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Title: HEAT EXCHANGER SIZING FOR 20 MW
GEOHERMAL POWER PLANTS AT MX SITES

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SUMMARY

This report presents the details of the analyses used to size the heaters, steam condenser, and working fluid condenser for a proposed 20 MW geothermal power plant application at MX sites in the southwest. These units would use a mixture of hydrocarbons (90% isobutane--10% n-hexane) to extract energy from moderate temperature resources (resource temperatures of 365°F, 400°F, and 450°F were considered). The working fluid will be maintained at supercritical pressures in the heater units. Studies have shown that this cycle will provide a significant net power increase over standard dual boiling single fluid cycles currently in use, e.g., the Raft River 5 MW pilot plant.

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1. INTRODUCTION

The use of geothermal energy to provide electrical power at Utah and Nevada MX missile sites is currently being proposed. This report presents the heat exchanger thermal specifications for a typical 20 MW geothermal power plant designed for resource temperatures of 365°F, 400°F, and 450°F. These plants will be unique in that they will utilize a working fluid mixture of 90% isobutane--10% n-hexane (by weight) operating at supercritical pressures in a binary geothermal cycle to extract energy from the geothermal resource. Studies have shown¹ that this supercritical cycle will provide an improvement in performance over dual boiling cycles currently in use.

The flow diagram of the proposed cycle is shown in Figure 1. A considerable amount of steam flashes from the geothermal fluid at the resource temperatures being considered; this steam is condensed to add heat to the working fluid in heat exchanger No. 3. Portions of the working fluid are heated by liquid geothermal fluid in heat exchangers No. 1 and No. 2, then recombined before final heating in heat exchanger No. 3. The working fluid is maintained at supercritical pressures in these three heat exchangers.

2. ANALYSIS

Fluid state points and flowrates for each of the heat exchangers were obtained from Reference 2. The values used in this study are tabulated in Table 1 for each resource temperature. Temperatures in brackets indicate a value calculated from an energy balance on the heat exchanger.

In order to fully utilize the low temperature resource and resultant close temperature approaches in the heat exchangers, pure countercurrent flow heat exchangers (E-shells) were selected. This configuration will provide a higher thermodynamic efficiency than multiple tubepass units which have a combination of counter and co-current flow. In addition, working fluid condensation was performed in the tubes in order to minimize the effects of differential condensation (separation of the heavier component as it begins to condense, thus lowering the condensation temperature of the remaining mixture). Differential condensation results in a decrease in the already small mean temperature difference in the condenser with a corresponding severe loss in overall cycle efficiency. Calculations done in this study showed that the condenser performance can be reduced by as much as 72% if differential condensation predominates.

2.1 Computer Codes

The heat exchanger sizing was performed with the ST-4 (Mod. 5.2) and CST-1 (Mod. 1.1) heat exchanger computer codes. These are proprietary codes available to EG&G as a member company of Heat Transfer Research, Inc. (HTRI) and can be used to design and rate shell-and-tube heat exchangers (ST-4) and shell-and-tube condensers (CST-1). Due to the proprietary nature of the codes, listings cannot be published; however, input and output information can be documented.

2.2 Fluid Properties

2.2.1 Working Fluid

The working fluid used in this cycle is a 90% isobutane--10% n-hexane (by weight) mixture of hydrocarbons. The heaters are operated at working fluid supercritical pressures (680 psia for 400°F and 450°F resources and 520 psia for the 365°F resource), while the condenser is operated subcritically (50 psia). The thermodynamic properties of the mixture were calculated by THERPP³ which uses the Modified-Benedict-Webb-Rubin equation of state. The TRAPP code⁴ was used to calculate the mixture transport properties for this study. Tables 2 through 7 present the thermodynamic and transport properties of the working fluid at 48, 50, and 52 psia for use in the working fluid condenser runs. Table 8 presents the properties at 520 and 540 psia for use in the 365°F resource heater runs, while Table 9 presents the properties at 670 and 680 psia for use in the 400°F and 450°F heater runs.

The property tables show that THERPP and TRAPP predict slightly different mixture densities due to different equations of state in each code. The density input into the CST-1 and ST-4 codes was that calculated by the THERPP code to be thermodynamically consistent. The density differences are not felt to have a significant impact on the results of this study.

Figure 2 shows the heat capacity of the working fluid as a function of temperature and pressure. The augmentation of heat capacity near the critical point is evident for the lower pressures and is minimal at the higher pressures. The large variation in properties will occur in the steam condenser during the final heating stage.

A working fluid fouling resistance of $0.0005 \frac{\text{hr} \cdot \text{ft}^2 \cdot ^\circ\text{F}}{\text{Btu}}$ is consistent with observed fouling characteristics of these hydrocarbons.

2.2.2 Geothermal Fluid and Cooling Water

Water properties were used for both the geothermal fluid and the cooling water. The built-in water properties in the HTRI codes were used. Fouling characteristics of the water at the resources are not yet known.

Representative numbers used in this study were $0.001 \frac{\text{hr} - \text{ft}^2 - ^\circ\text{F}}{\text{Btu}}$ for the geothermal fluid, $0.001 \frac{\text{hr} - \text{ft}^2 - ^\circ\text{F}}{\text{Btu}}$ for the geothermal steam, and $0.0005 \frac{\text{hr} - \text{ft}^2 - ^\circ\text{F}}{\text{Btu}}$ for the cooling water.

2.3 Cases Studied

A series of computer runs was required to converge on appropriate configurations for each of the 12 heat exchangers. The 400°F resource temperature heat exchangers were investigated first. Parameters considered were shell type, baffle type, tube size, fins vs. no fins, shell orientation, working fluid location, and shell length and diameter. (Not all parameters were varied on each exchanger.)

For the 400°F resource study, 21 runs were considered for the larger preheater (HX No. 1), 13 runs were considered for the smaller preheater (HX No. 2), 16 runs were considered for the heater (HX No. 3) and 24 runs were considered for the working fluid condenser (HX No. 4). Once the 400°F resource system was designed, the other two were simpler since much of the design was kept the same. For the 365°F resource, three runs were needed for the larger preheater (HX No. 1), four runs for the smaller preheater (HX No. 2), three runs for the heater (HX No. 3), and four runs for the working fluid condenser (HX No. 4). For the 450°F resource system, four runs were needed for the larger preheater (HX No. 1), four runs for the smaller preheater (HX No. 2), three runs for the heater (HX No. 3), and three runs for the working fluid condenser (HX No. 4). Results of these runs will be outlined in the following section.

3. RESULTS

3.1 400°F Resource

3.1.1 Large Preheater (HX No. 1)

The large preheater will be required to heat 2,334,000 lb/hr of 680 psia working fluid from 90.6°F to 298.9°F with 1,584,000 lb/hr of geothermal brine entering at 333.6°F. This is a required heat duty of 356,159,000 Btu/hr based on the working fluid state points and flow rate.

A tube size of 1.0 inch OD was established early for these large heat exchangers. Although there may be a penalty in shell thickness, the high pressure working fluid was placed on the shell side to be able to augment the low working fluid film conductance by using external fins on the tubes. This resulted in significantly higher overall U's and correspondingly smaller units. A similar study on a small 60 kW system showed 90° tube layout angles to be most efficient so this was used here also. No-tubes-in-window baffles were selected over double segmental because the runs indicated that tube vibration would be a problem with the segmental type baffles.

The specifications of the heater selected for this application are detailed in Table 10 and the summary computer printout is shown in Appendix A. The heater consists of three 78 inch ID 45 foot long horizontal E-shell units connected in series. No-tubes-in-window baffles with 15% vertical cut are specified. Each unit has 2157 Admiralty metal low fin tubes (19 fins/inch) with a nominal OD of 1.0 inch.

The total heat transfer surface area is 200,882 ft², the overall design U is 66.77 $\frac{\text{Btu}}{\text{ft}^2 \cdot \text{hr} \cdot ^\circ\text{F}}$ and the effective ΔT is 26.7°F for a design heat duty of 358,123,000 Btu/hr. Since the required heat duty is 356,159,000 Btu/hr, the design margin is about 0.5%.

3.1.2 Small Preheater (HX No. 2)

The small preheater will be required to heat 179,000 lb/hr of 680 psia working fluid from 90.6°F to 298.9°F with 121,000 lb/hr of geothermal brine entering at 333.6°F. This is a required heat duty of 27,315,000 Btu/hr based on the working fluid state points and flow rate.

The design of the small preheater (HX No. 2) paralleled that of the large preheater (HX No. 1) and resulted in a similar configuration. Externally finned 1.0 inch OD tubes on a 90° layout angle were selected with the working fluid placed on the shell side. Vertical segmental baffles could be used in this case.

The specifications of the heater selected for this application are detailed in Table 11 and the summary computer printout is shown in Appendix B. The heater consists of six 17.25 inch ID 28 foot long horizontal E-shell units connected in series. Vertical segmental baffles with 31.7% cut are specified. Each unit has 113 Admiralty metal low fin tubes (19 fins/inch) with a nominal OD of 1.0 inch.

The total heat transfer surface area is 13,058 ft², the overall design U is 81.02 $\frac{\text{Btu}}{\text{ft}^2 \cdot \text{hr} \cdot ^\circ\text{F}}$ and the effective ΔT is 26.18°F for a design heat duty of 27,698,000 Btu/hr. Since the required heat duty is 27,315,000 Btu/hr, the design margin is about 1.4%.

3.1.3 Heater (HX No. 3)

The heater will heat 2,512,000 lb/hr of 675 psia working fluid from 298.9°F to 326.9°F while condensing 121,000 lb/hr of geothermal steam at 113.1 psia. The steam will enter the condenser at 336.9°F and leave at 333.6°F. This is a required heat duty of 106,381,000 Btu/hr based on the steam state points and flow rate.

The specifications of the heater selected for this application are detailed in Table 12 and the summary computer printout is shown in Appendix C. The heater consists of one 63.0 inch ID 43 foot long horizontal E-shell unit. The heater has 1315 Admiralty metal low fin tubes (19 fins/inch) with a nominal OD of 1.0 inch. The steam is condensed on the tubeside and the fins are used to augment the working fluid thermal conductance. No-tubes-in-window baffles with 17.4% vertical cut are specified.

The total heat transfer surface area is $38,052 \text{ ft}^2$, the overall design U is $138.08 \frac{\text{Btu}}{\text{ft}^2 \cdot \text{hr} \cdot ^\circ\text{F}}$ and the effective ΔT is 20.32°F for a design heat duty of 106,766,000 Btu/hr. Since the required heat duty is 106,381,000 Btu/hr, the design margin is about 0.3%.

3.1.4 Working Fluid Condenser (HX No. 4)

The working fluid condenser will condense 2,512,000 lb/hr of working fluid at 51.4 psia with 19,696,000 lb/hr of cooling water entering at 70°F . The working fluid enters at 145.1°F and leaves at 80.5°F . This is a required heat duty of 428,696,000 Btu/hr based upon the working fluid state points and flow rate.

The working fluid was placed inside the tubes to aid in minimizing differential condensation of the two components. Studies have shown that keeping the two components together as much as possible during the condensation process is much more efficient than differential condensation and results in a considerably larger temperature difference in the condenser. Since the working fluid (tubeside) film coefficients were relatively low, internal longitudinal fins were specified to increase the internal heat transfer area. Smaller (3/4 inch ID) tubes increase the internal fluid velocities and surface areas for a given shell size.

The specifications of the condenser selected for this application are detailed in Table 13 and the summary computer printout is shown in Appendix D. The condenser consists of four 96 inch ID 50 foot long horizontal E-shell units connected in parallel. Each unit has 5059 3/4 inch OD internally finned tubes of a 90% copper--10% nickel alloy. No-tubes-in-window baffles with 15% vertical cut were used to eliminate a potential tube vibration problem.

The total heat transfer surface area is 194,773 ft², the overall design U is 175.03 $\frac{\text{Btu}}{\text{ft}^2 \cdot \text{hr} \cdot ^\circ\text{F}}$ and the effective ΔT is 12.57°F for a design heat duty of 428,526,000 Btu/hr. This is a 0% design margin for the design fouling factors.

3.2 365°F Resource

3.2.1 Large Preheater (HX No. 1)

The large preheater will be required to heat 2,521,000 lb/hr of 530 psia working fluid from 84.2°F to 283.2°F with 2,225,000 lb/hr of geothermal brine entering at 308.2°F. This is a required heat duty of 380,433,000 Btu/hr based on the working fluid state points and flow rate.

The specifications of the heater selected for this application are detailed in Table 14 and the summary computer printout is shown in Appendix E. The heater consists of two 72 inch ID 55 foot long horizontal E-shell units connected in series. No-tubes-in-window baffles with 15% vertical cut are specified. Each unit has 1831 Admiralty metal low fin tubes (19 fins/inch) with a nominal OD of 1.0 inch.

The total heat transfer surface area is 139,132 ft², the overall design U is 74.78 $\frac{\text{Btu}}{\text{ft}^2 \cdot \text{hr} \cdot ^\circ\text{F}}$ and the effective ΔT is 37.0°F for a design heat duty of 384,958,000 Btu/hr. Since the required heat duty is 380,433,000 Btu/hr, the design margin is about 1%.

3.2.2 Small Preheater (HX No. 2)

The small preheater will be required to heat 1,600,000 lb/hr of 530 psia working fluid from 84.2°F to 283.2°F with 141,000 lb/hr of geothermal brine entering at 308.3°F. This is a required heat duty of 24,262,000 Btu/hr based on the working fluid state points and flow rate.

The specifications of the heater selected for this application are detailed in Table 15 and the summary computer printout is shown in Appendix F. The heater consists of six 15.25 inch ID 20 foot long horizontal E-shell units connected in series. Vertical segmental baffles with 32.7% cut are specified. Each unit has 86 Admiralty metal low fin tubes (19 fins/inch) with a nominal OD of 1.0 inch.

The total heat transfer surface area is 7081 ft², the overall design U is 93.63 $\frac{\text{Btu}}{\text{ft}^2 \cdot \text{hr} \cdot ^\circ\text{F}}$ and the effective ΔT is 37.2°F for a design heat duty of 24,664,000 Btu/hr. Since the required heat duty is 24,262,000 Btu/hr, the design margin is about 1.7%.

3.2.3 Heater (HX No. 3)

The heater will heat 2,680,000 lb/hr of 525 psia working fluid from 283.2°F to 300.2°F while condensing 141,000 lb/hr of geothermal steam at 77.6 psia. The steam will enter the condenser at 310.2°F and leave at 308.2°F. This is a required heat duty of 127,115,000 Btu/hr based on the steam state points and flow rate.

The specifications of the heater selected for this application are detailed in Table 16 and the summary computer printout is shown in Appendix G. The condenser consists of one 75.0 inch ID 49 foot long horizontal E-shell unit. The condenser has 1983 Admiralty metal low fin tubes (19 fins/inch) with a nominal OD of 1.0 inch. No-tubes-in-window baffles with 15.2% vertical cut are specified.

The total heat transfer surface area is 65,557 ft², the overall design U is 127.115 $\frac{\text{Btu}}{\text{ft}^2 \cdot \text{hr} \cdot ^\circ\text{F}}$ and the effective ΔT is 15.28°F for a design heat duty of 127,332,000 Btu/hr. Since the required heat duty is 127,115,000 Btu/hr, the design margin is about 0.5%.

3.2.4 Working Fluid Condenser (HX No. 4)

The working fluid condenser will condense 2,680,000 lb/hr of working fluid at 51.4 psia with 20,981,000 lb/hr of cooling water entering at 70°F. The working fluid enters at 142.6°F and leave at 80.5°F. This is a required heat duty of 454,330,000 Btu/hr based on the working fluid points and flow rate.

The specifications of the condenser selected for this application are detailed in Table 17 and the summary computer printout is shown in Appendix H. The condenser consists of four 96 inch ID 54 foot long horizontal E-shell units connected in parallel. Each unit has 5059 3/4 inch OD internally finned tubes of a 90% copper--10% nickel alloy. No-tubes-in-window baffles with 15.0% vertical cut were used.

The total heat transfer surface area is 210,666 ft², the overall design U is 177.89 $\frac{\text{Btu}}{\text{ft}^2 \cdot \text{hr} \cdot ^\circ\text{F}}$ and the effective ΔT is 12.34°F for a design heat duty of 462,447,000 Btu/hr. Since the required heat duty is 454,330,000 Btu/hr, the design margin is about 1.8%.

3.3 450°F Resource

3.3.1 Large Preheater (HX No. 1)

The large preheater will be required to heat 2,163,000 lb/hr of 680 psia working fluid from 90.6°F to 278.9°F with 1,202,000 lb/hr of geothermal brine entering at 333.6°F. This is a required heat duty of 277,646,000 Btu/hr based on the working fluid state points and flow rate.

The specifications of the preheater selected for this application are detailed in Table 18 and the summary computer printout is shown in Appendix I. The heater consists of five 52 inch ID 40 foot long horizontal E-shell units connected in series. No-tubes-in-window baffles with 16.1% vertical cut are specified. Each unit has 918 Admiralty metal low fin tubes (19 fins/inch) with a nominal OD of 1.0 inch.

The total heat transfer surface area is 126,539 ft², the overall design U is 77.39 $\frac{\text{Btu}}{\text{ft}^2 - \text{hr} - ^\circ\text{F}}$ and the effective ΔT is 29.8°F for a design heat duty of 291,826,000 Btu/hr. Since the required heat duty is 277,646,000 Btu/hr, the design margin is about 5%.

3.3.2 Small Preheater (HX No. 2)

The small preheater will be required to heat 337,000 lb/hr of 680 psia working fluid from 90.6°F to 278.9°F with 187,000 lb/hr of geothermal brine entering at 333.6°F. This is a required heat duty of 43,258,000 Btu/hr based on the working fluid state points and flow rate.

