATA,EX,  12, , 29.5E6, 27.3E6, 25.5E6, 18.0E6, 5.0E6, 0.1E6
MPDATA,ALPX, 12, , 6.4E-6, 7.3E-6, 7.6E-6, 8.2E-6, 8.6E-6, 9.5E-6
MPDATA,KXX,  12, , 35.1/cv,29.5/cv,26.6/cv,20.9/cv,15.7/cv, 1.0/cv
MPDATA,C,  12, , 0.103, 0.128, 0.138, 0.171, 0.198, 0.204
MP,DENS,  12,0.283
```

```
MP,NUXY,    12,0.300

! Mat 13: SA-403 WP 316 (16Cr-12Ni-2Mo)
MPDATA,EX,  13, , 28.3E6, 25.8E6, 24.8E6, 22.1E6, 18.1E6,  0.1E6
MPDATA,ALPX,13, , 8.5E-6, 9.7E-6,10.0E-6,10.5E-6,10.8E-6,11.5E-6
MPDATA,KXX, 13, , 8.2/cv,10.2/cv,11.2/cv,13.0/cv,14.7/cv,19.0/cv
MPDATA,C,   13, , 0.121,  0.130,  0.135,  0.141,  0.145,  0.155
MP,DENS,    13,0.283
MP,NUXY,    13,0.300

! Mat 14: SA-376, Type 316 (16Cr-12Ni-2Mo)
MPDATA,EX,  14, , 28.3E6, 25.8E6, 24.8E6, 22.1E6, 18.1E6,  0.1E6
MPDATA,ALPX,14, , 8.5E-6, 9.7E-6,10.0E-6,10.5E-6,10.8E-6,11.5E-6
MPDATA,KXX, 14, , 8.2/cv,10.2/cv,11.2/cv,13.0/cv,14.7/cv,19.0/cv
MPDATA,C,   14, , 0.121,  0.130,  0.135,  0.141,  0.145,  0.155
MP,DENS,    14,0.283
MP,NUXY,    14,0.300

! Mat 15: A-106 Grade C (C>0.3%)
MPDATA,EX,  15, , 29.3E6, 27.1E6, 25.3E6, 17.9E6,  8.0E6,  0.1E6
MPDATA,ALPX, 15, , 6.4E-6, 7.3E-6, 7.6E-6, 8.2E-6, 8.6E-6, 9.5E-6
MPDATA,KXX,  15, , 35.1/cv,29.5/cv,26.6/cv,20.9/cv,15.7/cv, 1.0/cv
MPDATA,C,    15, , 0.103,  0.128,  0.138,  0.171,  0.198,  0.204
MP,DENS,     15,0.283
MP,NUXY,     15,0.300

! Mat 16: A-508 Class 2 (3/4Ni-1/2Mo-1/3Cr-V)
MPDATA,EX,  16, , 27.8E6, 25.7E6, 24.6E6, 21.5E6, 16.0E6,  0.1E6
MPDATA,ALPX, 16, , 6.4E-6, 7.3E-6, 7.6E-6, 8.2E-6, 8.6E-6, 9.5E-6
MPDATA,KXX,  16, , 23.5/cv,22.7/cv,21.6/cv,19.0/cv,15.1/cv, 5.0/cv
MPDATA,C,    16, , 0.105,  0.130,  0.140,  0.173,  0.154,  0.204
MP,DENS,     16,0.283
MP,NUXY,     16,0.300

! Mat 17: SA-371 ER308L (assumed SA-240-304L (18Cr-8Ni))
MPDATA,EX,  17, , 28.3E6, 25.8E6, 24.8E6, 22.1E6, 18.1E6,  0.1E6
MPDATA,ALPX,17, , 8.5E-6, 9.7E-6,10.0E-6,10.5E-6,10.8E-6,11.5E-6
MPDATA,KXX, 17, , 8.6/cv,10.9/cv,11.8/cv,13.6/cv,15.3/cv,21.0/cv
MPDATA,C,   17, , 0.116,  0.131,  0.135,  0.140,  0.145,  0.159
MP,DENS,    17,0.283
MP,NUXY,    17,0.300

! Mat 18: Alloy 690 for Alloy 52M
MPDATA,EX,  18, , 30.3E6, 28.3E6, 27.6E6, 25.3E6, 22.6E6,  0.1E6
MPDATA,ALPX,18, , 7.7E-6, 8.1E-6, 8.3E-6, 8.5E-6, 8.8E-6, 9.5E-6
MPDATA,KXX, 18, , 6.8/cv, 9.4/cv,10.6/cv,13.1/cv,15.5/cv,22.0/cv
MPDATA,C,   18, , 0.107,  0.121,  0.125,  0.135,  0.147,  0.167
MP,DENS,    18,0.293
MP,NUXY,    18,0.290

! Mat 19: Alloy 82/182
MPDATA,EX,  19, , 31.0E6, 29.0E6, 28.2E6, 25.9E6, 23.1E6,  0.1E6
MPDATA,ALPX,19, , 6.8E-6, 7.6E-6, 7.9E-6, 8.4E-6, 9.0E-6,10.0E-6
MPDATA,KXX, 19, , 8.6/cv,10.6/cv,11.6/cv,13.8/cv,16.0/cv,22.0/cv
MPDATA,C,   19, , 0.108,  0.120,  0.125,  0.139,  0.148,  0.177
MP,DENS,    19,0.300
MP,NUXY,    19,0.290