The specifications of the preheater selected for this application are detailed in Table 19 and the summary computer printout is shown in Appendix J. The heater consists of five 24 inch ID 35 foot long horizontal E-shell units connected in series. No-tubes-in-window baffles with a 15% vertical cut are specified. Each unit has 188 Admiralty metal low fin tubes (19 fins/inch) with a nominal OD of 1.0 inch.

The total heat transfer surface area is 22,648 ft², the overall design U is 66.01 $\frac{\text{Btu}}{\text{ft}^2 - \text{hr} - ^\circ\text{F}}$ and the effective ΔT is 29.5°F for a design heat duty of 44,101,000 Btu/hr. Since the required heat duty is 43,258,000 Btu/hr, the design margin is about 2%.

3.3.3 Heater (HX No. 3)

The heater will heat 2,500,000 lb/hr of 675 psia working fluid from 278.9°F to 326.9°F while condensing 187,000 lb/hr of geothermal steam at 113.1 psia. The steam will enter the condenser at 336.9°F and leave at 333.6°F. This is a required heat duty of 164,489,000 Btu/hr based on the steam state points and flow rate.

The specifications of the heater selected for this application are detailed in Table 20 and the summary computer printout is shown in Appendix K. The condenser consists of one 66 inch ID 48 foot long horizontal E-shell unit. The condenser has 1513 Admiralty metal low fin tubes (19 fins/inch) with a nominal OD of 1.0 inch. No-tubes-in-window baffles with 15.6% vertical cut are specified.

The total heat transfer surface area is 48,971 ft², the overall design U is 139.02 $\frac{\text{Btu}}{\text{ft}^2 \cdot \text{hr} \cdot ^\circ\text{F}}$ and the effective ΔT is 24.36°F for a design heat duty of 165,842,000 Btu/hr. Since the required heat duty is 164,489,000 Btu/hr, the design margin is about 0.8%.

3.3.4 Working Fluid Condenser (HX No. 4)

The working fluid condenser will condense 2,500,000 lb/hr of working fluid at 51.4 psia with 19,600,000 lb/hr of cooling water entering at 70°F. The working fluid enters at 145.1°F and leaves at 80.5°F. This is a required heat duty of 426,642,000 Btu/hr based on the working fluid state points and flow rate.

The specifications of the condenser selected for this application are detailed in Table 21 and the summary computer printout is shown in Appendix L. The condenser consists of four 96 inch ID 50 foot long horizontal E-shell units connected in parallel. Each unit has 5059 3/4 inch OD internally finned tubes of a 90% copper--10% nickel alloy. No-tubes-in-window baffles with 15.0% vertical cut were used.

The total heat transfer surface area is $194,773 \text{ ft}^2$, the overall design U is $174.87 \frac{\text{Btu}}{\text{ft}^2 \cdot \text{hr} \cdot ^\circ\text{F}}$ and the effective ΔT is 12.64°F for a design heat duty of $480,518,000 \text{ Btu/hr}$. Since the required heat duty is $426,642,000 \text{ Btu/hr}$, the design margin is about 1%.

4. CONCLUSIONS

A preliminary sizing of the heat exchangers for the 20 MW geothermal plant has been made to use in preliminary system cost analyses. For this study the design margins were kept minimal and the design criteria was to keep the heat transfer area low without excessive shell length/diameter ratios. Pressure drop considerations dictated the series or parallel combinations of exchangers.

Once a specific application (resource temperature) is selected, another iteration of the sizing should be performed using these results as a starting point.

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4. J. F. Ely and H. J. M. Hanley, A Computer Program for the Prediction of Viscosity and Thermal Conductivity in Hydrocarbon Mixtures, Technical Note No. 1039, National Bureau of Standards, Boulder, Co, April 1981.
5. Personal Communication with C. J. Bliem, Geothermal Branch, February 1981.

Figure 1. System diagram for 20 MW geothermal power plant using binary fluid supercritical cycle.

Figure 2. Heat capacity of working fluid near critical point

TABLE 1
SUMMARY OF HEAT EXCHANGER STATE POINTS FOR MX STUDY

		Resource Temperature (°F)			
		365	400	450	
CONDENSER					
$\dot{W}_{cool}$	(lb/hr)	$20,981 \times 10^3$	$19,696 \times 10^3$	$19,600 \times 10^3$	← Calculated from heat duty
$T_{in, cool}$	(°F)	70.0	70.0	70.0	
$T_{out, cool}$	(°F)	(91.6)	(91.8)	(91.7)	
$P_{in, cool}$	(psia)	50.0	50.0	50.0	
$\dot{W}_{w.f.}$	(lb/hr)	$2,680 \times 10^3$	$2,512 \times 10^3$	$2,500 \times 10^3$	← From HX # 3
$T_{in, w.f.}$	(°F)	142.6	145.1	145.1	
$T_{out, w.f.}$	(°F)	80.5	80.5	80.5	
$P_{in, w.f.}$	(psia)	51.4	51.4	51.4	
HX # 1					
$\dot{W}_{G.F.}$	(lb/hr)	$2,225 \times 10^3$	$1,584 \times 10^3$	$1,202 \times 10^3$	← Calculated from heat duty
$T_{in, G.F.}$	(°F)	308.2	333.6	333.6	
$T_{out, G.F.}$	(°F)	(138.4)	(110.7)	(104.5)	
$P_{in, G.F.}$	(psia)	75.6	111.1	111.1	
$\dot{W}_{w.f.}$	(lb/hr)	$2,521 \times 10^3$	$2,334 \times 10^3$	$2,163 \times 10^3$	← From HX # 3
$T_{in, w.f.}$	(°F)	84.2	90.6	90.6	
$T_{out, w.f.}$	(°F)	(283.2)	(298.9)	(278.9)	
$P_{in, w.f.}$	(psia)	530.	680.	680.	
HX # 2					
$\dot{W}_{G.F.}$	(lb/hr)	141×10^3	121×10^3	187×10^3	← Calculated from heat duty
$T_{in, G.F.}$	(°F)	308.2	333.6	333.6	
$T_{out, G.F.}$	(°F)	(137.3)	(111.1)	(104.2)	
$P_{in, G.F.}$	(psia)	75.6	111.1	111.1	
$\dot{W}_{w.f.}$	(lb/hr)	160×10^3	179×10^3	337×10^3	← From HX # 3
$T_{in, w.f.}$	(°F)	84.2	90.6	90.6	
$T_{out, w.f.}$	(°F)	(283.2)	(298.9)	(278.9)	
$P_{in, w.f.}$	(psia)	530.	680.	680.	
HX # 3					
$\dot{W}_{steam}$	(lb/hr)	141×10^3	121×10^3	187×10^3	← Calculated from heat duty
$T_{in, steam}$	(°F)	310.2	336.9	336.9	
$T_{out, steam}$	(°F)	308.2	333.6	333.6	
$P_{in, steam}$	(psia)	77.6	113.1	113.1	
$\dot{W}_{w.f.}$	(lb/hr)	$2,680 \times 10^3$	$2,512 \times 10^3$	$2,500 \times 10^3$	← Calculated from heat duty
$T_{in, w.f.}$	(°F)	(283.2)	(298.9)	(278.9)	
$T_{out, w.f.}$	(°F)	300.2	326.9	326.9	
$P_{in, w.f.}$	(psia)	525.	675.	675.

TABLE 2

WORKING FLUID THERMODYNAMIC PROPERTIES, 48 PSIA

THERPP code used.

Isobutane = 1

MW₁ = 58.120

ω₁ = .90

X₁ = .93028

N-Hexane = 2

MW₂ = 86.172

ω₂ = .10

X₂ = .06972

$$X_1 = \frac{\frac{\omega_1}{MW_1}}{\frac{\omega_1}{MW_1} + \frac{\omega_2}{MW_2}}$$

$$h_{70,48} = -789.79$$

619

Temp (°F)	C _{pe}	C _{pv}	h _l	h _l -h _{70,48}	h _v	h _v -h _{70,48}	ρ _l	ρ _v	ω _v	ω _{l,e}	ω _{l,v}	X _{1,l} (X ₂)	X _{1,v} (X ₂)
1. 150.	↑	.46393	↑	↑	-610.75	179.04	↑	.47284	1.0	↑	↑	↑	↑
2. 136.	↑	.45725	↑	↑	-617.19	172.60	↑	.48697	1.0	↑	↑	↑	↑
3. 120.	↑	.44990	↑	↑	-624.45	165.34	↑	.50452	1.0	↑	↑	↑	↑
4. 111.86	.57331	.44630	-709.31	80.48	-628.10	161.69	36.256	.60234	1.0	.46455	.90000	.56262 (.43738)	.93028 (.06972)
5. 92.	.56604	.43688	-751.33	38.46	-645.70	144.09	35.295	.57498	.75876	.69985	.96363	.77564 (.22436)	.97518 (.02482)
6. 86.	.56419	.43418	-767.70	22.09	-650.42	139.37	34.826	.56265	.56098	.79934	.97877	.85520 (.14480)	.98558 (.01442)
7. 82.	.56307	.43243	-779.89	9.90	-653.43	136.36	34.454	.55325	.21763	.87553	.98796	.91250 (.08750)	.99185 (.00815)
8. 80.81	.56275	.43192	-783.73	6.06	-654.30	135.49	34.335	.55027	0.	.90000	.99057	.93028 (.06972)	.99362 (.00638)
9. 80.	.56213	↓	-784.21	5.58	↓	↓	34.364	↓	0.	↓	↓	↓	↓
10. 70.	.55466	↓	-789.79	0.	↓	↓	34.746	↓	0.	↓	↓	↓	↓

TABLE 3

WORKING FLUID TRANSPORT PROPERTIES, 48 PSIA

TRAPP Code used.

Temp. (°F)	$X_{1,l}$	$X_{2,l}$	$X_{1,v}$	$X_{2,v}$	μ_l	μ_v	k_l	k_v	ρ_l	ρ_v
1. 150.	↑	↑	↑	↑	↑	.00852	↑	.01245	↑	.4700
2. 136.	↑	↑	↑	↑	↑	.00832	↑	.01193	↑	.4835
3. 120.	↑	↑	↑	↑	↑	.00810	↑	.01135	↑	.5003
4. 111.86	.56262	.43738	.93028	.06972	.16936	.00798	.05694	.01107	36.617	.5093
5. 92.	.77564	.22436	.97518	.02482	.15401	.00777	.05599	.01051	35.878	.5195
6. 86.	.85520	.14480	.98558	.01442	.14669	.00770	.05534	.01033	35.482	.5237
7. 82.	.91250	.08750	.99185	.00815	.14106	.00766	.05478	.01021	35.159	.5268
8. 80.81	.93028	.06972	.99362	.00638	.139271	.00764	.05459	.01018	35.0520	.5278
9. 80.	↓	↓	↓	↓	.13986	↓	.05468	↓	35.086	↓
10. 70.	↓	↓	↓	↓	.14740	↓	.05588	↓	35.503	↓

Isobutane = 1
 $w_1 = .90$
 $x_1 = .93028$

N-Hexane = 2
 $w_2 = .10$
 $x_2 = .06972$

TABLE 4

WORKING FLUID THERMODYNAMIC PROPERTIES, 50 PSIA

Isobutane $w_1 = .90$ $X_1 = .93028$
N-Hexane $w_2 = .10$ $X_2 = .06972$

THERPP code used.

Temp (°F)	C_{P_e}	C_{P_v}	h_e	$h_g - h_{70,48}$	h_v	$h_v - h_{70,48}$	P_e	P_v	w_v	$w_{1,e}$	$w_{1,v}$	$X_{1,l}$ (X_2)	$X_{1,v}$ (X_2)
1. 150.	↑	.46485	↑	↑	-610.95	178.84	↑	.49414	1.0	↑	↑	↑	↑
2. 136.	↑	.45829	↑	↑	-617.41	172.38	↑	.50909	1.0	↑	↑	↑	↑
3. 120.	↑	.45109	↑	↑	-624.68	165.11	↑	.52765	1.0	↑	↑	↑	↑
4. 114.16	.57500	.44856	-708.69	80.10	-627.31	162.48	36.135	.62535	1.0	.46995	.90000	.56795 (.43205)	.93028 (.06972)
5. 94.	.56772	.43910	-751.57	38.22	-645.22	144.57	35.147	.59637	.74588	.71041	.96458	.78435 (.21565)	.97583 (.02417)
6. 88.	.56594	.43644	-768.04	21.75	-649.95	139.84	34.674	.58357	.52842	.81064	.97974	.86389 (.13611)	.98624 (.01376)
7. 86.	.56540	.43577	-774.03	15.76	-651.47	138.32	34.492	.57880	.38154	.84790	.98443	.89207 (.10793)	.98945 (.01055)
8. 83.38	.56473	.43445	-782.29	7.50	-653.42	136.37	34.236	.57218	0.	.90000	.99032	.93028 (.06972)	.99345 (.00655)
9. 80.	.56210	↓	-784.20	5.59	↓	↓	34.367	↓	0.	↓	↓	↓	↓
10. 70.	.55464	↓	-789.79	0	↓	↓	34.748	↓	0.	↓	↓	↓	↓

42-381 50 SHEETS 5 SQUARE
42-382 100 SHEETS 5 SQUARE
42-389 200 SHEETS 5 SQUARE
Made in U.S.A.

TABLE 5

WORKING FLUID TRANSPORT PROPERTIES, 50 PSIA

Isobutane $w_1 = .90$ $x_1 = .93028$
N-Hexane $w_2 = .10$ $x_2 = .06972$

TRAPP Code used.

Temp. (°F)	$x_{1,l}$	$x_{2,l}$	$x_{1,v}$	$x_{2,v}$	μ_l	μ_v	k_l	k_v	P_l	P_v
1. 150.	↑	↑	↑	↑	↑	.00853	↑	.01246	↑	.4910
2. 136.	↑	↑	↑	↑	↑	.00833	↑	.01194	↑	.5053
3. 120.	↑	↑	↑	↑	↑	.00811	↑	.01137	↑	.5230
4. 114.16	.56795	.43205	.93028	.06972	.16665	.00802	.05662	.01116	36.493	.5298
5. 94.	.78435	.21565	.97583	.02417	.15115	.00781	.05563	.01059	35.729	.5406
6. 88.	.86389	.13611	.98624	.01376	.14389	.00774	.05496	.01041	35.327	.5450
7. 86.	.89207	.10793	.98945	.01055	.14118	.00772	.05469	.01036	35.170	.5466
8. 83.38	.93028	.06972	.99345	.00655	.13742	.00769	.05429	.01028	34.943	.5488
9. 80.	↓	↓	↓	↓	.13986	↓	.05468	↓	35.086	↓
10. 70.	↓	↓	↓	↓	.14740	↓	.05588	↓	35.503	↓

TABLE 6

WORKING FLUID THERMODYNAMIC PROPERTIES, 52 PSIA

Isobutane $w_1 = .90$ $x_1 = .93028$
N-Hexane $w_2 = .10$ $x_2 = .06972$

THERPP code used.

Temp. (°F)	$C_{p\ell}$	C_{pv}	h_ℓ	$h_\ell - h_{70, \ell}$	h_v	$h_v - h_{70, v}$	P_ℓ	P_v	w_v	$w_{1,\ell}$	$w_{1,v}$	$x_{1,\ell}$ (x_2)	$x_{1,v}$ (x_2)
1. 150.	↑	.46580	↑	↑	-611.16	178.63	↑	.51557	1.0	↑	↑	↑	↑
2. 140.	↑	.46116	↑	↑	-615.78	174.01	↑	.52673	1.0	↑	↑	↑	↑
3. 130.	↑	.45666	↑	↑	-620.37	169.42	↑	.53580	1.0	↑	↑	↑	↑
4. 116.39	.57665	.45078	-708.09	81.70	-626.55	163.24	36.018	.64830	1.0	.47519	.90000	.57310 (.42690)	.93028 (.06972)
5. 96.	.56941	.44130	-751.64	38.15	-644.70	145.09	35.008	.61786	.73388	.71973	.96536	.79199 (.20801)	.97637 (.02363)
6. 90.	.56770	.43869	-768.18	21.61	-649.45	140.34	34.530	.60456	.49674	.82048	.98055	.87140 (.12860)	.98680 (.01320)
7. 88.	.56718	.43783	-774.19	15.60	-650.97	138.82	34.348	.59963	.33057	.85789	.98526	.89950 (.10050)	.99001 (.00999)
8. 85.88	.56667	.43694	-780.85	8.94	-652.57	137.22	34.140	.59411	0.	.90000	.99007	.93028 (.06972)	.99328 (.00672)
9. 80.	.56207	↓	-784.20	5.59	↓	↓	34.368	↓	0.	↓	↓	↓	↓
10. 70.	.55461	↓	-789.78	.01	↓	↓	34.749	↓	0.	↓	↓	↓	↓

42-381 50 SHEETS 5 SQUARE
42-382 100 SHEETS 5 SQUARE
42-389 200 SHEETS 5 SQUARE
Made in U.S.A.

TABLE 7

WORKING FLUID TRANSPORT PROPERTIES, 52 PSIA

Isobutane $w_1 = .90$ $x_1 = .93028$
N-Hexane $w_2 = .10$ $x_2 = .06972$

TRAPP code used.