! Mat 20: Alloy 82/182
MPDATA,EX,  20, , 31.0E6, 29.0E6, 28.2E6, 25.9E6, 23.1E6,  0.1E6
MPDATA,ALPX,20, , 6.8E-6, 7.6E-6, 7.9E-6, 8.4E-6, 9.0E-6,10.0E-6
MPDATA,KXX, 20, , 8.6/cv,10.6/cv,11.6/cv,13.8/cv,16.0/cv,22.0/cv
MPDATA,C,   20, , 0.108,  0.120,  0.125,  0.139,  0.148,  0.177
MP,DENS,    20,0.300
MP,NUXY,    20,0.290

! MAT 21: ER308L (assumed SA-240-304L (18Cr-8Ni))
MPDATA,EX,  21, , 28.3E6, 25.8E6, 24.8E6, 22.1E6, 18.1E6,  0.1E6
MPDATA,ALPX,21, , 8.5E-6, 9.7E-6,10.0E-6,10.5E-6,10.8E-6,11.5E-6
```

```
MPDATA,KXX, 21, , 8.6/cv,10.9/cv,11.8/cv,13.6/cv,15.3/cv,21.0/cv
MPDATA,C,  21, , 0.116, 0.131, 0.135, 0.140, 0.145, 0.159
MP,DENS,  21,0.283
MP,NUXY,  21,0.300

! MAT 22: SS Type 316 (assumed as SA-376, Type 316 (16Cr-12Ni-2Mo)
MPDATA,EX, 22, , 28.3E6, 25.8E6, 24.8E6, 22.1E6, 18.1E6, 0.1E6
MPDATA,ALPX,22, , 8.5E-6, 9.7E-6,10.0E-6,10.5E-6,10.8E-6,11.5E-6
MPDATA,KXX, 22, , 8.2/cv,10.2/cv,11.2/cv,13.0/cv,14.7/cv,19.0/cv
MPDATA,C,  22, , 0.121, 0.130, 0.135, 0.141, 0.145, 0.155
MP,DENS,  22,0.283
MP,NUXY,  22,0.300

! MAT 23: A-336, Grade F8M (assumed similar to SA-430 FP316 (16Cr-12Ni-2Mo))
MPDATA,EX, 23, , 28.3E6, 25.8E6, 24.8E6, 22.1E6, 18.1E6, 0.1E6
MPDATA,ALPX,23, , 8.5E-6, 9.7E-6,10.0E-6,10.5E-6,10.8E-6,11.5E-6
MPDATA,KXX, 23, , 8.2/cv,10.2/cv,11.2/cv,13.0/cv,14.7/cv,19.0/cv
MPDATA,C,  23, , 0.121, 0.130, 0.135, 0.141, 0.145, 0.155
MP,DENS,  23,0.283
MP,NUXY,  23,0.300

! MAT 24: A-182 F 316 (16Cr-12Ni-2Mo)
MPDATA,EX, 24, , 28.3E6, 25.8E6, 24.8E6, 22.1E6, 18.1E6, 0.1E6
MPDATA,ALPX,24, , 8.5E-6, 9.7E-6,10.0E-6,10.5E-6,10.8E-6,11.5E-6
MPDATA,KXX, 24, , 8.2/cv,10.2/cv,11.2/cv,13.0/cv,14.7/cv,19.0/cv
MPDATA,C,  24, , 0.121, 0.130, 0.135, 0.141, 0.145, 0.155
MP,DENS,  24,0.283
MP,NUXY,  24,0.300


/COM,*************************************************************
/COM, Multilinear Isotropic Properties
/COM,*************************************************************

! MAT 1: A-351, Grade CF8M (16Cr-12Ni-2Mo)
TB,MISO,1,6,5
TBTEMP,70
TBPT,,0.00149823,42400
TBPT,,0.13000430,69800
TBPT,,0.25461383,97200
TBPT,,0.42197259,124600
TBPT,,0.63258489,152000
TBTEMP,500
TBPT,,0.00127907,33000
TBPT,,0.06160812,52500
TBPT,,0.14218000,72000
TBPT,,0.26923098,91500
TBPT,,0.45116470,111000
TBTEMP,700
TBPT,,0.00115726,28700
TBPT,,0.04713410,48775
TBPT,,0.12118403,68850
TBPT,,0.24571857,88925
TBPT,,0.43216804,109000
TBTEMP,1100
TBPT,,0.00104072,23000
TBPT,,0.02629713,38000
TBPT,,0.07687375,53000
TBPT,,0.17394654,68000
TBPT,,0.33574811,83000
TBTEMP,1500
TBPT,,0.00066298,12000
TBPT,,0.03013522,17250
TBPT,,0.07723242,22500
TBPT,,0.16327215,27750
TBPT,,0.30372152,33000
TBTEMP,2500
TBPT,,0.01000000,1000
TBPT,,0.25436656,2000
```

```
TBPT,,0.46213394,3000
TBPT,,0.70703966,4000
TBPT,,0.98409152,5000

! MAT 2:  SA-105 Grade 2 (Hi Carbon)
TB,MISO,2,6,5
TBTEMP,70
TBPT,,0.00122867,36000
TBPT,,0.01893525,49500
TBPT,,0.05297164,63000
TBPT,,0.12392872,76500
TBPT,,0.25439221,90000
TBTEMP,500
TBPT,,0.00108118,29300
TBPT,,0.01229602,44475
TBPT,,0.04191157,59650
TBPT,,0.11241880,74825
TBPT,,0.25418036,90000
TBTEMP,700
TBPT,,0.00101976,25800
TBPT,,0.00975556,41850
TBPT,,0.03699139,57900
TBPT,,0.10680945,73950
TBPT,,0.25407809,90000
TBTEMP,1100
TBPT,,0.00106145,19000
TBPT,,0.09176400,25750
TBPT,,0.17082863,32500
TBPT,,0.28305377,39250
TBPT,,0.43306968,46000
TBTEMP,1500
TBPT,,0.00150000,12000
TBPT,,0.24664089,15000
TBPT,,0.35451397,18000
TBPT,,0.48186660,21000
TBPT,,0.62868946,24000
TBTEMP,2500
TBPT,,0.01000000,1000
TBPT,,0.25436656,2000
TBPT,,0.46213394,3000
TBPT,,0.70703966,4000
TBPT,,0.98409152,5000

! MAT 3: SA-508 Class 2 (3/4Ni-1/2Mo-1/3Cr-V)
TB,MISO,3,6,5
TBTEMP,70
TBPT,,0.00179856,50000
TBPT,,0.00653691,60250
TBPT,,0.01833861,70500
TBPT,,0.05088838,80750
TBPT,,0.13083992,91000
TBTEMP,500
TBPT,,0.00168093,43200
TBPT,,0.00425816,55150
TBPT,,0.01312261,67100
TBPT,,0.04326163,79050
TBPT,,0.13069290,91000
TBTEMP,700
TBPT,,0.00165447,40700
TBPT,,0.00375477,53275
TBPT,,0.01167549,65850
TBPT,,0.04078828,78425
TBPT,,0.13065390,91000
TBTEMP,1100
TBPT,,0.00111628,24000
TBPT,,0.01290523,36000
TBPT,,0.04300007,48000
TBPT,,0.11360829,60000
TBPT,,0.25422138,72000
```

```
TBTEMP,1500
TBPT,,0.00043750,7000
TBPT,,0.02891253,17750
TBPT,,0.10122020,28500
TBPT,,0.23776149,39250
TBPT,,0.45454186,50000
TBTEMP,2500
TBPT,,0.01000000,1000
TBPT,,0.25436656,2000
TBPT,,0.46213394,3000
TBPT,,0.70703966,4000
TBPT,,0.98409152,5000

! MAT 4: Alloy 82/182
TB,MISO,4,6,5
TBTEMP,70
TBPT,,0.00175806,54500
TBPT,,0.06261424,77125
TBPT,,0.13236682,99750
TBPT,,0.24105550,122375
TBPT,,0.39724103,145000
TBTEMP,500
TBPT,,0.00163793,47500
TBPT,,0.06087695,67625
TBPT,,0.13000821,87750
TBPT,,0.23828025,107875
TBPT,,0.39439449,128000
TBTEMP,700
TBPT,,0.00165957,46800
TBPT,,0.06227835,66350
TBPT,,0.13214714,85900
TBPT,,0.24120331,105450
TBPT,,0.39809217,125000
TBTEMP,1100
TBPT,,0.00173745,45000
TBPT,,0.06880255,62250
TBPT,,0.14043334,79500
TBPT,,0.24996336,96750
TBPT,,0.40536485,114000
TBTEMP,1500
TBPT,,0.00129004,29800
TBPT,,0.18149804,41100
TBPT,,0.29961162,52400
TBPT,,0.44846834,63700
TBPT,,0.62851140,75000
TBTEMP,2500
TBPT,,0.01000000,1000
TBPT,,0.25436656,2000
TBPT,,0.46213394,3000
TBPT,,0.70703966,4000
TBPT,,0.98409152,5000

! MAT 5: A-376, Type 316 (16Cr-12Ni-2Mo)
TB,MISO,5,6,5
TBTEMP,70
TBPT,,0.00149823,42400
TBPT,,0.13000430,69800
TBPT,,0.25461383,97200
TBPT,,0.42197259,124600
TBPT,,0.63258489,152000
TBTEMP,500
TBPT,,0.00127907,33000
TBPT,,0.06160812,52500
TBPT,,0.14218000,72000
TBPT,,0.26923098,91500
TBPT,,0.45116470,111000
TBTEMP,700
TBPT,,0.00115726,28700
TBPT,,0.04713410,48775
```

```
TBPT,,0.12118403,68850
TBPT,,0.24571857,88925
TBPT,,0.43216804,109000
TBTEMP,1100
TBPT,,0.00104072,23000
TBPT,,0.02629713,38000
TBPT,,0.07687375,53000
TBPT,,0.17394654,68000
TBPT,,0.33574811,83000
TBTEMP,1500
TBPT,,0.00066298,12000
TBPT,,0.03013522,17250
TBPT,,0.07723242,22500
TBPT,,0.16327215,27750
TBPT,,0.30372152,33000
TBTEMP,2500
TBPT,,0.01000000,1000
TBPT,,0.25436656,2000
TBPT,,0.46213394,3000
TBPT,,0.70703966,4000
TBPT,,0.98409152,5000