Temp. (°F)	$X_{1,l}$	$X_{2,l}$	$X_{1,v}$	$X_{2,v}$	μ_l	μ_v	k_l	k_v	P_l	P_v
1. 150.	↑	↑	↑	↑	↑	.00854	↑	.01247	↑	.5121
2. 140.	↑	↑	↑	↑	↑	.00840	↑	.01209	↑	.5228
3. 130.	↑	↑	↑	↑	↑	.00826	↑	.01173	↑	.5340
4. 116.39	.57310	.12690	.93028	.06972	.16406	.00806	.05631	.01125	36.372	.5503
5. 96.	.79199	.20801	.97637	.02363	.14848	.00785	.05527	.01067	35.587	.5616
6. 90.	.87140	.12860	.98680	.01320	.14130	.00778	.05460	.01050	35.179	.5662
7. 88.	.89950	.10050	.99001	.00999	.13864	.00776	.05433	.01044	35.021	.5679
8. 85.88	.93028	.06972	.99328	.00672	.13564	.00773	.05400	.01037	34.837	.5697
9. 80.	↓	↓	↓	↓	.13986	↓	.05468	↓	35.086	↓
10. 70.	↓	↓	↓	↓	.14740	↓	.05588	↓	35.503	↓

TABLE 8

WORKING FLUID THERMODYNAMIC PROPERTIES, 520 AND 540 PSIA

Isobutane $w_1 = .90$ $X_1 = .93028$
N-Hexane $w_2 = .10$ $X_2 = .06972$

$$h_{70,48} = -782.79$$

THERPP Code used.

520 psia

540 psia

Temp. (°F)	C_p	h	$h-h_{70,48}$	ρ	ρ	μ	k	C_p	h	$h-h_{70,48}$	ρ	ρ	μ	k
1. 330.	.80375	-554.04	235.75	6.0728	5.8517	.01440	.02260	.84523	-556.56	233.23	6.5527	6.2873	.01474	.02279
2. 320.	.86579	-562.36	227.43	6.5134	6.2280	.01452	.02229	.93406	-565.41	224.38	7.1038	6.7486	.01495	.02253
3. 310.	.98490	-571.54	218.25	7.1301	6.7309	.01476	.02204	1.1267	-575.57	214.22	7.9334	7.4268	.01541	.02255
4. 300.	1.3084	-582.67	207.12	8.1599	7.5292	.01534	.02216	1.8350	-589.42	200.37	9.6015	8.7204	.01655	.02311
5. 280.	1.8726	-638.77	151.02	20.195	22.572	.04376	.03533	1.5533	-640.97	148.82	20.942	22.879	.04486	.03573
6. 250.	.85927	-672.44	117.35	25.775	26.323	.05896	.03959	.84805	-672.70	117.09	25.889	26.427	.05949	.03976
7. 220.	.72849	-695.94	93.85	28.244	28.637	.07177	.04256	.72538	-696.02	93.77	28.301	28.694	.07215	.04267
8. 180.	.65127	-723.36	66.43	30.546	30.957	.08905	.04605	.65016	-723.37	66.42	30.578	30.993	.08937	.04613
9. 140.	.60457	-748.42	41.37	32.373	32.915	.10880	.04973	.60404	-748.40	41.39	32.394	32.940	.10909	.04980
10. 80.	.55599	-783.15	6.64	34.695	35.483	.14673	.05608	.55577	-783.11	6.68	34.708	35.500	.14702	.05613

42-381 50 SHEETS 5 SQUARE
42-382 100 SHEETS 5 SQUARE
42-389 200 SHEETS 5 SQUARE
MADE IN U.S.A.

TABLE 9

WORKING FLUID THERMODYNAMIC PROPERTIES, 670 AND 680 PSIA

$$h_{70,48} = -789.79$$

Isobutane

$$MW_1 = 58.120$$

$$\omega_1 = .90$$

$$X_1 = .93028$$

N-Hexane

$$MW_2 = 86.172$$

$$\omega_2 = .10$$

$$X_2 = .06972$$

THERPP code used.

670 psia

680 psia

Temp. (°F)	C_p	h	$h-h_{70,48}$	ρ	ρ	μ	k	C_p	h	$h-h_{70,48}$	ρ	ρ	μ	k
1. 330.	1.3114	-578.22	211.57	11.290	11.232	.02005	.02649	1.3288	-580.08	209.71	11.755	11.889	.02092	.02700
2. 320.	1.5088	-592.46	197.33	13.407	14.757	.02514	.02889	1.4868	-594.16	195.63	13.895	15.612	.02667	.02964
3. 310.	1.5687	-607.90	181.89	16.140	18.979	.03376	.03245	1.5243	-609.33	180.46	16.588	19.346	.03470	.03284
4. 300.	1.4505	-623.18	166.61	19.079	21.388	.04031	.03472	1.3989	-624.11	165.68	19.391	21.566	.04087	.03494
5. 280.	1.0211	-647.47	142.32	23.249	24.247	.05015	.03763	1.0062	-647.76	142.03	23.359	24.327	.05048	.03775
6. 250.	.79571	-674.04	115.75	26.523	27.023	.06265	.04079	.79270	-674.13	115.66	26.566	27.064	.06288	.04086
7. 220.	.70822	-696.46	93.33	28.641	29.043	.07455	.04336	.70709	-696.48	93.31	28.666	29.068	.07473	.04341
8. 180.	.64356	-723.38	66.41	30.778	31.217	.09141	.04667	.64309	-723.38	66.41	30.793	31.234	.09156	.04671
9. 140.	.60076	-748.22	41.57	32.529	33.100	.11099	.05025	.60052	-748.21	41.58	32.539	33.112	.11114	.05028
10. 80.	.55435	-782.80	6.99	34.792	35.607	.14893	.05652	.55425	-782.77	7.02	34.798	35.615	.14908	.05655
THERPP				TRAPP				THERPP				TRAPP		

TABLE 10

HX#1 SPECIFICATION SHEET, 400°F RESOURCE

$$L/D = 6.92$$

1	CUSTOMER MX - 20 MW (e) 400 F		JOB NO.	
2	ADDRESS		REFERENCE NO. HX1/R16	
3	PLANT LOCATION		PROPOSAL NO.	
4	SERVICE OF UNIT Heat Exchanger #1		DATE	
5	SIZE 78 x 540 TYPE		ITEM NO.	
6	(HORIZ.) (VERT.)		CONNECTED IN Series	
7	SQ. FT. SURF./UNIT (GROSS) 67149	SHELLS/UNIT 3	SQ. FT. SURF./SHELL (GROSS) 201446	
8	PERFORMANCE OF ONE UNIT			
9	SHELL SIDE		TUBE SIDE	
10	FLUID CIRCULATED Working Fluid **		Geothermal Fluid	
11	TOTAL FLUID ENTERING 2.344 x 10⁶ lb/hr		1.584 x 10⁶ lb/hr	
12	VAPOR			
13	LIQUID			
14	STEAM			
15	NON-CONDENSABLES			
16	FLUID VAPORIZED OR CONDENSED			
17	STEAM CONDENSED			
18	DENSITY (IN/OUT) *	34.40 / 19.16 LB/FT³	59.60	LB/FT ³
19	VISCOSITY	.085	.268	
20	MOLECULAR WEIGHT			
21	SPECIFIC HEAT	.667 BTU/LB.°F	1.004	BTU/LB.°F
22	THERMAL CONDUCTIVITY	.0455 BTU/HR-FT.°F	.385	BTU/HR-FT.°F
23	ENTHALPY			BTU/LB
24	TEMPERATURE IN	90.6 °F	333.6	°F
25	TEMPERATURE OUT	298.9 °F	110.7	°F
26	OPERATING PRESSURE	680 PSIA	111	PSIA
27	NO. PASSES PER SHELL	1	1	
28	VELOCITY	1.88 FT/SEC	1.01	FT/SEC
29	PRESSURE DROP	13.09 PSI	0.78	PSI
30	FOULING RESISTANCE (MIN.)	.0005	.0010	
31	HEAT EXCHANGED-BTU/HR	3.5616 x 10⁸	MTD CORRECTED-°F	26.7
32	TRANSFER RATE—SERVICE	66.77	CLEAN	89.99
33	CONSTRUCTION OF ONE SHELL			
34	DESIGN PRESSURE		PSI	PSI
35	TEST PRESSURE		PSI	PSI
36	DESIGN TEMPERATURE	Nom Tk	°F	°F
37	TUBES Admiralty ***	NO. 2157 O.D. 1.00 B.W.G. .049 LENGTH 540	PITCH 1.312	90°
38	SHELL Carbon Steel	I.D. 78 O.D.	SHELL COVER	(INTEG) (REMOV)
39	CHANNEL OR BONNET		CHANNEL COVER	
40	TUBESHEET—STATIONARY		TUBESHEET—FLOATING	
41	BAFFLES—CROSS 9	TYPE Segmental NTIW	FLOATING HEAD COVER	
42	BAFFLES—LONG	TYPE (15% diam cut)	IMPINGEMENT PROTECTION	
43	TUBE SUPPORTS 10			
44	TUBE TO TUBESHEET JOINT			
45	GASKETS			
46	CONNECTIONS—SHELL SIDE	IN 23.3 OUT 23.3	RATING	
47	CHANNEL SIDE	IN 21.3 OUT 21.3	RATING	
48	CORROSION ALLOWANCE—SHELL SIDE		TUBE SIDE	
49	CODE REQUIREMENTS		TEMA CLASS R	
50	REMARKS * AVERAGE IF ONLY ONE VALUE GIVEN			
51	** 90% (mass) Isobutane, 10% n-Hexane			
52	*** 19 Fins/inch (A_{fin}/A_{inside}) = 3.41			
53				
54				

TABLE 11

HX#2 SPECIFICATION SHEET, 400° F RESOURCE

$$L/D = 19.76$$

1	CUSTOMER <i>MX 20 MW (e)</i>			JOB NO.	
2	ADDRESS			REFERENCE NO. <i>HX2/R13</i>	
3	PLANT LOCATION			PROPOSAL NO.	
4	SERVICE OF UNIT <i>Heat Exchanger #2 CALTERWATE</i>			DATE	
5	SIZE <i>17 X 336</i> TYPE <i>AEL</i> (HORIZ.) (VERT.)			CONNECTED IN <i>Service</i>	
6	SQ. FT. SURF./UNIT (GROSS) (EFF.) <i>13109</i>			SHELLS/UNIT <i>6</i> SQ. FT. SURF./SHELL (GROSS) (EFF.)	
7	PERFORMANCE OF ONE UNIT				
8	SHELL SIDE		TUBE SIDE		
9	FLUID CIRCULATED				
10	TOTAL FLUID ENTERING				
11	VAPOR				
12	LIQUID				
13	STEAM				
14	NON-CONDENSABLES				
15	FLUID VAPORIZED OR CONDENSED				
16	STEAM CONDENSED				
17	DENSITY (IN/OUT) ^{°K}		LB/FT ³		LB/FT ³
18	VISCOSITY		CP		CP
19	MOLECULAR WEIGHT				
20	SPECIFIC HEAT		BTU/LB.° F		BTU/LB.° F
21	THERMAL CONDUCTIVITY		BTU/HR-FT.° F		BTU/HR-FT.° F
22	LATENT HEAT		BTU/LB		BTU/LB
23	TEMPERATURE IN		° F		° F
24	TEMPERATURE OUT		° F		° F
25	OPERATING PRESSURE		PSIG		PSIG
26	NO. PASSES PER SHELL				
27	VELOCITY		FT/SEC		FT/SEC
28	PRESSURE DROP		PSI		PSI
29	FOULING RESISTANCE (MIN.)				
30	HEAT EXCHANGED-BTU/HR		MTD CORRECTED-° F		<i>26.2</i>
31	TRANSFER RATE—SERVICE		CLEAN		<i>117.96</i>
32	CONSTRUCTION OF ONE SHELL				
33	DESIGN PRESSURE		PSI		PSI
34	TEST PRESSURE		PSI		PSI
35	DESIGN TEMPERATURE		° F		° F
36	TUBES x x		NO. <i>113</i> O.D. <i>1</i> BWG		LENGTH <i>336</i> PITCH <i>70° 1.312</i>
37	SHELL		I.D. <i>17.25</i> O.D.		SHELL COVER (INTEG) (REMOV)
38	CHANNEL OR BONNET		CHANNEL COVER		
39	TUBESHEET—STATIONARY		TUBESHEET-FLOATING		
40	BAFFLES—CROSS <i>13</i> TYPE <i>Sep</i>		FLOATING HEAD COVER		
41	BAFFLES—LONG TYPE (<i>31.74% Dia Cut</i>)		IMPINGEMENT PROTECTION		
42	TUBE SUPPORTS				
43	TUBE TO TUBESHEET JOINT				
44	GASKETS				
45	CONNECTIONS-SHELL SIDE		IN		OUT RATING
46	CHANNEL SIDE		IN		OUT RATING
47	CORROSION ALLOWANCE—SHELL SIDE		TUBE SIDE		TEMA CLASS
48	CODE REQUIREMENTS				
49	REMARKS <i>* AVERAGE IF ONLY ONE VALUE GIVEN</i>				
50					
51					
52					
53					
54					

TABLE 12

HX#3 SPECIFICATION SHEET, 400°F RESOURCE

$$L/O = 8.19$$

1	CUSTOMER MX - 20 MW(e) - 400 F		JOB NO.
2	ADDRESS		REFERENCE NO. HX3/C11
3	PLANT LOCATION		PROPOSAL NO.
4	SERVICE OF UNIT Heat Exchanger #3		DATE
5	SIZE 63 X 516 TYPE AEL (HORIZ.) (VERT.)		ITEM NO.
6	SQ. FT. SURF./UNIT (GROSS) 38522 SHELLS/UNIT 1		CONNECTED IN
7	SQ. FT. SURF./SHELL (GROSS) 38522		
8	PERFORMANCE OF ONE UNIT		
9	SHELL SIDE		TUBE SIDE
10	FLUID CIRCULATED Working Fluid **		Geothermal Steam
11	TOTAL FLUID ENTERING 2.512 x 10⁶ lb/hr		1.21 x 10⁵ lb/hr
12	VAPOR		
13	LIQUID		
14	STEAM		
15	NON-CONDENSABLES		
16	FLUID VAPORIZED OR CONDENSED		
17	STEAM CONDENSED 1.21 x 10⁵ lb/hr		
18	DENSITY (IN/OUT) * 19.08 / 11.95 LB/FT³		0.250 / 56.39 LB/FT³
19	VISCOSITY 0.403 / 0.217		0.0151 / 0.1608
20	MOLECULAR WEIGHT		
21	SPECIFIC HEAT 1.450 / 1.373 BTU/LB.*F		0.590 / 1.038 BTU/LB.*F
22	THERMAL CONDUCTIVITY 0.347 / 0.272 BTU/HR-FT.*F		0.186 / 0.390 BTU/HR-FT.*F
23	ENTHALPY BTU/LB		BTU/LB
24	TEMPERATURE IN 298.5 °F		335.2 °F
25	TEMPERATURE OUT 326.9 °F		332.8 °F
26	OPERATING PRESSURE 675.0 PSIG		113.1 PSIG
27	NO. PASSES PER SHELL 1		1
28	VELOCITY 5.38 FT/SEC		20.17 FT/SEC
29	PRESSURE DROP 8.79 PSI		1.09 PSI
30	FOULING RESISTANCE (MIN.) 0.0005		0.0010
31	HEAT EXCHANGED-BTU/HR 1.0634 x 10⁸		MTD CORRECTED.*F 20.32
32	TRANSFER RATE—SERVICE 138.08		CLEAN 296.07
33	CONSTRUCTION OF ONE SHELL		
34	DESIGN PRESSURE		PSI
35	TEST PRESSURE		PSI
36	DESIGN TEMPERATURE None TIL		*F
37	TUBES Admiralty *** NO. 1315 O.D. 1.00 BWG 049 LENGTH 516 PITCH 1.312 90°		
38	SHELL C. Steel I.D. 63.0 O.D.		SHELL COVER (INTEG) (REMOV)
39	CHANNEL OR BONNET		CHANNEL COVER
40	TUBESHEET—STATIONARY		TUBESHEET—FLOATING
41	BAFFLES—CROSS 7 TYPE Segmental (NTIW)		FLOATING HEAD COVER
42	BAFFLES—LONG TYPE (17.4% dia cut)		IMPINGEMENT PROTECTION
43	TUBE SUPPORTS 8		
44	TUBE TO TUBESHEET JOINT		
45	GASKETS		
46	CONNECTIONS—SHELL SIDE IN 35.3 OUT 35.3		RATING
47	CHANNEL SIDE IN 12.1 OUT 8.1		RATING
48	CORROSION ALLOWANCE—SHELL SIDE		TUBE SIDE
49	CODE REQUIREMENTS		TEMA CLASS R
50	REMARKS * AVERAGE IF ONLY ONE VALUE GIVEN		
51	** 90% mass Isobutane 10% n-Hexane		
52	*** Wolverine "Low Fin" tubes - 19 fins/in $A_{fin}/A_{inside} = 3.365$		
53			
54			