! MAT 6: A-336, Grade F8M (assumed similar to SA-430 FP316 (16Cr-12Ni-2Mo))
TB,MISO,6,6,5
TBTEMP,70
TBPT,,0.00149823,42400
TBPT,,0.13000430,69800
TBPT,,0.25461383,97200
TBPT,,0.42197259,124600
TBPT,,0.63258489,152000
TBTEMP,500
TBPT,,0.00127907,33000
TBPT,,0.06160812,52500
TBPT,,0.14218000,72000
TBPT,,0.26923098,91500
TBPT,,0.45116470,111000
TBTEMP,700
TBPT,,0.00115726,28700
TBPT,,0.04713410,48775
TBPT,,0.12118403,68850
TBPT,,0.24571857,88925
TBPT,,0.43216804,109000
TBTEMP,1100
TBPT,,0.00104072,23000
TBPT,,0.02629713,38000
TBPT,,0.07687375,53000
TBPT,,0.17394654,68000
TBPT,,0.33574811,83000
TBTEMP,1500
TBPT,,0.00066298,12000
TBPT,,0.03013522,17250
TBPT,,0.07723242,22500
TBPT,,0.16327215,27750
TBPT,,0.30372152,33000
TBTEMP,2500
TBPT,,0.01000000,1000
TBPT,,0.25436656,2000
TBPT,,0.46213394,3000
TBPT,,0.70703966,4000
TBPT,,0.98409152,5000

! MAT 7: SA-240-304L (18Cr-8Ni)
TB,MISO,7,6,5
TBTEMP,70
TBPT,,0.00123675,35000
TBPT,,0.07774887,64750
TBPT,,0.18214087,94500
TBPT,,0.33827321,124250
TBPT,,0.55033453,154000
```

```
TBTEMP,500
TBPT,,0.00085271,22000
TBPT,,0.03589114,42750
TBPT,,0.10594921,63500
TBPT,,0.23140905,84250
TBPT,,0.42629537,105000
TBTEMP,700
TBPT,,0.00080645,20000
TBPT,,0.02810960,40000
TBPT,,0.09083667,60000
TBPT,,0.21112697,80000
TBPT,,0.40756128,100000
TBTEMP,1100
TBPT,,0.00074208,16400
TBPT,,0.01383547,30050
TBPT,,0.05190777,43700
TBPT,,0.13922645,57350
TBPT,,0.30447287,71000
TBTEMP,1500
TBPT,,0.00071823,13000
TBPT,,0.06529820,18250
TBPT,,0.13548971,23500
TBPT,,0.24290793,28750
TBPT,,0.39505954,34000
TBTEMP,2500
TBPT,,0.01000000,1000
TBPT,,0.25436656,2000
TBPT,,0.46213394,3000
TBPT,,0.70703966,4000
TBPT,,0.98409152,5000

! MAT 8: SA-371 ER308L (assumed SA-240-304L (18Cr-8Ni))
TB,MISO,8,6,5
TBTEMP,70
TBPT,,0.00123675,35000
TBPT,,0.07774887,64750
TBPT,,0.18214087,94500
TBPT,,0.33827321,124250
TBPT,,0.55033453,154000
TBTEMP,500
TBPT,,0.00085271,22000
TBPT,,0.03589114,42750
TBPT,,0.10594921,63500
TBPT,,0.23140905,84250
TBPT,,0.42629537,105000
TBTEMP,700
TBPT,,0.00080645,20000
TBPT,,0.02810960,40000
TBPT,,0.09083667,60000
TBPT,,0.21112697,80000
TBPT,,0.40756128,100000
TBTEMP,1100
TBPT,,0.00074208,16400
TBPT,,0.01383547,30050
TBPT,,0.05190777,43700
TBPT,,0.13922645,57350
TBPT,,0.30447287,71000
TBTEMP,1500
TBPT,,0.00071823,13000
TBPT,,0.06529820,18250
TBPT,,0.13548971,23500
TBPT,,0.24290793,28750
TBPT,,0.39505954,34000
TBTEMP,2500
TBPT,,0.01000000,1000
TBPT,,0.25436656,2000
TBPT,,0.46213394,3000
TBPT,,0.70703966,4000
TBPT,,0.98409152,5000
```

```
! MAT 9: Alloy 82/182
TB,MISO,9,6,5
TBTEMP,70
TBPT,,0.00175806,54500
TBPT,,0.06261424,77125
TBPT,,0.13236682,99750
TBPT,,0.24105550,122375
TBPT,,0.39724103,145000
TBTEMP,500
TBPT,,0.00163793,47500
TBPT,,0.06087695,67625
TBPT,,0.13000821,87750
TBPT,,0.23828025,107875
TBPT,,0.39439449,128000
TBTEMP,700
TBPT,,0.00165957,46800
TBPT,,0.06227835,66350
TBPT,,0.13214714,85900
TBPT,,0.24120331,105450
TBPT,,0.39809217,125000
TBTEMP,1100
TBPT,,0.00173745,45000
TBPT,,0.06880255,62250
TBPT,,0.14043334,79500
TBPT,,0.24996336,96750
TBPT,,0.40536485,114000
TBTEMP,1500
TBPT,,0.00129004,29800
TBPT,,0.18149804,41100
TBPT,,0.29961162,52400
TBPT,,0.44846834,63700
TBPT,,0.62851140,75000
TBTEMP,2500
TBPT,,0.01000000,1000
TBPT,,0.25436656,2000
TBPT,,0.46213394,3000
TBPT,,0.70703966,4000
TBPT,,0.98409152,5000