TABLE 13

HX#4 SPECIFICATION SHEET, 400°F RESOURCE

$$L/D = 6.25$$

1	CUSTOMER MX - 20 MW(e) - 400 F		JOB NO.
2	ADDRESS ALTERNATE HORIZONTAL CONDENSER		REFERENCE NO. CX1/C16
3	PLANT LOCATION WITH 3/4" TUBES		PROPOSAL NO.
4	SERVICE OF UNIT CONDENSER		DATE
5	SIZE 96 X 600	TYPE AEL (HORIZ.) (VERT.)	ITEM NO.
6	CONNECTED IN PARALLEL		
7	SQ. FT. SURF./UNIT (GROSS) 605.5	SHELLS/UNIT 4	SQ. FT. SURF./SHELL (GROSS) 242180
8	198668 PERFORMANCE OF ONE UNIT 49667		
9	SHELL SIDE		TUBE SIDE
10	FLUID CIRCULATED COOLING WATER		WORKING FLUID **
11	TOTAL FLUID ENTERING 4924000 16/hr		628003 16/hr
12	VAPOR		
13	LIQUID		
14	STEAM		
15	NON-CONDENSABLES		
16	FLUID VAPORIZED OR CONDENSED		
17	STEAM CONDENSED		
18	DENSITY (IN/OUT) *	62.2 / 62.0 LB/FT³	.472 / 34.33 LB/FT³
19	VISCOSITY	.978 / .756 CP	.08854 / .139 CP
20	MOLECULAR WEIGHT		
21	SPECIFIC HEAT	1.00 BTU/LB.*F	.464 / .562 BTU/LB.*F
22	THERMAL CONDUCTIVITY	.355 / .361 BTU/HR-FT.*F	.0125 / .0546 BTU/HR-FT.*F
23	ENTHALPY		
24	TEMPERATURE IN	70.0 °F	112.8 °F
25	TEMPERATURE OUT	91.8 °F	87.1 °F
26	OPERATING PRESSURE	50.0 PSIA	51.40 PSIG
27	NO. PASSES PER SHELL	1	1
28	VELOCITY	1.49 1.66 FT/SEC	12.23 14.43 FT/SEC
29	PRESSURE DROP	9.35 9.51 PSI	0.24 1.05 PSI
30	FOULING RESISTANCE (MIN.)	0.001	0.0005
31	HEAT EXCHANGED-BTU/HR	107 153 000	MTD CORRECTED °F 12.80 12.57
32	TRANSFER RATE-SERVICE	141.79 175.03	CLEAN 201.46 2.75.89
33	CONSTRUCTION OF ONE SHELL		
34	DESIGN PRESSURE		PSI
35	TEST PRESSURE		PSI
36	DESIGN TEMPERATURE	50 59 TK	°F
37	TUBES ***	NO. 6419 O.D. 0.250 B.W.G. .049 LENGTH 576 PITCH 1.0620 90°	
38	SHELL C. Steel	I.D. 108 O.D.	SHELL COVER 600 (INTEG) (REMOV)
39	CHANNEL OR BONNET	96	CHANNEL COVER
40	TUBESHEET-STATIONARY		TUBESHEET-FLOATING
41	BAFFLES-CROSS 19	TYPE Segmental NTIW	FLOATING HEAD COVER
42	BAFFLES-LONG	TYPE (15% DIA CUT)	IMPINGEMENT PROTECTION
43	TUBE SUPPORTS None		
44	TUBE TO TUBESHEET JOINT		
45	GASKETS		
46	CONNECTIONS-SHELL SIDE	IN 36.0 OUT 36.0	RATING
47	CHANNEL SIDE	IN 36.0 OUT 12.0	RATING
48	CORROSION ALLOWANCE-SHELL SIDE		TUBE SIDE
49	CODE REQUIREMENTS		TEMA CLASS
50	REMARKS * AVERAGE IF ONLY ONE VALUE GIVEN		
51	** 90% (mass) Isobutane 10% Hexane		
52	*** Internally Finned 16 Longitudinal Fins 0.067 high $A_{if}/A_{plain} = 1.91$		

TABLE 14

HX#1 SPECIFICATION SHEET, 365°F RESOURCE

40 = 9.17

1	CUSTOMER <i>MX - 20 MW (re)</i>		365 F		JOB NO.
2	ADDRESS				REFERENCE NO. <i>BHX1/R3</i>
3	PLANT LOCATION				PROPOSAL NO.
4	SERVICE OF UNIT <i>Heat Exchanger # 1</i>				DATE
5	SIZE <i>72 X 660</i>		TYPE <i>AEL</i>		ITEM NO.
6	SQ. FT. SURF./UNIT <i>(GROSS) 69565.8</i>		SHELLS/UNIT <i>2</i>		CONNECTED IN <i>Series</i>
7	SQ. FT. SURF./SHELL <i>(GROSS) 139451</i>				
8	PERFORMANCE OF ONE UNIT				
9	SHELL SIDE		TUBE SIDE		
10	FLUID CIRCULATED <i>Working Fluid **</i>		<i>Geo Fluid</i>		
11	TOTAL FLUID ENTERING <i>2527000 lb/hr</i>		<i>2225000 lb/hr</i>		
12	VAPOR				
13	LIQUID				
14	STEAM				
15	NON-CONDENSABLES				
16	FLUID VAPORIZED OR CONDENSED				
17	STEAM CONDENSED				
18	DENSITY <i>(in/out) 34.54 / 18.27 lb/ft³</i>		<i>57.21 / 61.31 lb/ft³</i>		
19	VISCOSITY <i>.0875 CP</i>		<i>.265 CP</i>		
20	MOLECULAR WEIGHT				
21	SPECIFIC HEAT <i>.658 BTU/LB.*F</i>		<i>1.004 BTU/LB.*F</i>		
22	THERMAL CONDUCTIVITY <i>.0457 BTU/HR-FT.*F</i>		<i>.386 BTU/HR-FT.*F</i>		
23	LATENT HEAT		BTU/LB		
24	TEMPERATURE IN <i>84.2 °F</i>		<i>308.2 °F</i>		
25	TEMPERATURE OUT <i>243.2 °F</i>		<i>138.4 °F</i>		
26	OPERATING PRESSURE <i>530 PSI</i>		<i>75.6 PSI</i>		
27	NO. PASSES PER SHELL <i>1</i>		<i>1</i>		
28	VELOCITY <i>1.45 FT/SEC</i>		<i>1.67 FT/SEC</i>		
29	PRESSURE DROP <i>5.58 PSI</i>		<i>1.47 PSI</i>		
30	FOULING RESISTANCE (MIN.) <i>.0005</i>		<i>.001</i>		
31	HEAT EXCHANGED-BTU/HR <i>330433018</i>		MTD CORRECTED-°F <i>37.0</i>		
32	TRANSFER RATE—SERVICE <i>74.78</i>		CLEAN <i>105.17</i>		
33	CONSTRUCTION OF ONE SHELL				
34	DESIGN PRESSURE		PSI		PSI
35	TEST PRESSURE		PSI		PSI
36	DESIGN TEMPERATURE		°F		°F
37	TUBES <i>**</i>		NO. <i>1831</i> O.D. <i>1.00</i> BWG		LENGTH <i>660</i> PITCH <i>90° 1.312</i>
38	SHELL		I.D. <i>72</i> O.D.		SHELL COVER (INTEG) (REMOV)
39	CHANNEL OR BONNET				CHANNEL COVER
40	TUBESHEET—STATIONARY				TUBESHEET-FLOATING
41	BAFFLES—CROSS <i>6</i> TYPE <i>Sec. NTIW</i>				FLOATING HEAD COVER
42	BAFFLES—LONG TYPE <i>(15% diam cut)</i>				IMPINGEMENT PROTECTION
43	TUBE SUPPORTS <i>2 / Baffle space</i>				
44	TUBE TO TUBESHEET JOINT				
45	GASKETS				
46	CONNECTIONS—SHELL SIDE IN <i>25.3</i> OUT <i>25.3</i>		RATING		
47	CHANNEL SIDE IN <i>19.3</i> OUT <i>19.3</i>		RATING		
48	CORROSION ALLOWANCE—SHELL SIDE		TUBE SIDE		
49	CODE REQUIREMENTS		TEMA CLASS		
50	REMARKS <i>AVERAGE IF ONLY ONE VALUE GIVEN</i>				
51	<i>** 90% (mass) Isobutane 10% n-Hexane</i>				
52	<i>*** 19 Fins/inch Similar to Wolverine "Low Fin" tubing Air/Air = 3.365</i>				
53					
54					

TABLE 15

HX#2 SPECIFICATION SHEET, 365° F RESOURCE

$$L/D = 15.74$$

1					JOB NO.
2	CUSTOMER <i>MX - 20MW(c) - 365 F</i>				REFERENCE NO. <i>BHX2/R4</i>
3	ADDRESS				PROPOSAL NO.
4	PLANT LOCATION				DATE
5	SERVICE OF UNIT <i>Heat Exchanger #2</i>				ITEM NO.
6	SIZE <i>15 X 240</i>	TYPE <i>AEL</i>	(HORIZ.) (VERT.)	CONNECTED IN <i>Series</i>	
7	SQ. FT. SURF./UNIT ^(GROSS) _(EFF.) <i>7116</i>	SHELLS/UNIT <i>6</i>	SQ. FT. SURF./SHELL ^(GROSS) _(EFF.) <i>1180.2</i>		
8	PERFORMANCE OF ONE UNIT				
9	SHELL SIDE		TUBE SIDE		
10	FLUID CIRCULATED <i>Working Fluid **</i>		<i>Geo Fluid</i>		
11	TOTAL FLUID ENTERING <i>160 x 10³ lb/hr</i>		<i>141 x 10³ lb/hr</i>		
12	VAPOR				
13	LIQUID				
14	STEAM				
15	NON-CONDENSABLES				
16	FLUID VAPORIZED OR CONDENSED				
17	STEAM CONDENSED				
18	DENSITY (IN/OUT) ^{°F}	<i>34.54 / 18.06</i>	LB/FT ³	<i>57.2 / 61.3</i>	LB/FT ³
19	VISCOSITY	<i>.0875</i>	CP	<i>.266</i>	CP
20	MOLECULAR WEIGHT				
21	SPECIFIC HEAT	<i>.658</i>	BTU/LB.°F	<i>1.004</i>	BTU/LB.°F
22	THERMAL CONDUCTIVITY	<i>.0457</i>	BTU/HR-FT.°F	<i>.3855</i>	BTU/HR-FT.°F
23	LATENT HEAT		BTU/LB		BTU/LB
24	TEMPERATURE IN	<i>84.2</i>	°F	<i>308.2</i>	°F
25	TEMPERATURE OUT	<i>283.2</i>	°F	<i>137.3</i>	°F
26	OPERATING PRESSURE	<i>530</i>	PSIG	<i>75.6</i>	PSIG
27	NO. PASSES PER SHELL	<i>1</i>		<i>1</i>	
28	VELOCITY	<i>1.94</i>	FT/SEC	<i>2.25</i>	FT/SEC
29	PRESSURE DROP	<i>10.80</i>	PSI	<i>2.46</i>	PSI
30	FOULING RESISTANCE (MIN.)	<i>0.0005</i>		<i>0.001</i>	
31	HEAT EXCHANGED-BTU/HR	<i>24262 x 10⁶</i>	MTD CORRECTED-°F	<i>37.2</i>	
32	TRANSFER RATE-SERVICE	<i>93.63</i>	CLEAN	<i>146.71</i>	
33	CONSTRUCTION OF ONE SHELL				
34	DESIGN PRESSURE		PSI		PSI
35	TEST PRESSURE		PSI		PSI
36	DESIGN TEMPERATURE		°F		°F
37	TUBES	NO. <i>86</i>	O.D. <i>1.00</i> BWG	LENGTH <i>240</i>	PITCH <i>1.312 - 90°</i>
38	SHELL	I.D. <i>15.25</i> O.D.	SHELL COVER (INTEG) (REMOV)		
39	CHANNEL OR BONNET		CHANNEL COVER		
40	TUBESHEET-STATIONARY		TUBESHEET-FLOATING		
41	BAFFLES-CROSS <i>9</i> TYPE <i>Seg.</i>		FLOATING HEAD COVER		
42	BAFFLES-LONG TYPE <i>(32.73% Diam)</i>		IMPINGEMENT PROTECTION		
43	TUBE SUPPORTS	<i>Horizontal Cut</i>			
44	TUBE TO TUBESHEET JOINT				
45	GASKETS				
46	CONNECTIONS-SHELL SIDE	IN <i>10.2</i>	OUT <i>10.2</i>	RATING	
47	CHANNEL SIDE	IN <i>6.1</i>	OUT <i>6.1</i>	RATING	
48	CORROSION ALLOWANCE-SHELL SIDE	TUBE SIDE			
49	CODE REQUIREMENTS	TEMA CLASS			
50	REMARKS * AVERAGE IF ONLY ONE VALUE GIVEN				
51	<i>** 90% (mass) isobutane 10% n-butane</i>				
52					
53					
54					

TABLE 16

HX#3 SPECIFICATION SHEET, 365°F RESOURCE

$$L/D = 7.44$$

1	CUSTOMER <i>MX - 20 MW (2) - 365 F</i>				JOB NO.
2	ADDRESS				REFERENCE NO. <i>B17X3/R3</i>
3	PLANT LOCATION				PROPOSAL NO.
4	SERVICE OF UNIT <i>Heat Exchanger #2</i>				DATE
5	SIZE <i>75 X 588</i> TYPE <i>(HORIZ.)</i> CONNECTED IN				ITEM NO.
6	SQ. FT. SURF./UNIT <i>GROSS 66301</i> SHELLS/UNIT <i>1</i> SQ. FT. SURF./SHELL <i>GROSS (EFF.)</i>				
7	PERFORMANCE OF ONE UNIT				
8					
9	SHELL SIDE		TUBE SIDE		
10	FLUID CIRCULATED <i>Working Fluid **</i>		<i>Geo Fluid (14psi)</i>		
11	TOTAL FLUID ENTERING <i>2.685 x 10⁵ lb/hr</i>		<i>1.41 x 10⁵ lb/hr</i>		
12	VAPOR				
13	LIQUID				
14	STEAM				
15	NON-CONDENSABLES				
16	FLUID VAPORIZED OR CONDENSED				
17	STEAM CONDENSED				
18	DENSITY (IN/OUT) * <i>18.39 / 8.16</i>		<i>17.25 / 5.21</i>		
19	VISCOSITY <i>.0395 / .0153</i>		<i>.0145 / .1767</i>		
20	MOLECULAR WEIGHT				
21	SPECIFIC HEAT <i>1.788 / 1.308</i>		<i>.5517 / 1.627</i>		
22	THERMAL CONDUCTIVITY <i>.0333 / .0222</i>		<i>.0175 / .393</i>		
23	ENTHALPY				
24	TEMPERATURE IN <i>283.2</i>		<i>310.2</i>		
25	TEMPERATURE OUT <i>300.2</i>		<i>308.2</i>		
26	OPERATING PRESSURE <i>525</i>		<i>77.6</i>		
27	NO. PASSES PER SHELL <i>1</i>		<i>1</i>		
28	VELOCITY <i>4.93</i>		<i>21.38</i>		
29	PRESSURE DROP <i>8.32</i>		<i>1.89</i>		
30	FOULING RESISTANCE (MIN.) <i>.0005</i>		<i>.001</i>		
31	HEAT EXCHANGED-BTU/HR <i>12712 x 10⁸</i>		MTD CORRECTED * F <i>15.28</i>		
32	TRANSFER RATE—SERVICE <i>127.55</i>		CLEAN <i>251.56</i>		
33	CONSTRUCTION OF ONE SHELL				
34	DESIGN PRESSURE		PSI		PSI
35	TEST PRESSURE		PSI		PSI
36	DESIGN TEMPERATURE		° F		° F
37	TUBES <i>Admiralty ***</i> NO. <i>1983</i> O.D. <i>1.00</i> DWG		LENGTH <i>588</i>		PITCH <i>1.3/2 90°</i>
38	SHELL <i>Carbon Steel</i> I.D. <i>75</i> O.D.		SHELL COVER		(INTEG) (REMOV)
39	CHANNEL OR BONNET		CHANNEL COVER		
40	TUBESHEET—STATIONARY		TUBESHEET—FLOATING		
41	BAFFLES—CROSS <i>7</i> TYPE <i>Segmented (NTIW)</i>		FLOATING HEAD COVER		
42	BAFFLES—LONG TYPE <i>(Cut 15.2% dia)</i>		IMPINGEMENT PROTECTION		
43	TUBE SUPPORTS <i>1 support / baffle space</i>				
44	TUBE TO TUBESHEET JOINT				
45	GASKETS				
46	CONNECTIONS—SHELL SIDE IN <i>35.3</i> OUT <i>35.3</i>		RATING		
47	CHANNEL SIDE IN <i>12.1</i> OUT <i>8.1</i>		RATING		
48	CORROSION ALLOWANCE—SHELL SIDE TUBE SIDE				
49	CODE REQUIREMENTS TEMA CLASS <i>I</i>				
50	REMARKS * AVERAGE IF ONLY ONE VALUE GIVEN				
51	<i>** 90% (mass) Isobutene 10% n Hexane</i>				
52	<i>*** Similar to Wolverine "Low Fin" Aout/4in = 3.365</i>				
53					
54					

TABLE 17

HX#4 SPECIFICATION SHEET, 365°F RESOURCE

$$\frac{L}{D} = 6.75$$

1	CUSTOMER <i>MY - 20 MW (e) - 365 F</i>				JOB NO.
2	ADDRESS				REFERENCE NO. <i>BCX1/R3A</i>
3	PLANT LOCATION				PROPOSAL NO.
4	SERVICE OF UNIT <i>Condenser - horizontal - 3/4" tubes</i>				DATE
5	SIZE <i>96 x 648</i>	TYPE <i>AEL</i>	(HORIZ.) (VERT.)	CONNECTED IN <i>Parallel</i>	ITEM NO.
6	SQ. FT. SURF./UNIT (GROSS) (LEFF) <i>214560</i>	SHELLS/UNIT <i>4</i>	SQ. FT. SURF./SHELL (GROSS) (LEFF) <i>53640</i>		
7	PERFORMANCE OF ONE UNIT				
8	SHELL SIDE		TUBE SIDE		
9	FLUID CIRCULATED <i>Cooling Water</i>		Working Fluid <i>?</i>		
10	TOTAL FLUID ENTERING <i>5.245 x 10⁶ lb/hr</i>		<i>670 x 10³ lb/hr</i>		
11	VAPOR				
12	LIQUID				
13	STEAM				
14	NON-CONDENSABLES				
15	FLUID VAPORIZED OR CONDENSED				
16	STEAM CONDENSED				
17	DENSITY (LBM/FT ³)	<i>62.25 / 62.00</i>	LB/FT ³	<i>0.473 / 34.33</i>	LB/FT ³
18	VISCOSITY	<i>.978 / .757</i>	CP	<i>.00852 / .139</i>	CP
19	MOLECULAR WEIGHT				
20	SPECIFIC HEAT	<i>1.00 / 1.00</i>	BTU/LB·°F	<i>.464 / .563</i>	BTU/LB·°F
21	THERMAL CONDUCTIVITY	<i>.355 / .361</i>	BTU/HR-FT·°F	<i>.0125 / .0346</i>	BTU/HR-FT·°F
22	LATENT HEAT		BTU/LB		BTU/LB
23	TEMPERATURE IN	<i>70</i>	°F	<i>142.6</i>	°F
24	TEMPERATURE OUT	<i>91.6</i>	°F	<i>80.5</i>	°F
25	OPERATING PRESSURE	<i>50</i>	PSIG	<i>50.6</i>	PSIG
26	NO. PASSES PER SHELL	<i>1</i>		<i>1</i>	
27	VELOCITY	<i>1.87</i>	FT/SEC	<i>15.45</i>	FT/SEC
28	PRESSURE DROP	<i>9.95</i>	PSI	<i>1.28</i>	PSI
29	FOULING RESISTANCE (MIN.)	<i>.001</i>		<i>.0005</i>	
30	HEAT EXCHANGED-BTU/HR	<i>113,542 x 10⁶</i>	MTD CORRECTED-°F	<i>12.34</i>	
31	TRANSFER RATE—SERVICE	<i>177.80</i>	CLEAN	<i>283.07</i>	
32	CONSTRUCTION OF ONE SHELL				
33	DESIGN PRESSURE		PSI		PSI
34	TEST PRESSURE		PSI		PSI
35	DESIGN TEMPERATURE		°F		°F
36	TUBES ***	NO. <i>5059</i>	O.D. <i>0.75</i>	BWG	LENGTH <i>648</i>
37	SHELL	I.D. <i>96</i>	O.D.	SHELL COVER	PITCH <i>90° - 1.062</i>
38	CHANNEL OR BONNET			SHELL COVER	(INTG) (REMOV)
39	TUBESHEET—STATIONARY			CHANNEL COVER	
40	BAFFLES—CROSS	<i>12</i>	TYPE <i>Seg (NTIW)</i>	TUBESHEET-FLOATING	
41	BAFFLES—LONG		TYPE <i>(15% diam cut)</i>	FLOATING HEAD COVER	
42	TUBE SUPPORTS	<i>1</i>	Baffle space	IMPINGEMENT PROTECTION	
43	TUBE TO TUBESHEET JOINT				
44	GASKETS				
45	CONNECTIONS—SHELL SIDE	IN <i>36</i>	OUT <i>36</i>	RATING	
46	CHANNEL SIDE	IN <i>36</i>	OUT <i>12</i>	RATING	
47	CORROSION ALLOWANCE—SHELL SIDE		TUBE SIDE		
48	CODE REQUIREMENTS			TEMA CLASS	
49	REMARKS *** IF ONE VALUE GIVEN				
50	<i>** 90% (mass) Isobutane 10% n-Hexane</i>				
51	<i>*** Forge Fin = Internally Finned 16 Longitudinal Fins 0.06" in high</i>				
52	<i>Al Fin / Al plain = 1.91</i>				
53					
54					

TABLE 18

HX#1 SPECIFICATION SHEET, 450°F RESOURCE

$$L/D = 9.23$$

1	CUSTOMER <i>MX - 20 MW(e) 450 F</i>		JOB NO.
2	ADDRESS		REFERENCE NO. <i>AHX1/R4</i>
3	PLANT LOCATION		PROPOSAL NO.
4	SERVICE OF UNIT <i>Heat Exchanger # 1</i>		DATE
5	SIZE <i>52 x 480</i>	TYPE <i>AEL</i>	ITEM NO.
6	(HORIZ.) (VERT.)		CONNECTED IN <i>Series</i>
7	SQ. FT. SURF./UNIT <i>(GROSS) 25307.7</i>	SHELLS/UNIT <i>5</i>	SQ. FT. SURF./SHELL <i>(GROSS) 126439</i>
8	PERFORMANCE OF ONE UNIT		
9	SHELL SIDE		TUBE SIDE
10	FLUID CIRCULATED <i>Working Fluid **</i>		<i>Boilermaker Fluid</i>
11	TOTAL FLUID ENTERING <i>2163000 lb/hr</i>		<i>1202000 lb/hr</i>
12	VAPOR		
13	LIQUID		
14	STEAM		
15	NON-CONDENSABLES		
16	FLUID VAPORIZED OR CONDENSED		
17	STEAM CONDENSED		
18	DENSITY (IN/OUT) *	<i>34.30 / 23.32 LB/FT³</i>	<i>59.68 LB/FT³</i>
19	VISCOSITY	<i>.5894</i>	<i>.273</i>
20	MOLECULAR WEIGHT		
21	SPECIFIC HEAT	<i>.651 BTU/LB.*F</i>	<i>1.004 BTU/LB.*F</i>
22	THERMAL CONDUCTIVITY	<i>.0463 BTU/HR-FT.*F</i>	<i>.385 BTU/HR-FT.*F</i>
23	ENTHALPY	<i>BTU/LB</i>	<i>BTU/LB</i>
24	TEMPERATURE IN	<i>90.6 °F</i>	<i>333.6 °F</i>
25	TEMPERATURE OUT	<i>278.9 °F</i>	<i>104.5 °F</i>
26	OPERATING PRESSURE	<i>680 PSIG</i>	<i>111 PSIG</i>
27	NO. PASSES PER SHELL	<i>1</i>	<i>1</i>
28	VELOCITY	<i>1.83 FT/SEC</i>	<i>1.79 FT/SEC</i>
29	PRESSURE DROP	<i>14.90 PSI</i>	<i>2.57 PSI</i>
30	FOULING RESISTANCE (MIN.)	<i>.0005</i>	<i>.0001</i>
31	HEAT EXCHANGED-BTU/HR	<i>277 645 925</i>	MTD CORRECTED °F <i>29.8</i>
32	TRANSFER RATE—SERVICE	<i>77.39</i>	CLEAN <i>110.42</i>
33	CONSTRUCTION OF ONE SHELL		
34	DESIGN PRESSURE	PSI	PSI
35	TEST PRESSURE	PSI	PSI
36	DESIGN TEMPERATURE	°F	°F
37	TUBES ***	NO. <i>918</i> O.D. <i>1.00</i> BWG	LENGTH <i>480</i> PITCH <i>90° - 1.312 in</i>
38	SHELL	I.D. <i>52</i> O.D.	SHELL COVER (INTEG) (REMOV)
39	CHANNEL OR BONNET		CHANNEL COVER
40	TUBESHEET—STATIONARY		TUBESHEET-FLOATING
41	BAFFLES—CROSS <i>4</i> TYPE <i>Segmental</i>		FLOATING HEAD COVER
42	BAFFLES—LONG TYPE <i>Vertical cut 15.7%</i>		IMPINGEMENT PROTECTION
43	TUBE SUPPORTS <i>2 / baffle spacing</i>		
44	TUBE TO TUBESHEET JOINT		
45	GASKETS		
46	CONNECTIONS—SHELL SIDE	IN OUT	RATING
47	CHANNEL SIDE	IN OUT	RATING
48	CORROSION ALLOWANCE—SHELL SIDE	TUBE SIDE	
49	CODE REQUIREMENTS	TEMA CLASS	
50	REMARKS * AVERAGE IF ONLY ONE VALUE GIVEN		
51	** 90% (mass) Isobutene, 10% n-pentane		
52	*** 19 fins/inch similar to Wolverine "Low Fin" tubing, $A_{out}/A_{in} = 3.365$		
53			
54			

TABLE 19

HX#2 SPECIFICATION SHEET, 450° F RESOURCE

17.5
L/D = 20.00

1			JOB NO.
2	CUSTOMER	MX - 20 MW (e) 450	REFERENCE NO. AHX2/R4
3	ADDRESS		PROPOSAL NO.
4	PLANT LOCATION		DATE
5	SERVICE OF UNIT	Heat Exchanger # 2	ITEM NO.
6	SIZE	24 X 480 420 TYPE AEL (HORIZ.) (VERT.)	CONNECTED IN Series
7	SQ. FT. SURF./UNIT (GROSS) (EFF.)	4529.5 SHELLS/UNIT 5	SQ. FT. SURF./SHELL (GROSS) (EFF.) 22730
8	PERFORMANCE OF ONE UNIT		
9		SHELL SIDE	TUBE SIDE
10	FLUID CIRCULATED	Working Fluid **	Condensal Geosteam
11	TOTAL FLUID ENTERING	337 000 lb/hr	187 000 lb/hr
12	VAPOR		
13	LIQUID		
14	STEAM		
15	NON-CONDENSABLES		
16	FLUID VAPORIZED OR CONDENSED		
17	STEAM CONDENSED		
18	DENSITY (IN/OUT) *	34.40 / 23.32 LB/FT ³	56.37 / 61.43 LB/FT ³
19	VISCOSITY	.089	.223
20	MOLECULAR WEIGHT		
21	SPECIFIC HEAT	.651 BTU/LB.* F	1.003 BTU/LB.* F
22	THERMAL CONDUCTIVITY	.0463 BTU/HR-FT.* F	.385 BTU/HR-FT.* F
23	ENTHALPY		
24	TEMPERATURE IN	90.6 ° F	333.6 ° F
25	TEMPERATURE OUT	278.9 ° F	104.2 ° F
26	OPERATING PRESSURE	640 PSIA	111.1 PSIA
27	NO. PASSES PER SHELL	1	1
28	VELOCITY	1.18 FT/SEC	1.36 FT/SEC
29	PRESSURE DROP	14.52 PSI	1.36 PSI
30	FOULING RESISTANCE (MIN.)	.0005	.001
31	HEAT EXCHANGED-BTU/HR	43 257 826	MTD CORRECTED ° F 29.5
32	TRANSFER RATE—SERVICE	66.01	CLEAN 88.61
33	CONSTRUCTION OF ONE SHELL		
34	DESIGN PRESSURE		PSI
35	TEST PRESSURE		PSI
36	DESIGN TEMPERATURE		° F
37	TUBES ***	NO. 188 O.D. 1.00 BWG	LENGTH 480 420 PITCH 90° 1.312
38	SHELL	I.D. 24 O.D.	SHELL COVER (INTEG) (REMOV)
39	CHANNEL OR BONNET		CHANNEL COVER
40	TUBESHEET—STATIONARY		TUBESHEET-FLOATING
41	BAFFLES—CROSS 7	TYPE Seg. NTIW	FLOATING HEAD COVER
42	BAFFLES—LONG	TYPE (15% diam cut)	IMPINGEMENT PROTECTION
43	TUBE SUPPORTS		
44	TUBE TO TUBESHEET JOINT		
45	GASKETS		
46	CONNECTIONS-SHELL SIDE	IN OUT	RATING
47	CHANNEL SIDE	IN OUT	RATING
48	CORROSION ALLOWANCE—SHELL SIDE	TUBE SIDE	
49	CODE REQUIREMENTS		TEMA CLASS
50	REMARKS * AVERAGE IF ONLY ONE VALUE GIVEN		
51	** 90% (mass) Isobutane 10% Hexane		
52	*** Similar to 19 fin/inch Wolverine "Low Fin" Tubing A _{out} /A _{in} = 9.365		
53			
54			

TABLE 20

HX#3 SPECIFICATION SHEET, 450°F RESOURCE

$$L/D = 8.73$$

1	CUSTOMER <i>MX - 20MW(e) - 450F</i>		JOB NO.
2	ADDRESS		REFERENCE NO. <i>AHX3.1R3</i>
3	PLANT LOCATION		PROPOSAL NO.
4	SERVICE OF UNIT <i>Heat Exchanger #3</i>		DATE
5	SIZE <i>66 X 576</i> TYPE <i>(HORIZ.)</i>		ITEM NO.
6	SQ. FT. SURF./UNIT <i>49439</i> SHELLS/UNIT <i>1</i>		CONNECTED IN
7	SQ. FT. SURF./SHELL <i>(GROSS)</i>		(GROSS) (EFF.)
8	PERFORMANCE OF ONE UNIT		
9	FLUID CIRCULATED	SHELL SIDE	TUBE SIDE
10	TOTAL FLUID ENTERING	<i>Working Fluid</i>	<i>Geo Fluid (Vapor)</i>
11	VAPOR	<i>2.5'00 X 10⁶ lb/hr</i>	<i>1.87 X 10⁵ lb/hr</i>
12	LIQUID		
13	STEAM		
14	NON-CONDENSABLES		
15	FLUID VAPORIZED OR CONDENSED		
16	STEAM CONDENSED		
17	DENSITY (IN/OUT)	<i>11.95 / 22.93 LB/FT³</i>	<i>2.47 / 56.37 LB/FT³</i>
18	VISCOSITY	<i>.0216 / .0495 cp</i>	<i>.0151 / .161 cp</i>
19	MOLECULAR WEIGHT		
20	SPECIFIC HEAT	<i>1.372 / 1.053 BTU/LB·F</i>	<i>.586 / 1.038 BTU/LB·F</i>
21	THERMAL CONDUCTIVITY	<i>.0272 / .0374 BTU/HR-FT·F</i>	<i>.0186 / .399 BTU/HR-FT·F</i>
22	ENTHALPY	BTU/LB	BTU/LB
23	TEMPERATURE IN	<i>278.9 °F</i>	<i>336.9 °F</i>
24	TEMPERATURE OUT	<i>326.9 °F</i>	<i>333.6 °F</i>
25	OPERATING PRESSURE	<i>675 PSIG</i>	<i>113.1 PSIG</i>
26	NO. PASSES PER SHELL	<i>1</i>	<i>1</i>
27	VELOCITY	<i>4.80 FT/SEC</i>	<i>29.37 FT/SEC</i>
28	PRESSURE DROP	<i>9.87 PSI</i>	<i>2.61 PSI</i>
29	FOULING RESISTANCE (MIN.)	<i>.0005</i>	<i>.001</i>
30	HEAT EXCHANGED-BTU/HR	<i>1.6449 X 10⁸</i>	MTD CORRECTED-°F <i>24.16</i>
31	TRANSFER RATE-SERVICE	<i>139.02</i>	CLEAN <i>300.42</i>
32	CONSTRUCTION OF ONE SHELL		
33	DESIGN PRESSURE	PSI	PSI
34	TEST PRESSURE	PSI	PSI
35	DESIGN TEMPERATURE	°F	°F
36	TUBES <i>Admiralty</i>	NO. <i>1513</i> O.D. <i>1.00</i> BWG <i>14</i> LENGTH <i>576</i>	PITCH <i>90°</i> <i>1.3120</i>
37	SHELL	I.D. <i>66"</i> O.D.	SHELL COVER (INTEG) (REMOV)
38	CHANNEL OR BONNET		CHANNEL COVER
39	TUBESHEET-STATIONARY		TUBESHEET-FLOATING
40	BAFFLES-CROSS	<i>8</i> TYPE <i>Segmental (RTI.W.)</i>	FLOATING HEAD COVER
41	BAFFLES-LONG	TYPE <i>(Cut 15.62% dia)</i>	IMPINGEMENT PROTECTION
42	TUBE SUPPORTS	<i>1 / baffle spacing</i>	
43	TUBE TO TUBESHEET JOINT		
44	GASKETS		
45	CONNECTIONS-SHELL SIDE	IN <i>35.3</i> OUT <i>35.3</i> RATING	
46	CHANNEL SIDE	IN <i>12.1</i> OUT <i>8.1</i> RATING	
47	CORROSION ALLOWANCE-SHELL SIDE		TUBE SIDE
48	CODE REQUIREMENTS		TEMA CLASS <i>R</i>
49	REMARKS - AVERAGE IF ONLY ONE VALUE GIVEN		
50	<i>** 90% (mass) Iso butane 10% n-hexane</i>		
51	<i>*** Low Fin Aout/Ain = 3.365</i>		
52			
53			
54			