! MAT 10: Alloy 82/182
TB,MISO,10,6,5
TBTEMP,70
TBPT,,0.00175806,54500
TBPT,,0.06261424,77125
TBPT,,0.13236682,99750
TBPT,,0.24105550,122375
TBPT,,0.39724103,145000
TBTEMP,500
TBPT,,0.00163793,47500
TBPT,,0.06087695,67625
TBPT,,0.13000821,87750
TBPT,,0.23828025,107875
TBPT,,0.39439449,128000
TBTEMP,700
TBPT,,0.00165957,46800
TBPT,,0.06227835,66350
TBPT,,0.13214714,85900
TBPT,,0.24120331,105450
TBPT,,0.39809217,125000
TBTEMP,1100
TBPT,,0.00173745,45000
TBPT,,0.06880255,62250
TBPT,,0.14043334,79500
TBPT,,0.24996336,96750
TBPT,,0.40536485,114000
TBTEMP,1500
TBPT,,0.00129004,29800
TBPT,,0.18149804,41100
```

```
TBPT,,0.29961162,52400
TBPT,,0.44846834,63700
TBPT,,0.62851140,75000
TBTEMP,2500
TBPT,,0.01000000,1000
TBPT,,0.25436656,2000
TBPT,,0.46213394,3000
TBPT,,0.70703966,4000
TBPT,,0.98409152,5000

! MAT 11: SS Type 316 (assumed as SA-376, Type 316 (16Cr-12Ni-2Mo)
TB,MISO,11,6,5
TBTEMP,70
TBPT,,0.00149823,42400
TBPT,,0.13000430,69800
TBPT,,0.25461383,97200
TBPT,,0.42197259,124600
TBPT,,0.63258489,152000
TBTEMP,500
TBPT,,0.00127907,33000
TBPT,,0.06160812,52500
TBPT,,0.14218000,72000
TBPT,,0.26923098,91500
TBPT,,0.45116470,111000
TBTEMP,700
TBPT,,0.00115726,28700
TBPT,,0.04713410,48775
TBPT,,0.12118403,68850
TBPT,,0.24571857,88925
TBPT,,0.43216804,109000
TBTEMP,1100
TBPT,,0.00104072,23000
TBPT,,0.02629713,38000
TBPT,,0.07687375,53000
TBPT,,0.17394654,68000
TBPT,,0.33574811,83000
TBTEMP,1500
TBPT,,0.00066298,12000
TBPT,,0.03013522,17250
TBPT,,0.07723242,22500
TBPT,,0.16327215,27750
TBPT,,0.30372152,33000
TBTEMP,2500
TBPT,,0.01000000,1000
TBPT,,0.25436656,2000
TBPT,,0.46213394,3000
TBPT,,0.70703966,4000
TBPT,,0.98409152,5000

! Mat 12: A-516 Grade 70 (Carbon Steel, (<=4" C<0.3%)
TB,MISO,12,6,5
TBTEMP,70
TBPT,,0.00128814,38000
TBPT,,0.00318094,48250
TBPT,,0.01044011,58500
TBPT,,0.03748028,68750
TBPT,,0.12248521,79000
TBTEMP,500
TBPT,,0.00113553,31000
TBPT,,0.00213243,43000
TBPT,,0.00690500,55000
TBPT,,0.03035742,67000
TBPT,,0.12229910,79000
TBTEMP,700
TBPT,,0.00106667,27200
TBPT,,0.00187807,40150
TBPT,,0.00565952,53100
TBPT,,0.02712894,66050
TBPT,,0.12220785,79000
```

```
TBTEMP,1100
TBPT,,0.00116667,21000
TBPT,,0.09174106,27000
TBPT,,0.16567172,33000
TBPT,,0.27134322,39000
TBPT,,0.41435243,45000
TBTEMP,1500
TBPT,,0.00300000,15000
TBPT,,0.25584461,18750
TBPT,,0.36731136,22500
TBPT,,0.49884093,26250
TBPT,,0.65042369,30000
TBTEMP,2500
TBPT,,0.01000000,1000
TBPT,,0.25436656,2000
TBPT,,0.46213394,3000
TBPT,,0.70703966,4000
TBPT,,0.98409152,5000

! Mat 13: SA-403 WP 316 (16Cr-12Ni-2Mo)
TB,MISO,13,6,5
TBTEMP,70
TBPT,,0.00149823,42400
TBPT,,0.13000430,69800
TBPT,,0.25461383,97200
TBPT,,0.42197259,124600
TBPT,,0.63258489,152000
TBTEMP,500
TBPT,,0.00127907,33000
TBPT,,0.06160812,52500
TBPT,,0.14218000,72000
TBPT,,0.26923098,91500
TBPT,,0.45116470,111000
TBTEMP,700
TBPT,,0.00115726,28700
TBPT,,0.04713410,48775
TBPT,,0.12118403,68850
TBPT,,0.24571857,88925
TBPT,,0.43216804,109000
TBTEMP,1100
TBPT,,0.00104072,23000
TBPT,,0.02629713,38000
TBPT,,0.07687375,53000
TBPT,,0.17394654,68000
TBPT,,0.33574811,83000
TBTEMP,1500
TBPT,,0.00066298,12000
TBPT,,0.03013522,17250
TBPT,,0.07723242,22500
TBPT,,0.16327215,27750
TBPT,,0.30372152,33000
TBTEMP,2500
TBPT,,0.01000000,1000
TBPT,,0.25436656,2000
TBPT,,0.46213394,3000
TBPT,,0.70703966,4000
TBPT,,0.98409152,5000

! Mat 14: SA-376, Type 316 (16Cr-12Ni-2Mo)
TB,MISO,14,6,5
TBTEMP,70
TBPT,,0.00149823,42400
TBPT,,0.13000430,69800
TBPT,,0.25461383,97200
TBPT,,0.42197259,124600
TBPT,,0.63258489,152000
TBTEMP,500
TBPT,,0.00127907,33000
TBPT,,0.06160812,52500
```

```
TBPT,,0.14218000,72000
TBPT,,0.26923098,91500
TBPT,,0.45116470,111000
TBTEMP,700
TBPT,,0.00115726,28700
TBPT,,0.04713410,48775
TBPT,,0.12118403,68850
TBPT,,0.24571857,88925
TBPT,,0.43216804,109000
TBTEMP,1100
TBPT,,0.00104072,23000
TBPT,,0.02629713,38000
TBPT,,0.07687375,53000
TBPT,,0.17394654,68000
TBPT,,0.33574811,83000
TBTEMP,1500
TBPT,,0.00066298,12000
TBPT,,0.03013522,17250
TBPT,,0.07723242,22500
TBPT,,0.16327215,27750
TBPT,,0.30372152,33000
TBTEMP,2500
TBPT,,0.01000000,1000
TBPT,,0.25436656,2000
TBPT,,0.46213394,3000
TBPT,,0.70703966,4000
TBPT,,0.98409152,5000

! Mat 15: A-106 Grade C (C>0.3%)
TB,MISO,15,6,5
TBTEMP,70
TBPT,,0.00136519,40000
TBPT,,0.02425642,52500
TBPT,,0.06072018,65000
TBPT,,0.13132092,77500
TBPT,,0.25456366,90000
TBTEMP,500
TBPT,,0.00120295,32600
TBPT,,0.01532231,46950
TBPT,,0.04716487,61300
TBPT,,0.11804259,75650
TBPT,,0.25433308,90000
TBTEMP,700
TBPT,,0.00113043,28600
TBPT,,0.01183181,43950
TBPT,,0.04098994,59300
TBPT,,0.11137719,74650
TBPT,,0.25421675,90000
TBTEMP,1100
TBPT,,0.00122905,22000
TBPT,,0.11479271,28000
TBPT,,0.19283680,34000
TBPT,,0.29793227,40000
TBPT,,0.43330045,46000
TBTEMP,1500
TBPT,,0.00025000,2000
TBPT,,0.16947088,2875
TBPT,,0.28794548,3750
TBPT,,0.43757830,4625
TBPT,,0.61834898,5500
TBTEMP,2500
TBPT,,0.01000000,1000
TBPT,,0.25436656,2000
TBPT,,0.46213394,3000
TBPT,,0.70703966,4000
TBPT,,0.98409152,5000

! Mat 16: A-508 Class 2 (3/4Ni-1/2Mo-1/3Cr-V)
TB,MISO,16,6,5
```

```
TBTEMP,70
TBPT,,0.00179856,50000
TBPT,,0.00653691,60250
TBPT,,0.01833861,70500
TBPT,,0.05088838,80750
TBPT,,0.13083992,91000
TBTEMP,500
TBPT,,0.00168093,43200
TBPT,,0.00425816,55150
TBPT,,0.01312261,67100
TBPT,,0.04326163,79050
TBPT,,0.13069290,91000
TBTEMP,700
TBPT,,0.00165447,40700
TBPT,,0.00375477,53275
TBPT,,0.01167549,65850
TBPT,,0.04078828,78425
TBPT,,0.13065390,91000
TBTEMP,1100
TBPT,,0.00111628,24000
TBPT,,0.01290523,36000
TBPT,,0.04300007,48000
TBPT,,0.11360829,60000
TBPT,,0.25422138,72000
TBTEMP,1500
TBPT,,0.00043750,7000
TBPT,,0.02891253,17750
TBPT,,0.10122020,28500
TBPT,,0.23776149,39250
TBPT,,0.45454186,50000
TBTEMP,2500
TBPT,,0.01000000,1000
TBPT,,0.25436656,2000
TBPT,,0.46213394,3000
TBPT,,0.70703966,4000
TBPT,,0.98409152,5000