TABLE 21

CONDENSER SPECIFICATION SHEET, 450°F RESOURCE

$$\frac{L}{D} = 6.25$$

1	CUSTOMER		MX - 20MWce - 450F		JOB NO.	
2	ADDRESS				REFERENCE NO.	ACX1/R3
3	PLANT LOCATION				PROPOSAL NO.	
4	SERVICE OF UNIT		Condenser - Horizontal 3/4" Tubes		DATE	
5	SIZE	96 x 600	TYPE	AEL	ITEM NO.	
6	(GROSS) (EFF)		(HORIZ.) (VERT.)		CONNECTED IN	
7	SQ. FT. SURF./UNIT		SHELLS/UNIT		SQ. FT. SURF./SHELL	
8	(GROSS) (EFF)		4		(GROSS) (EFF)	
9	198668		4		49667	
10	PERFORMANCE OF ONE UNIT					
11	FLUID CIRCULATED		SHELL SIDE		TUBE SIDE	
12	TOTAL FLUID ENTERING		Cooling Water		Working Fluid **	
13	VAPOR		4.928 x 10 ⁶ lb/hr		625 x 10 ³ lb/hr	
14	LIQUID					
15	STEAM					
16	NON-CONDENSABLES					
17	FLUID VAPORIZED OR CONDENSED					
18	STEAM CONDENSED					
19	DENSITY (IN/OUT) x		62.25 / 62.06		.472 / .3433	
20	VISCOSITY		.978 / .757		.00852 / .139	
21	MOLECULAR WEIGHT					
22	SPECIFIC HEAT		1.00 / 1.00		.464 / .563	
23	THERMAL CONDUCTIVITY		.355 / .361		.0125 / .0546	
24	LATENT HEAT					
25	TEMPERATURE IN		70 °F		145.1 °F	
26	TEMPERATURE OUT		91.7 °F		80.5 °F	
27	OPERATING PRESSURE		50 PSIG		51.4 PSIG	
28	NO. PASSES PER SHELL		1		1	
29	VELOCITY		1.66 FT/SEC		17.36 FT/SEC	
30	PRESSURE DROP		9.51 PSI		1.03 PSI	
31	FOULING RESISTANCE (MIN.)		.001		.0005	
32	HEAT EXCHANGED-BTU/HR		106.66 x 10 ⁶		MTD CORRECTED °F 12.64	
33	TRANSFER RATE-SERVICE		174.4		CLEAN 275.49	
34	CONSTRUCTION OF ONE SHELL					
35	DESIGN PRESSURE				PSI	
36	TEST PRESSURE				PSI	
37	DESIGN TEMPERATURE		TK		°F	
38	TUBES		NO. 5059 O.D. 0.750 BWG .049 LENGTH 600		PITCH 90° - 1.062	
39	SHELL		I.D. 76 O.D.		SHELL COVER (INTG) (REMOV)	
40	CHANNEL OR BONNET				CHANNEL COVER	
41	TUBESHEET-STATIONARY				TUBESHEET-FLOATING	
42	BAFFLES-CROSS 16		TYPE Seg. (NTIW)		FLOATING HEAD COVER	
43	BAFFLES-LONG		TYPE (15% Diam Cut)		IMPINGEMENT PROTECTION	
44	TUBE SUPPORTS		None			
45	TUBE TO TUBESHEET JOINT					
46	GASKETS					
47	CONNECTIONS-SHELL SIDE		IN 36		OUT 36	
48	CHANNEL SIDE		IN 36		OUT 12	
49	CORROSION ALLOWANCE-SHELL SIDE				TUBE SIDE	
50	CODE REQUIREMENTS				TEMA CLASS	
51	REMARKS * AVG. VALUE IF ONLY ONE GIVEN					
52	* 90% (mass) Isobutane 10% n-Heptane					
53	* & * Forc. Fin Internally Finned 16 Longitudinal Fins 0.067 in. high					
54	A ₁ fin / A ₁ plain = 1.91					

APPENDIX A

HX#1 RUN SUMMARY, 400⁰F RESOURCE

(Pages A-1 to A-4)

CARD 1 CONTROL INFORMATION

01	CIN	INPUT UNITS CODE	0.
02	COOT	OUTPUT UNITS CODE	0.
03	CCI	CALCULATION TYPE	1.*
04	CHS	FLUID ALLOCATION	2.
05	CHS	HEAT DUTY CODE	3.
06	ODUTY	HEAT DUTY(1.0E6)	0.00000
07	CTP	TUBE PASS CODE	0.
08	ZTPD	NO OF TUBE PASSES	1.
09	ZMSD	SHELLS IN SERIES	3.
10	ZMPD	SHELLS IN PARALLEL	1.*
11	CS1	SHELL CONSTRUCTION	1.*
12	CTRH	EXCHANGER TYPE	0.
13	CR1	REAR HEAD TYPE	1.
14	CR2	BAFFLE TYPE	4.
15	BCC	BAFFLE ORIENTATION	0.
16	GOUTS	TUBESIDE STEPWISE	1.
17			
18	GOMEX	SERIES STEP EVAL	0.
19	COPI	OUTPUT CODE	0.
20	CMON	MONITOR CODE	1.
21	CARR	AUTO REKATE CODE	0.

CARD 2 SHELLSIDE INFORMATION

01	CHSD	SEAL STRIP CODE	0.
02	CHSE	PAIRS OF STRIPS	0.
03	CHSAX	MAX SHELL SIZE	200.000
04	CHSMIN	MIN SHELL SIZE	0.000
05	CHMAX	MAX OVERALL COEF	0.00
06	KVD	SHR-V-SQUARED	1500.000*
07	CFIC	TUBE COUNT CODE	0.
08	CHT01	INLET HEIGHT	0.000
09	CHT02	OUTLET HEIGHT	0.000
10	SPHS1	INLET PENALTY	1.000*
11	SPHS2	OUTLET PENALTY	1.000*
12	CHNS	EQUAL LND SPACING	0.
13	CHNZ	NOZZLE ORIENTATION	0.
14	CF3	WINDOW CONSTRUCT	0.
15	DBCK	CLEARANCE CODE	0.
16	CLD	BAF-SHELL CLEAR	0.00000
17	CAU	TUBE-BAF CLEAR	0.00000
18	CDTLD	LUND-SHELL CLEAR	0.00000
19	GDDPS	SHELLSIDE UP USE	1.
20	CHSMX	MAX BAF SPACING	0.000
21	PMAX	TOTAL CP	0.00

CARD 3 SHELL, BUNDLE AND BAFFLE

01	CSO	SHELL ID	78.000
02	BCD	BAFFLE CUT (PCT)	0.00
03	FWNB	FRACT WINDOW AREA	0.000
04	HOVD	TUBE ROWS OVERLAP	0.00
05	ZCPD	NO OF CROSSPASSES	10.
06	XLHCD	CENTRAL BAF SPACE	0.0000
07	XLB1D	INLET BAF SPACING	0.0000
08	XLB2D	OUTLET BAF SPACE	0.0000
09	PPVN	NO VERT PASS LANE	0.
10	PPHN	NO HORZ PASS LANE	0.
11	WPPV	WIDTH VERT LANES	0.000
12	WPPH	WIDTH HORZ LANES	0.000
13	XLBD	BAFFLE THICKNESS	0.0000
14	XLBD1	TUBEHOLE BAF THIK	0.0000
15	GOFIT3	LONG BAFFLE CODE	0.
16	GODEL	DELTA LMTD CORR	0.
17	DUHNZ	MULTIPLE NOZ CODE	1.*
19	TEMA	TEMA SHELL STYLE	AEL*
20	CAXAL	TUBESIDE AXIAL NOZ	0.

CARD 4 TUBESIDE INFORMATION

01	TLOV	TUBE LENGTH	42.000
02	TLMAX	MAXIMUM LENGTH	48.000
03	TLINC	LENGTH INCREMENT	1.000
04	PT	TUBE PITCH	1.3120
05	TLA	LAYOUT ANGLE	90.
06	ZNTD	NO OF TUBE/S/SHELL	0.
07	DT0	TUBE OD	1.0000
08	TTB	TUBE THICKNESS	.0650
09	CMAT	TUBE MATERIAL CODE	41.
10	CTK	THERMAL CONDUCT	0.000
11	CFIN	FINNED TUBE CODE	1.
12	XNF	NO OF FINS/LENGTH	19.00
13	XFH	FIN HEIGHT	.0570
14	DFR	FIN ROOT DIAMETER	.8770
15	XLF	FIN THICKNESS	.0180
16	FARP	SURF AREA/LENGTH	.695
17	TRTH	THICKNESS UNDER FIN	.0440

*HOT FLUID NAME - CLOFLUID -**

CARD 5 PROCESS INFORMATION

01	FCO1	FLUID CONDITION	0.
02			
03	W01	FLOW RATE(1.0E3)	1584.00
04	TIND1	INLET TEMPERATURE	333.60
05	TOUT1	OUTLET TEMPERATURE	0.00
06	P11	INLET PRESSURE	111.10
07	RFD1	FOUL RESISTANCE	.00100
08	FL1	FOUL LAYER THICK	0.00000
09	HC1	HEAT TRANS COEF	0.00
10	SF1	SAFETY FACTOR	1.000*
11	YIN1	INLET VAPOR QUAL	0.000
12	YEX1	EXIT VAPOR QUALITY	0.000
13	TS11	COND DEG SUP HEAT	0.00
14	TSC1	COND DEG SUB COOL	0.00

*COLD FLUID NAME - ISOR+NHX -**

CARD 6 PROCESS INFORMATION

01	FCO2	FLUID CONDITION	0.
02			
03	W02	FLOW RATE(1.0E3)	2334.00
04	TIND2	INLET TEMPERATURE	90.60
05	TOUT2	OUTLET TEMPERATURE	298.90
06	P12	INLET PRESSURE	680.00
07	RFD2	FOUL RESISTANCE	.00050
08	FL2	FOUL LAYER THICK	0.00000
09	HC2	HEAT TRANS COEF	0.00
10	SF2	SAFETY FACTOR	1.000*
11	YIN2	INLET VAPOR QUAL	0.000
12	YEX2	EXIT VAPOR QUALITY	0.000
13	TS12	BOIL DEG SUP HEAT	0.00
14	TSC2	BOIL DEG SUB COOL	0.00

CARD 5 TUBESHEET AND VIBRATION

01	TS1D	TUBESHEET THICK	0.0000
02	CS2	EXP JOINT CODE	0.
03	CS3	DOUBLE TUBESHEET	0.
04	STRES	ALLOWABLE STRESS	0.00
05	CVIB	VIBRATION CODE	1.
06	EMOD	ELASTIC MODULUS	0.000
07	DMAT	TUBE DENSITY	0.00
10	RE1	.0300*	11 KE2 2.5604*
12	CJ1	0.	13 CJ2 0.
14	CF1	2.6791*	15 CF2 1.0000*

CARD 7 MAXIMUM DP AND VELOCITY

01	PM1	ALLOWABLE DP	5.00
02	VM1	MAXIMUM VELOCITY	0.00
03	PM2	MAX NOZZLE DP(PCT)	0.00
04	DNZ11	INLET NOZZLE ID	0.000
05	DNZ12	OUTLET NOZZLE ID	0.000
06	PD1	DESIGN PRESSURE	0.00
07			
08	VMIN1	MINIMUM VELOCITY	0.00

CARD 9 MAXIMUM DP AND VELOCITY

01	PM2	ALLOWABLE DP	15.00
02	VM2	MAXIMUM VELOCITY	0.00
03	PM2	MAX NOZZLE DP(PCT)	0.00
04	DNZ12	INLET NOZZLE ID	0.000
05	DNZ22	OUTLET NOZZLE ID	0.000
06	PD2	DESIGN PRESSURE	0.00
07			
08	VMIN2	MINIMUM VELOCITY	0.00
09	F12	PH	0.0
10	F22	TOTAL ALKALINITY	0.
11	F32	CALCIUM HARDNESS	0.
12	F42	TOT DISSOLVED SOLID	0.

** A * INDICATES **
 ** A DEFAULT VALUE **

HOT FLUID (GEOLUID) PHYSICAL PROPERTIES

COMPONENT 1
 NAME GEOLUID

CARD 10 PHYSICAL PROPERTY CONTROL

03 HMMN 0.0000
 04 APC 1.
 05 API 0.00
 06 AMW 0.00
 07 HCF 0.00
 08 PZERO 0.

CALCULATED PHYSICAL PROPERTY CONSTANTS

D.B. NAME WATER
 MOL FRACT 1.0000
 WT. FRACT 1.0000
 MOL WT. 18.02
 CRIT TEMP 1165.20
 CRIT PRES 3208.20
 TEMPERATURE LIMITS
 UPPER 1165.20
 LOWER 494.69

CALCULATED MIXTURE VALUES

MOLECULAR WEIGHT 18.02
 CRITICAL VALUES-TEMPERATURE 1165.20 PRESSURE 3208.20
 TEMPERATURE LIMITS-UPPER 1165.20 LOWER 494.69

COLD FLUID (ISOBUTANE) PHYSICAL PROPERTIES PROFILE

40 PXP	ISOBARS	(K=1)	670.000	(K=2)	660.000							
FPC		0.00	0.00	0.00	0.00							
	(K)	1=1	1=2	1=3	1=4	1=5	1=6	1=7	1=8	1=9	1=10	
41 TXP	1	330.00	320.00	310.00	300.00	280.00	250.00	220.00	180.00	140.00	80.00	
	2	330.00	320.00	310.00	300.00	280.00	250.00	220.00	180.00	140.00	80.00	
43 YXP												
44 ROVP												
45 XMUVP												
46 XKVP												
47 HVXP												
48 CPVP												
50 ROLP	1	11.2900	13.4070	16.1400	19.0790	23.2490	26.5230	28.6410	30.7780	32.5290	34.7920	
	2	11.7550	13.8950	16.5880	19.3910	23.3590	26.5660	28.6660	30.7930	32.5390	34.7980	
51 XMULP	1	.0201	.0251	.0338	.0403	.0502	.0627	.0745	.0914	.1110	.1489	
	2	.0207	.0267	.0347	.0409	.0505	.0629	.0747	.0916	.1111	.1491	
52 XKLP	1	.0265	.0289	.0325	.0347	.0376	.0408	.0434	.0467	.0503	.0565	
	2	.0270	.0296	.0328	.0349	.0378	.0409	.0434	.0467	.0503	.0566	
53 HLXP	1	211.5700	197.3300	181.8900	166.6100	142.3200	115.7500	93.3300	66.4100	41.5700	6.9900	
	2	209.7100	195.6300	180.4600	165.6800	142.0300	115.6600	93.3100	66.4100	41.5800	7.0200	
54 CPLP	1	1.3114	1.5088	1.5687	1.4505	1.0211	.7957	.7082	.6436	.6008	.5544	
	2	1.3288	1.4868	1.5243	1.3989	1.0062	.7927	.7071	.6431	.6005	.5543	
55 SIGP												
56 PCLP												

** CARD 42 (QXF) AND CARD 49 (PCVP) ARE NOT USED IN THE ST-4 PROGRAM **

HTRI SHELL AND TUBE HEAT EXCHANGER PROGRAM 51-4

FINAL RESULTS PROBLEM DESCRIPTION-NA STUDY

DESIGN CASE COUNTERCURRENT FLOW IN A T.T.W. ALL SHELL WITH H.T.T.W. BUNDLE

HTRI VERSION

PAGE NO- 22

CASE-HX1/R16

ALT. SOLN.- 3

*** PROCESS DATA ***

01 FLUID NAME COLD SHELLSIDE HOT TUBESIDE
02 FLUID CONDITION SENS. LIQUID SENS. LIQUID
03 TOTAL FLOW RATE (1.0E+3) (LL/HK) 2334.000 1584.000

04 TEMPERATURE, IN/OUT (DEG F) 90.6 / 298.9 333.6 / 116.7
05 TEMPERATURE, AVERAGE/SKIN (DEG F) 194.8 / 201.4 222.1 / 209.0
06 PRESSURE, INLET/AVERAGE (PSIA) 680.00 / 672.50 111.10 / 108.60

07 PRESSURE DROP, TOTAL/ALLOW (PSI) 13.69 / 15.00 .767 / 5.00
08 VELOCITY, CALC./MAX.ALLOW (FT/SEC) 1.68 / 0.00 1.01 / 0.00

09 FILM COEF (SAFE FACT) (BTU/HR-FT²-F) 275.08 (1.00) 468.88 (1.00)
10 FOULING RESISTANCE (HR-FT²-F/BTU) .00050 .00100

11 DENSITY (LB/FT³) 29.9947 59.6088
12 THERMAL CONDUCTIVITY (BTU/HR-FT-F) .0455 .3854
13 SPECIFIC HEAT CAPACITY (BTU/LB-F) .6672 1.0040
14 VISCOSITY AT AVERAGE TEMP (CP) .08523 .26793
15 VISCOSITY AT SKIN TEMP (CP) .08243 .28699

*** OVERALL PERFORMANCE DATA *** (TUBESIDE STEPWISE)
16 TOTAL HEAT DUTY REQUIRED (1.0E+6) (BTU/HK) 356.158714
17 EFFECTIVE MTD, (LMTD)(F)(DELTA) = (DEG F) 26.73(1.00)(1.00) = 26.7
18 F FACTOR=(TUBE)(BAFFLES)(F/G)(HOT/COLD)=(1.000)(1.000)(1.000)(1.000)
19 OVERALL COEF, REQ/D/CLAN/ACTUAL (BTU/HR-FT²-F) 66.33 / 89.99 / 66.77

*** CONSTRUCTION INFORMATION ***

20 NO. SHELLS SERIES 3 PARALLEL 1 TOTAL SURFACE AREA (FT²) 201446
21 NO. PASSES SHELL 1 TUBE 1 EFF. SURF. AREA (FT²/SHELL) 66948.5
22 SHELL I.D. (IN) 78.000 TLMA SHELL TYPE E KIRAR HEAD FATS

23 BAFFLE TYPE VERT N.T.T.W. NO. CROSSPASSES/SHELL PASS 10
24 CENTRAL SPACING (IN) 53.600 BAFFLE CUT (PCT. DIA) 15.00
25 INLET SPACING (IN) 53.600 CUT AREA (PCT) 14.4 2) 0.0 3) 0.0
26 OUTLET SPACING (IN) 53.600 CUT HEIGHT FROM CENTER LINE (IN) 0.0
27 BAFFLE THICKNESS (IN) .750 PWS-1) 27.3 2) 0.0 3) 0.0

28 NO. PAIRS SEAL DEVICES 0 IMPINGEMENT PLATE INCLUDED NO
29 TOT. TUBESHEET THICK. (IN) 4.0 PERCENT TUBES REMOVED (BOTH) 18.440