! Mat 17: SA-371 ER308L (assumed SA-240-304L (18Cr-8Ni))
TB,MISO,17,6,5
TBTEMP,70
TBPT,,0.00123675,35000
TBPT,,0.07774887,64750
TBPT,,0.18214087,94500
TBPT,,0.33827321,124250
TBPT,,0.55033453,154000
TBTEMP,500
TBPT,,0.00085271,22000
TBPT,,0.03589114,42750
TBPT,,0.10594921,63500
TBPT,,0.23140905,84250
TBPT,,0.42629537,105000
TBTEMP,700
TBPT,,0.00080645,20000
TBPT,,0.02810960,40000
TBPT,,0.09083667,60000
TBPT,,0.21112697,80000
TBPT,,0.40756128,100000
TBTEMP,1100
TBPT,,0.00074208,16400
TBPT,,0.01383547,30050
TBPT,,0.05190777,43700
TBPT,,0.13922645,57350
TBPT,,0.30447287,71000
TBTEMP,1500
TBPT,,0.00071823,13000
TBPT,,0.06529820,18250
TBPT,,0.13548971,23500
TBPT,,0.24290793,28750
TBPT,,0.39505954,34000
```

```
TBTEMP,2500
TBPT,,0.01000000,1000
TBPT,,0.25436656,2000
TBPT,,0.46213394,3000
TBPT,,0.70703966,4000
TBPT,,0.98409152,5000

! Mat 18: Alloy 690 for Alloy 52M
TB,MISO,18,6,5
TBTEMP,70
TBPT,,0.00160726,48700
TBPT,,0.06305922,75275
TBPT,,0.14216441,101850
TBPT,,0.26637521,128425
TBPT,,0.44418534,155000
TBTEMP,500
TBPT,,0.00128975,36500
TBPT,,0.03965509,59125
TBPT,,0.10337548,81750
TBPT,,0.21471146,104375
TBPT,,0.38738296,127000
TBTEMP,700
TBPT,,0.00125000,34500
TBPT,,0.03540485,57125
TBPT,,0.09681837,79750
TBPT,,0.20767351,102375
TBPT,,0.38365967,125000
TBTEMP,1100
TBPT,,0.00125296,31700
TBPT,,0.04930235,50775
TBPT,,0.12020713,69850
TBPT,,0.23732894,88925
TBPT,,0.41123796,108000
TBTEMP,1500
TBPT,,0.00124336,28100
TBPT,,0.26183017,44075
TBPT,,0.43043443,60050
TBPT,,0.62896232,76025
TBPT,,0.85475925,92000
TBTEMP,2500
TBPT,,0.01000000,1000
TBPT,,0.25436656,2000
TBPT,,0.46213394,3000
TBPT,,0.70703966,4000
TBPT,,0.98409152,5000

! Mat 19: Alloy 82/182
TB,MISO,19,6,5
TBTEMP,70
TBPT,,0.00175806,54500
TBPT,,0.06261424,77125
TBPT,,0.13236682,99750
TBPT,,0.24105550,122375
TBPT,,0.39724103,145000
TBTEMP,500
TBPT,,0.00163793,47500
TBPT,,0.06087695,67625
TBPT,,0.13000821,87750
TBPT,,0.23828025,107875
TBPT,,0.39439449,128000
TBTEMP,700
TBPT,,0.00165957,46800
TBPT,,0.06227835,66350
TBPT,,0.13214714,85900
TBPT,,0.24120331,105450
TBPT,,0.39809217,125000
TBTEMP,1100
TBPT,,0.00173745,45000
TBPT,,0.06880255,62250
```

```
TBPT,,0.14043334,79500
TBPT,,0.24996336,96750
TBPT,,0.40536485,114000
TBTEMP,1500
TBPT,,0.00129004,29800
TBPT,,0.18149804,41100
TBPT,,0.29961162,52400
TBPT,,0.44846834,63700
TBPT,,0.62851140,75000
TBTEMP,2500
TBPT,,0.01000000,1000
TBPT,,0.25436656,2000
TBPT,,0.46213394,3000
TBPT,,0.70703966,4000
TBPT,,0.98409152,5000

! Mat 20: Alloy 82/182
TB,MISO,20,6,5
TBTEMP,70
TBPT,,0.00175806,54500
TBPT,,0.06261424,77125
TBPT,,0.13236682,99750
TBPT,,0.24105550,122375
TBPT,,0.39724103,145000
TBTEMP,500
TBPT,,0.00163793,47500
TBPT,,0.06087695,67625
TBPT,,0.13000821,87750
TBPT,,0.23828025,107875
TBPT,,0.39439449,128000
TBTEMP,700
TBPT,,0.00165957,46800
TBPT,,0.06227835,66350
TBPT,,0.13214714,85900
TBPT,,0.24120331,105450
TBPT,,0.39809217,125000
TBTEMP,1100
TBPT,,0.00173745,45000
TBPT,,0.06880255,62250
TBPT,,0.14043334,79500
TBPT,,0.24996336,96750
TBPT,,0.40536485,114000
TBTEMP,1500
TBPT,,0.00129004,29800
TBPT,,0.18149804,41100
TBPT,,0.29961162,52400
TBPT,,0.44846834,63700
TBPT,,0.62851140,75000
TBTEMP,2500
TBPT,,0.01000000,1000
TBPT,,0.25436656,2000
TBPT,,0.46213394,3000
TBPT,,0.70703966,4000
TBPT,,0.98409152,5000

! MAT 21: ER 308L (assumed SA-240-304L (18Cr-8Ni))
TB,MISO,21,6,5
TBTEMP,70
TBPT,,0.00123675,35000
TBPT,,0.07774887,64750
TBPT,,0.18214087,94500
TBPT,,0.33827321,124250
TBPT,,0.55033453,154000
TBTEMP,500
TBPT,,0.00085271,22000
TBPT,,0.03589114,42750
TBPT,,0.10594921,63500
```

```
TBPT,,0.23140905,84250
TBPT,,0.42629537,105000
TBTEMP,700
TBPT,,0.00080645,20000
TBPT,,0.02810960,40000
TBPT,,0.09083667,60000
TBPT,,0.21112697,80000
TBPT,,0.40756128,100000
TBTEMP,1100
TBPT,,0.00074208,16400
TBPT,,0.01383547,30050
TBPT,,0.05190777,43700
TBPT,,0.13922645,57350
TBPT,,0.30447287,71000
TBTEMP,1500
TBPT,,0.00071823,13000
TBPT,,0.06529820,18250
TBPT,,0.13548971,23500
TBPT,,0.24290793,28750
TBPT,,0.39505954,34000
TBTEMP,2500
TBPT,,0.01000000,1000
TBPT,,0.25436656,2000
TBPT,,0.46213394,3000
TBPT,,0.70703966,4000
TBPT,,0.98409152,5000

! MAT 22: SS Type 316 (assumed as SA-376, Type 316 (16Cr-12Ni-2Mo)
TB,MISO,22,6,5
TBTEMP,70
TBPT,,0.00149823,42400
TBPT,,0.13000430,69800
TBPT,,0.25461383,97200
TBPT,,0.42197259,124600
TBPT,,0.63258489,152000
TBTEMP,500
TBPT,,0.00127907,33000
TBPT,,0.06160812,52500
TBPT,,0.14218000,72000
TBPT,,0.26923098,91500
TBPT,,0.45116470,111000
TBTEMP,700
TBPT,,0.00115726,28700
TBPT,,0.04713410,48775
TBPT,,0.12118403,68850
TBPT,,0.24571857,88925
TBPT,,0.43216804,109000
TBTEMP,1100
TBPT,,0.00104072,23000
TBPT,,0.02629713,38000
TBPT,,0.07687375,53000
TBPT,,0.17394654,68000
TBPT,,0.33574811,83000
TBTEMP,1500
TBPT,,0.00066298,12000
TBPT,,0.03013522,17250
TBPT,,0.07723242,22500
TBPT,,0.16327215,27750
TBPT,,0.30372152,33000
TBTEMP,2500
TBPT,,0.01000000,1000
TBPT,,0.25436656,2000
TBPT,,0.46213394,3000
TBPT,,0.70703966,4000
TBPT,,0.98409152,5000

! MAT 23: A-336, Grade F8M (assumed similar to SA-430 FP316 (16Cr-12Ni-2Mo))
TB,MISO,23,6,5
TBTEMP,70
```

```
TBPT,,0.00149823,42400
TBPT,,0.13000430,69800
TBPT,,0.25461383,97200
TBPT,,0.42197259,124600
TBPT,,0.63258489,152000
TBTEMP,500
TBPT,,0.00127907,33000
TBPT,,0.06160812,52500
TBPT,,0.14218000,72000
TBPT,,0.26923098,91500
TBPT,,0.45116470,111000
TBTEMP,700
TBPT,,0.00115726,28700
TBPT,,0.04713410,48775
TBPT,,0.12118403,68850
TBPT,,0.24571857,88925
TBPT,,0.43216804,109000
TBTEMP,1100
TBPT,,0.00104072,23000
TBPT,,0.02629713,38000
TBPT,,0.07687375,53000
TBPT,,0.17394654,68000
TBPT,,0.33574811,83000
TBTEMP,1500
TBPT,,0.00066298,12000
TBPT,,0.03013522,17250
TBPT,,0.07723242,22500
TBPT,,0.16327215,27750
TBPT,,0.30372152,33000
TBTEMP,2500
TBPT,,0.01000000,1000
TBPT,,0.25436656,2000
TBPT,,0.46213394,3000
TBPT,,0.70703966,4000
TBPT,,0.98409152,5000

! MAT 24: A-182 F 316 (16Cr-12Ni-2Mo)
TB,MISO,24,6,5
TBTEMP,70
TBPT,,0.00149823,42400
TBPT,,0.13000430,69800
TBPT,,0.25461383,97200
TBPT,,0.42197259,124600
TBPT,,0.63258489,152000
TBTEMP,500
TBPT,,0.00127907,33000
TBPT,,0.06160812,52500
TBPT,,0.14218000,72000
TBPT,,0.26923098,91500
TBPT,,0.45116470,111000
TBTEMP,700
TBPT,,0.00115726,28700
TBPT,,0.04713410,48775
TBPT,,0.12118403,68850
TBPT,,0.24571857,88925
TBPT,,0.43216804,109000
TBTEMP,1100
TBPT,,0.00104072,23000
TBPT,,0.02629713,38000
TBPT,,0.07687375,53000
TBPT,,0.17394654,68000
TBPT,,0.33574811,83000
TBTEMP,1500
TBPT,,0.00066298,12000
TBPT,,0.03013522,17250
TBPT,,0.07723242,22500
TBPT,,0.16327215,27750
TBPT,,0.30372152,33000
TBTEMP,2500
```

```
TBPT,,0.01000000,1000
TBPT,,0.25436656,2000
TBPT,,0.46213394,3000
TBPT,,0.70703966,4000
TBPT,,0.98409152,5000
```