30 TUBE TYPE (FINS/IN) 19 TUBECOUNT PER SHELL 2157
31 OVERALL LENGTH (FT) 42.000 TUBE PITCH (IN) 1.3120
32 EFFECTIVE LENGTH (FT) 44.667 OUTSIDE DIAMETER (IN) 1.600
33 LAYOUT ANGLE (DEG) 90 INSIDE DIAMETER (IN) .789
34 PITCH RATIO 1.432 SURFACE AREA RATIO (OUT/IN) 3.365
35 FIN TUBE EQ. DIA. (IN) .916 FIN EQ. DIA. CONDENSING (IN) 0.0000
36 WEIGHT ESTIMATION (LB/SHELL) DRY 102059 WET 209738

*** SHELLSIDE PERFORMANCE ***

01 NOM. VEL, X-FLOW/WINDOW 2.47 / 6.93
02 FILM COEF, X-FLOW/WINDOW 299.57 / 0.0
03 FLOW FRACTIONS FOR HEAT TRANSFER .733
04 A = .195 B = .664 C = .034 E = .106 F = 0.000

*** SHELLSIDE HEAT TRANSFER CORRECTIONS ***
05 TOTAL BETA GAMA END FIN
06 .920 .920 1.000 .998 1.000

*** PRESSURE DROPS *** (PERCENT TOTAL D/P)
07 WIND 32.51 NOZZLE SHELL 3.07 / 7.44
08 END 11.16 (IN/OUT) TUBE 26.69 / 15.51

*** H.T. PARAMETERS *** SHELL TUBE
09 WALL CORRECTION 1.005 .989
10 PRANDTL NO. 3.0 1.7
11 AVERAGE REYNOLDS NO. 82794 21962
12 BUNDLE INLET REYNOLDS NO. 49564 36606
13 BUNDLE OUTLET REYNOLDS NO. 173908 9349
14 FOULING LAYER (IN) 0.00000 0.00000

*** THERMAL RESISTANCES *** (PCT. OVERALL)
15 SHELL TUBE FOULING METAL OVER DES
16 24.27 47.91 25.80 2.008 .658
17 TOTAL FOULING RESISTANCE .003865
18 DIFFERENTIAL RESISTANCE .000099

*** SHELL NOZZLE INFO. *** INLET OUTLET
19 INSIDE DIAMETER (IN) 25.3 23.3
20 VELOCITY (FT/SEC) 5.42 11.48
21 DENSITY (LB/FT³) 34.399 19.158
22 NOZZLE R-V-SO (LB/FT-S2) 1011 2524
23 BUNDLE R-V-SO (LB/FT-S2) 256 540
24 HEIGHT UNDER NOZZLE (IN) 11.7 11.7

*** TUBE NOZZLE INFO. *** INLET OUTLET
25 INSIDE DIAMETER (IN) 21.3 21.3
26 VELOCITY (FT/SEC) 3.17 2.89
27 DENSITY (LB/FT³) 56.368 61.735

*** DIAMETRAL CLEARANCES ***
28 BAFFLE-TO-SHELL (IN) .3433
29 BUNDLE-TO-SHELL (IN) .8750
30 TUBE-TO-BAFFLEHOLE (IN) .0246
31 MULTI-SEG. BAFFLE OVERLAP (IN) 0.000
32 FIN EFFICIENCY = .956 FIN RESIST. = .00015

HTRI ST-4 MOD. 5.1		HTRI VERSION		PAGE NO- 24	
PROBLEM DESCRIPTION-MX STUDY		-		CASE-HX1/116	
FLOW INDUCED VIBRATION ANALYSIS		SENS. LIQUID SHELL SIDE			
01 LOG DECREMENT .0000 AXIAL STRESS LOADING		0.0 (KPSI)			
02 BETA 2.679 ADDED MASS FACTOR 2.5604		POSITION IN BUNDLE			
03 LENGTH FOR NATURAL FREQUENCY (FT)		INLET	CENTER	OUTLET	
04 LENGTH/TEMA MAXIMUM SPAN (---)		4.467	4.467	4.467	
05 NUMBER OF SPANS (---)		1.020	1.020	1.020	
06 NATURAL FREQUENCY(FTUBE) (HZ)		10	10	10	
07		13.98*	14.27	15.05	
FLOW VELOCITIES					
08 WINDOW (PARALLEL FLOW) (FT/SEC)		4.86	5.57	8.72	
09					
10 C-STREAM VELOCITY (FT/SEC)		2.02	2.32	3.64	
11 E-STREAM VELOCITY (FT/SEC)		9.18	10.53	16.49	
12					
13 CROSSFLOW VELOCITY (FT/SEC)		1.64	1.88	2.94	
14 CRITICAL VELOCITY (FT/SEC)		1.21	1.30	1.63	
15 CROSSFLOW REYNOLDS NUMBER (---)		44877.	74965.	157464.	
16 CROSSFLOW RHO-V-SQ (LB/FT-S2)		92.	105.	165.	
17 FREQUENCY RATIOS (FVXSD)/(FTUBE) (---)		.478	.548	.858	
18					
19					
20					
DAMAGE NUMBERS					
21 BAFFLE (---)		.0228	.0261	.0409	
22 COLLISION (---)		.0272	.0312	.0488	
23 RHO/SQRT(MU)(SEE STV-1, FIG 9-6)		58.6026	66.0438	61.1361	
VIBRATION AMPLITUDES					
24					
25 CROSSFLOW-INDUCED (IN)		.01607	.01999	.06112	
BUNDLE PARAMETERS AT NOZZLES		ENTRANCE		EXIT	
26 IMPINGEMENT PLATE		NO			
27 FLOW AREA (FT2)		6.9134		6.3722	
28 VELOCITY (FT/SEC)		2.73		5.31	
29 RHO-V-SQ (LB/FT-S2)		256.		540.	
30 TEMA E SHELL WITH		VERT N.T.I.W. BAFFLES AND EXTS BUNDLE			
31 NUMBER OF INTERMEDIATE SUPPORT PLATES PER SPAN		0			
32 FINNED ADMIRALTY TUBES		1.0000 DIAMETER (IN)		90 DEGREE LAYOUT	
33 PITCH RATIO		1.432			
* FREQUENCY RATIOS ARE BASED ON THE LOWEST NATURAL FREQUENCY					

APPENDIX B

HX#2 RUN SUMMARY, 400⁰F RESOURCE

(Pages B-1 to B-4)

CARD 1 CONTROL INFORMATION				*CARD 2* SHELLSIDE INFORMATION				*CARD 3* SHELL, BUNDLE AND BAFFLE			
01	CIN	INPUT UNITS CODE	0.	01	CNSD	SEAL STRIP CODE	0.	01	DSD	SHELL ID	0.000
02	COUT	OUTPUT UNITS CODE	0.	02	ZNSD	PAIRS OF STRIPS	0.	02	BCD	BAFFLE CUT (PCT)	0.00
03	CCI	CALCULATION TYPE	1.*	03	DSMAX	MAX SHELL SIZE	200.000	03	FNWB	FRACT WINDOW AREA	0.000
04	CHS	FLUID ALLOCATION	2.	04	DSMIN	MIN SHELL SIZE	0.000	04	HOVD	TUBE PDWS OVERLAP	0.00
05	CHH	HEAT DUTY CODE	3.	05	UMAX	MAX OVERALL COEF	0.00	05	ZCPD	NO OF CROSSPASSES	0.
06	QDUTY	HEAT DUTY (1.0E6)	0.00000	06	RVD	RHO-V-SQUARED	1500.000*	06	XLBCD	CENTRAL BAF SPACE	0.0000
07	CTP	TUBE PASS CODE	0.	07	CFTC	TUBECOUNT CODE	0.	07	XLB1D	INLET BAF SPACING	0.0000
08	ZTPD	NO OF TUBE PASSES	1.	08	HNT01	INLET HEIGHT	0.000	08	XLB2D	OUTLET BAF SPACE	0.0000
09	ZMSD	SHELLS IN SERIES	6.	09	HNT02	OUTLET HEIGHT	0.000	09	PPVN	NO VERT PASS LANE	0.
10	ZMPD	SHELLS IN PARALLEL	1.*	10	SFHS1	INLET PENALTY	1.000*	10	PPHN	NO HORZ PASS LANE	0.
11	CS1	SHELL CONSTRUCTION	1.*	11	SFHS2	OUTLET PENALTY	1.000*	11	WPPV	WIDTH VERT LANES	0.000
12	CTBH	EXCHANGER TYPE	0.	12	CEBS	EQUAL END SPACING	0.	12	WPPH	WIDTH HORZ LANES	0.000
13	CB1	REAR HEAD TYPE	1.	13	CNOZ	NOZZLE ORIENTATION	0.	13	XLBO	BAFFLE THICKNESS	0.0000
14	CB2	BAFFLE TYPE	1.*	14	CB3	WINDOW CONSTRUCT	0.	14	XLBD	TUBEHOLE BAF THIK	0.0000
15	BCC	BAFFLE ORIENTATION	0.	15	DBDK	CLEARANCE CODE	0.	15	GOFT3	LONG BAFFLE CODE	0.
16	GUOTS	TUBESIDE STEPWISE	1.	16	CEB	BAF-SHELL CLEAR	0.0000	16	GOEL	DELTA LMTD CORR	0.
17				17	CAD	TUBE-BAF CLEAR	0.0000	17	DUBNZ	MULTIPLE NOZ CODE	1.*
18	GOMEX	SERIES STEP EVAL	0.	18	COTLD	BUND-SHELL CLEAR	0.0000	18			
19	COP1	OUTPUT CODE	0.	19	GOBPS	SHELLSIDE DP USE	1.	19	TEMA	TEMA SHELL STYLE	AEL*
20	CMON	MONITOR CODE	1.	20	CBSMX	MAX BAF SPACING	0.000	20	CAXAL	TUBESIDE AXIAL NOZ	0.
21	CARR	AUTO RERATE CODE	0.	21	PMAX	TOTAL DP	0.00				

CARD 4 TUBESIDE INFORMATION				**HOT FLUID NAME -GEOFLUID **				**COLD FLUID NAME -ISO8+NHX **			
01	TLUV	TUBE LENGTH	22.000	01	FCON1	PROCESS INFORMATION	0.	01	FCON2	PROCESS INFORMATION	0.
02	ILMAX	MAXIMUM LENGTH	34.000	02				02			
03	TLINC	LENGTH INCREMENT	2.000	03	WD1	FLOW RATE (1.0E3)	121.00	03	WD2	FLOW RATE (1.0E3)	179.00
04	PT	TUBE PITCH	1.3120	04	TIND1	INLET TEMPERATURE	333.60	04	TIND2	INLET TEMPERATURE	90.60
05	TLA	LAYOUT ANGLE	90.	05	TOUT1	OUTLET TEMPERATURE	0.00	05	TOUT2	OUTLET TEMPERATURE	298.90
06	ZNTD	NO OF TUBES/SHELL	0.	06	P11	INLET PRESSURE	111.10	06	P12	INLET PRESSURE	680.00
07	DTO	TUBE OD	1.0000	07	RFD1	FOUL RESISTANCE	.00100	07	RFD2	FOUL RESISTANCE	.00050
08	TTB	TUBE THICKNESS	.0650	08	FL1	FOUL LAYER THICK	0.0000	08	FL2	FOUL LAYER THICK	0.0000
09	CMAT	TUBE MATERIAL CODE	41.	09	HC1	HEAT TRANS COEF	0.00	09	HC2	HEAT TRANS COEF	0.00
10	CTK	THERMAL CONDUCT	0.000	10	SF1	SAFETY FACTOR	1.000*	10	SF2	SAFETY FACTOR	1.000*
11	CFIN	FINNED TUBE CODE	1.	11	YIN1	INLET VAPOR QUAL	0.000	11	YIN2	INLET VAPOR QUAL	0.000
12	XNF	NO OF FINS/LENGTH	19.00	12	YEX1	EXIT VAPOR QUALITY	0.000	12	YEX2	EXIT VAPOR QUALITY	0.000
13	XFH	FIN HEIGHT	.0570	13	TSH1	COND DEG SUP HEAT	0.00	13	TSH2	BOIL DEG SUP HEAT	0.00
14	DFR	FIN ROOT DIAMETER	.8770	14	TSC1	COND DEG SUB COOL	0.00	14	TSC2	BOIL DEG SUB COOL	0.00
15	XLF	FIN THICKNESS	.0180								
16	FARP	SURF AREA/LENGTH	.695								
17	TRTH	THICKNESS UNDER FIN	.0440								

CARD 5 TUBESHEET AND VIBRATION				*CARD 7* MAXIMUM DP AND VELOCITY				*CARD 9* MAXIMUM DP AND VELOCITY			
01	TS10	TUBESHEET THICK	0.0000	01	PM1	ALLOWABLE DP	5.00	01	PH2	ALLOWABLE DP	15.00
02	CS2	EXP JOINT CODE	0.	02	VM1	MAXIMUM VELOCITY	0.00	02	VM2	MAXIMUM VELOCITY	0.00
03	CS3	DOUBLE TUBESHEET	0.	03	PNM1	MAX NOZZLE DP (PCT)	0.00	03	PNM2	MAX NOZZLE DP (PCT)	0.00
04	STRES	ALLOWABLE STRESS	0.00	04	DNZ11	INLET NOZZLE ID	0.000	04	DNZ12	INLET NOZZLE ID	0.000
05	CVIB	VIBRATION CODE	1.	05	DNZ21	OUTLET NOZZLE ID	0.000	05	DNZ22	OUTLET NOZZLE ID	0.000
06	EMOD	ELASTIC MODULUS	0.000	06	PD1	DESIGN PRESSURE	0.00	06	PD2	DESIGN PRESSURE	0.00
07	DMAT	TUBE DENSITY	0.00	07				07			
10	REL1	.0300*	11 RE2	08	VMIN1	MINIMUM VELOCITY	0.00	08	VMIN2	MINIMUM VELOCITY	0.00
12	CJ1	0.	13 CJ2	09	F12	PH	0.0	09	F12	PH	0.0
14	CF1	2.6791*	15 CF2	10	F22	TOTAL ALKALINITY	0.	10	F22	TOTAL ALKALINITY	0.
				11	F32	CALCIUM HARDNESS	0.	11	F32	CALCIUM HARDNESS	0.
								12	F42	TOT DISSOLVED SOLID	0.

** A * INDICATES **

** A DEFAULT VALUE **

** A * INDICATES **
 ** A DEFAULT VALUE **

HOT FLUID (GEOFLUID) PHYSICAL PROPERTIES

COMPONENT 1
 NAME GEOFLUID

CARD 10 PHYSICAL PROPERTY CONTROL

03 HMMN 0.0000
 04 APC 1.
 05 API 0.00
 06 AMW 0.00
 07 HCF 0.00
 08 PZERD 0.

CALCULATED PHYSICAL PROPERTY CONSTANTS

D.B. NAME WATER
 MOL FRACT 1.0000
 WT. FRACT 1.0000
 MOL WT. 18.02
 CRIT TEMP 1165.20
 CRIT PRES 3208.20
 TEMPERATURE LIMITS
 UPPER 1165.20
 LOWER 494.69

CALCULATED MIXTURE VALUES

MOLECULAR WEIGHT 18.02
 CRITICAL VALUES-TEMPERATURE 1165.20 PRESSURE 3208.20
 TEMPERATURE LIMITS-UPPER 1165.20 LOWER 494.69

COLD FLUID (ISOB+NHX) PHYSICAL PROPERTIES PROFILE

40 PXP FPC	ISOBARS	(K=1) 0.00	670.000 0.00	(K=2) 0.00	680.000 0.00						
41 TXP	(K)	I=1	I=2	I=3	I=4	I=5	I=6	I=7	I=8	I=9	I=10
	1	330.00	320.00	310.00	300.00	280.00	250.00	220.00	180.00	140.00	80.00
	2	330.00	320.00	310.00	300.00	280.00	250.00	220.00	180.00	140.00	80.00
43 YXP											
44 ROVP											
45 XMVVP											
46 XKVP											
47 HVXP											
48 CPVP											
50 ROLP	1	11.2900	13.4070	16.1400	19.0790	23.2490	26.5230	28.6410	30.7780	32.5290	34.7920
	2	11.7550	13.8950	16.5080	19.3910	23.3590	26.5660	28.6660	30.7930	32.5390	34.7980
51 XMULP	1	.0201	.0251	.0338	.0403	.0502	.0627	.0745	.0914	.1110	.1489
	2	.0209	.0267	.0347	.0409	.0505	.0629	.0747	.0916	.1111	.1491
52 XKLP	1	.0265	.0289	.0325	.0347	.0376	.0408	.0434	.0467	.0503	.0565
	2	.0270	.0296	.0328	.0349	.0378	.0409	.0434	.0467	.0503	.0566
53 HLXP	1	211.5700	197.3300	181.8900	166.6100	142.3200	115.7500	93.3300	66.4100	41.5700	6.9900
	2	209.7100	193.6300	180.4600	165.6800	142.0300	115.6600	93.3100	66.4100	41.5800	7.0200
54 CPLP	1	1.3114	1.5088	1.5687	1.4505	1.0211	.7957	.7082	.6436	.6008	.5544
	2	1.3288	1.4868	1.5243	1.3989	1.0062	.7927	.7071	.6431	.6005	.5543
55 SIGP											
56 PCIP											

** CARD 42 (QXF) AND CARD 49 (PCVP) ARE NOT USED IN THE ST-4 PROGRAM **

HTRI SHELL AND TUBE HEAT EXCHANGER PROGRAM ST-4 MOD 5.2
 FINAL RESULTS PROBLEM DESCRIPTION-MX STUDY
 DESIGN CASE COUNTERCURRENT FLOW IN A T.E.M.A. AEL SHELL WITH

HTRI VERSION
 SEGMENTAL BAFFLES

PAGE NO- 22
 CASE-HX2/R13
 ALT. SOLN.- 3

**** PROCESS DATA ****

	COLD SHELLSIDE	HOT TUBESIDE
01 FLUID NAME	ISOBUTANE	GEOLUID
02 FLUID CONDITION	SENS. LIQUID	SENS. LIQUID
03 TOTAL FLOW RATE (1.0E+3)(LB/HR)	179.000	121.000
04 TEMPERATURE, IN/OUT (DEG F)	90.6 / 298.9	333.6 / 109.8*
05 TEMPERATURE, AVERAGE/SKIN (DEG F)	194.8 / 200.5	221.7 / 209.6
06 PRESSURE, INLET/AVERAGE (PSIA)	680.00 / 672.50	111.10 / 108.60
07 PRESSURE DROP, TOTAL/ALLOW (PSI)	13.92 / 15.00	1.27 / 5.00
08 VELOCITY, CALC./MAX.ALLOW (FT/SEC)	1.90 / 0.00	1.47 / 0.00
09 FILM COEF (SAF.FACT) (BTU/HR-FT ² -F)	376.64 (1.00)	609.24 (1.00)
10 FOULING RESISTANCE (HR-FT ² -F/BTU)	.00050	.00100
11 DENSITY (LB/FT ³)	29.9947	59.6193
12 THERMAL CONDUCTIVITY (BTU/HR-FT-F)	.0455	.3853
13 SPECIFIC HEAT CAPACITY (BTU/LB-F)	.6672	1.0040
14 VISCOSITY AT AVERAGE TEMP (CP)	.08523	.26865
15 VISCOSITY AT SKIN TEMP (CP)	.08279	.28799
16 TOTAL HEAT DUTY REQUIRED (1.0E+6)(BTU/HR)		27.314657
17 EFFECTIVE MTD, (LMTD)(F)(DELTA) = (DEG F)	26.18(1.00)(1.00)	26.2
18 F FACTOR=(TUBE)(BAFFLES)(F/G)(HOT/COLD)=(1.000)(1.000)(1.000)(1.000)		
19 OVERALL COEF, REGD/CLEAN/ACTUAL(BTU/HR-FT ² -F)	79.92 / 117.96 /	81.02

**** OVERALL PERFORMANCE DATA **** (TUBESIDE STEPWISE)

**** CONSTRUCTION INFORMATION ****

	INFORMATION
20 NO. SHELLS SERIES 6 PARALLEL 1	TOTAL SURFACE AREA (FT ²) 13109
21 NO. PASSES SHELL 1 TUBE	EFF. SURF. AREA (FT ² /SHELL) 2176.4
22 SHELL I.D. (IN) 17.250	TEMA SHELL TYPE E REAR HEAD FXTS
23 BAFFLE TYPE VERT SEGMENTAL	NO. CROSSPASSES/SHELL PASS 14
24 CENTRAL SPACING (IN) 23.754	BAFFLE CUT (PCT. DIA) 31.74
25 INLET SPACING (IN) 23.754	CUT AREA(PCT) 1) 28.5 2) 0.0 3) 0.0
26 OUTLET SPACING (IN) 23.754	CUT HEIGHT FROM CENTER LINE (IN)
27 BAFFLE THICKNESS (IN) .375	PQS-1) 3.1 2) 0.0 3) 0.0
28 NO. PAIRS SEAL DEVICES 1	IMPINGEMENT PLATE INCLUDED NO
29 TOT.TUBESHEET THICK.(IN) 3.5	PERCENT TUBES REMOVED (NONE) 0.000
30 TUBE TYPE (FINS/IN) 19	TUBECOUNT PER SHELL 113
31 OVERALL LENGTH (FT) 28.060	TUBE PITCH (IN) 1.3120
32 EFFECTIVE LENGTH (FT) 27.713	OUTSIDE DIAMETER (IN) 1.000
33 LAYOUT ANGLE (DEG) 90	INSIDE DIAMETER (IN) .789
34 PITCH RATIO 1.432	SURFACE AREA RATIO (OUT/IN) 3.365
35 FIN TUBE EQ. DIA. (IN) .916	FIN EQ.DIA. CONDENSING (IN) 0.0000
36 WEIGHT ESTIMATION (LB/SHELL)	DRY 4290 WET 7292

**** SHELLSIDE PERFORMANCE ****

01 NOM. VEL, X-FLOW/WINDOW	1.94 /	5.72
02 FILM COEF, X-FLOW/WINDOW	296.6 /	537.9
03 FLOW FRACTIONS FOR HEAT TRANSFER	.925	
04 A = .038 B = .860 C = .059 E = .043 F = 0.000		
**** SHELLSIDE HEAT TRANSFER CORRECTIONS ****		
05 TOTAL BETA GAMA END FIN		
06 .920 .920 1.000 .978 1.000		
**** PRESSURE DROPS **** (PERCENT TOTAL DP)		
07 WIND 72.26 NOZZLE SHELL 4.42 / 3.94		
08 END 2.88 (IN/OUT) TUBE 8.88 / 5.16		
**** H.T. PARAMETERS ****		
09 WALL CORRECTION SHELL TUBE	1.004 .990	
10 PRANDTL NO. 3.0 1.7		
11 AVERAGE REYNOLDS NO. 81553 31939		
12 BUNDLE INLET REYNOLDS NO. 48821 53377		
13 BUNDLE OUTLET REYNOLDS NO. 171303 13524		
14 FOULING LAYER (IN) 0.00000 0.00000		
**** THERMAL RESISTANCES **** (PCT. OVERALL)		
15 SHELL TUBE FOULING METAL OVER DES		
16 21.51 44.75 31.31 2.430 1.380		
17 TOTAL FOULING RESISTANCE .003865		
18 DIFFERENTIAL RESISTANCE .000170		

**** SHELL NOZZLE INFO. ****

	INLET	OUTLET
19 INSIDE DIAMETER (IN)	10.2	12.1
20 VELOCITY (FT/SEC)	2.55	3.26
21 DENSITY (LB/FT ³)	34.399	19.158
22 NOZZLE R-V-SQ (LB/FT-SQ)	224	203
23 BUNDLE R-V-SQ (LB/FT-SQ)	1318	1257
24 HEIGHT UNDER NOZZLE (IN)	.3	.3
**** TUBE NOZZLE INFO. ****		
25 INSIDE DIAMETER (IN)	8.1	8.1
26 VELOCITY (FT/SEC)	1.68	1.53
27 DENSITY (LB/FT ³)	56.368	61.748

**** DIAMETRAL CLEARANCES ****

28 BAFFLE-TO-SHELL (IN)	.1229
29 BUNDLE-TO-SHELL (IN)	.5000
30 TUBE-TO-BAFFLEHOLE (IN)	.0246
31 MULTI-SEG. BAFFLE OVERLAP (IN)	0.000
32 FIN EFFICIENCY = .943 FIN RESIST. = .00013	

HTRI ST-4 MOD 5.2		HTRI VERSION		PAGE NO- 23	
PROBLEM DESCRIPTION-MX STUDY		-		CASE-HX2/R13	
FLOW INDUCED VIBRATION ANALYSIS			SENS. LIQUID SHELLSIDE		
01 LOG DECREMENT .0300 AXIAL STRESS LOADING			0.0 (KPST)		
02 BETA 2.679 ADDED MASS FACTOR 2.5604			POSITION IN BUNDLE		
			INLET	CENTER	OUTLET
03	LENGTH FOR NATURAL FREQUENCY (FT)		3.959	3.959	3.959
04	LENGTH/TEMA MAXIMUM SPAN (---)		.904	.904	.904
05	NUMBER OF SPANS (---)		7	7	7
06	NATURAL FREQUENCY (FT/LBE) (HZ)		18.15*	18.52	19.53
07 FLOW VELOCITIES					
08	WINDOW (PARALLEL FLOW) (FT/SEC)		4.79	5.50	8.61
09	WINDOW (CROSSFLOW) (FT/SEC)		.63	.73	1.14
10	C-STREAM VELOCITY (FT/SEC)		1.05	1.21	1.89
11	E-STREAM VELOCITY (FT/SEC)		4.32	4.96	7.76
12					
13	CROSSFLOW VELOCITY (FT/SEC)		1.65	1.90	2.97
14	CRITICAL VELOCITY (FT/SEC)		1.58	1.69	2.11
15	CROSSFLOW REYNOLDS NUMBER (---)		45349.	75753.	159120.
16	CROSSFLOW RHO-V-SQ (LB/FT-SQ)		94.	108.	169.
FREQUENCY RATIOS					
17	(FVXSD)/(FTUBE) (---)		.142	.163	.255
18					
19					
20					
DAMAGE NUMBERS					
21	BAFFLE (---)		.0366	.0420	.0657
22	COLLISION (---)		.0171	.0196	.0307
23	RHO/SQRT(MU) (SEE STV-1, FIG 9-6)		58.6026	66.0438	61.1361
VIBRATION AMPLITUDES					
24	PARALLEL FLOW (IN)		.001740	.001996	.003126
25	CROSSFLOW-INDUCED (IN)		.00798	.00920	.01488
BUNDLE PARAMETERS AT NOZZLES			ENTRANCE	EXIT	
26	IMPINGEMENT PLATE		NO	---	
27	FLOW AREA (FT2)		.2335	.3205	
28	VELOCITY (FT/SEC)		6.19	8.10	
29	RHO-V-SQ (LB/FT-SQ)		1318.	1257.	
30 TEMA E SHELL WITH VERT SEGMENTAL BAFFLES AND EXTS BUNDLE					
31 NUMBER OF INTERMEDIATE SUPPORT PLATES PER SPAN 0					
32 FINNED ADMIRALTY TUBES 1.0000 DIAMETER (IN) 90 DEGREE LAYOUT					
33 PITCH RATIO 1.432					

* FREQUENCY RATIOS ARE BASED ON THE LOWEST NATURAL FREQUENCY

APPENDIX C

HX#3 RUN SUMMARY, 400⁰F RESOURCE

(Page C-1 to C-6)

HTRI SHELL AND TUBE CONDENSER PROGRAM
INPUT DATA REPRINT US UNITS

CST-1 MOD 1.1
PROBLEM DESCRIPTION-MX STUDY

HTRI VERSION

PAGE NO- 1
CASE-HX3/C11

CARD 1 CONTROL INFORMATION			*CARD 5* BASIC SHELL DESCRIPTION			*CARD 12* TUBEFIELD DESCRIPTION		
01	CIN	INPUT UNITS CODE	01	TEMA	TEMA SHELL STYLE	01	ZNTD	NO OF TUBES/SHELL
02	CDUT	OUTPUT UNITS CODE	02	CS1	SHELL CONSTRUCTION	02	DTB	TUBE OD
03	CCI	CALCULATION TYPE	03	CB1	REAR HEAD TYPE	03	TTB	TUBE THICKNESS
04	CHS	FLUID ALLOCATION	04	OSO	SHELL ID	04	TLGV	TUBE LENGTH
05	CHB	HEAT DUTY CODE	05			05	PT	TUBE PITCH
06	QDUTY	HEAT DUTY(1.0E6)	06			06	TLA	TUBEFIELD PATTERN
07			07	CTP	TUBEPASS CODE	07	CHAT	TUBE MATERIAL CODE
08			08	ZTPD	NO OF TUBEPASSES	08	CTK	THERMAL CONDUCT
09	CCM	CALCULATION METHOD	09	ZNSD	PAIRS SEAL DEVICES	09	CFIN	TUBE TYPE
10	FLASH	RIGOROUS FLASH CODE	10	ZNSRO	NO OF SEAL ROOFS	11	TLMAX	MAX TUBE LENGTH
11	PURE	PURE CONDENSABLE	11	DROD	SEAL ROD DIAMETER	12	TLINC	INCREMENT LENGTH
12	POOL	POOL BOILING	12	SFFMD	SHELL FRIC MULT	13	TFMD	TUBE FRIC MULT
13			13			14	TFSTD	TUBE FRIC CODE
14	CVIB	VIBRATION CODE	14			15		
15	EOA	SHELL ORIENTATION						
16								
17								
18								
19								
20	CMON	MONITOR CODE						
21	COP1	PRINTOUT CODE						
22	CPROF	PROFILE CODE						
23								
CARD 6 BASIC BAFFLE GEOMETRY			*CARD 7* CONSTRUCTION INFORMATION			*CARD 13* EXTERNAL TUBE GEOMETRY		
01	CB2	BAFFLE TYPE	01	SFMSD1	INLET H.T. PENALTY	01	XNF	NO OF FINS/LENGTH
02	BCC	BAFFLE ORIENTATION	02	SFMSD2	OUTLET H.T. PENALTY	02	XFH	FIN HEIGHT
03	BCD	BAFFLE CUT (PCT)	03	SFMSU	U-BEND H.T. PENALTY	03	DFR	FIN ROOT DIAMETER
04	FNWB	FRACT WINDOW AREA	04	HNTD1	INLET NOZ HEIGHT	04	XLF	FIN THICKNESS
05	RVDW	NTIW RHO-V-SQUARED	05	HNTD2	OUTLET NOZ HEIGHT	05	FARP	SURF AREA/LENGTH
06	HOVD	TUBE ROWS OVERLAP	06	OBDK	CLEARANCE CODE	06	TRTH	THICKNESS UNDER FIN
07	ZCPD1	NO OF CROSSPASSES	07	CED	BAFFLE-SHELL CLEAR			
08	XLBCD1	CENTRAL BAF SPACE	08	CAD	TUBE-BAFFLE CLEAR			
09	XLBD1	INLET BAF SPACE	09	COILD	BUNDLE-SHELL CLEAR			
10	XLBD2	OUTLET BAF SPACE	10	TSID	TUBESHEET THICK			
11	XLBD	BAFFLE THICKNESS	11	STRES	ALLOWABLE STRESS			
12	XLBDT	TUBEHOLE BAF THICK	12	CS3	DOUBLE TUBESHEET			
13	CEBS	EQUAL END SPACING	13	CS2	EXP JOINT CODE			
14	CBMIX	MAX BAF SPACING	14	PPVN	NO VERT PASS LANE			
15	CB3	BAFFLE WINDOW	15	PPHN	NO HORZ PASS LANE			
16			16	WPPV	WIDTH VERT LANES			
17			17	WPPH	WIDTH HORZ LANES			
18								
19								
CARD 8 VARIABLE BAFFLE SPACING			*CARD 10* NOZZLE INFORMATION			*CARD 18* VIBRATION INFORMATION		
01	ZCPD2	CROSSPASSES REG-2	01	DNZDS1	SHEL-INLET NOZ ID	01	EMOD	TUB ELAST MODULUS
02	XLBCD2	BAF SPACING REG-2	02	DNZDS2	SHEL-OUTLET NOZ ID	02	DMAT	TUBE DENSITY
03	ZCPD3	CROSSPASSES REG-3	03	DNZDS3	SHEL-LIQUID NOZ ID	03	AXLD	AXIAL STRESS LOAD
04	XLBCD3	BAF SPACING REG-3	04	DNZDT1	TUBE-INLET NOZ ID	04	AHFD	ADDED MASS FACTOR
05	ZCPD4	CROSSPASSES REG-4	05	DNZDT2	TUBE-OUTLET NOZ ID	05	SUPPD	SUP PLATE/BAF SPACE
06	XLBCD4	BAF SPACING REG-4	06	DNZDT3	TUBE-LIQUID NOZ ID	06	CLDCD	VIB LOG DECREMENT
07	ZCPD5	CROSSPASSES REG-5	07	ADCD	ANNULAR DISTRIBUTOR	07	CBFD	STABILITY CONSTANT
08	XLBCD5	BAF SPACING REG-5	08	ALCD	ANN-DIST CLEARANCE	08		
			09	ADLD	ANN-DIST LENGTH			
			10	ADSA1	IN--DIST SLOT AREA			
			11	ADSA2	OUT-DIST SLOT AREA			
			12	ZNOZ1	NO NOZ SHELL INLET			
			13	ZNOZ2	NO NOZ SHELL OUTLET			
			14	CNOZ	NOZZLE ORIENTATION			
			15	CFIC	IMPINGEMENT CODE			
			16	RVD	RHO-V-SQUARED			
			17	CAXAL	TUBESIDE AXIAL NOZ			

** A * INDICATES **
** A DEFAULT VALUE **

HOT FLUID NAME--GEOSTEAM
CARD 20 PROCESS INFORMATION

01	FCO1	FLUID CONDITION	2.
02	WD1	FLOW RATE(1.0E3)	121.00
03	YIND1	INLET TEMPERATURE	336.90
04	TOUTD1	OUTLET TEMPERATURE	333.60
05	PIND1	INLET PRESSURE	113.10
06	YIND1	INLET VAPOR QUALITY	1.000
07	YOUTD1	EXIT VAPOR QUALITY	0.000
08	SFD1	H.T. SAFETY FACTOR	1.000*
09	TSHD1	COND DEG SUP HEAT	0.00
10	TSCD1	COND DEG SUB COOL	2.00
11	RFD1	FOUL RESISTANCE	0.00100
12	FL1	FOUL LAYER THICK	0.0000
13	HSUBD	SUBCOOL H.T. COEF	0.00
14	HTPZD	2-PHASE H.T. COEF	0.00

COLD FLUID NAME--ISOB+NHEX
CARD 22 PROCESS INFORMATION

01	FCO2	FLUID CONDITION	0.
02	WD2	FLOW RATE(1.0E3)	2512.00
03	YIND2	INLET TEMPERATURE	0.00
04	TOUTD2	OUTLET TEMPERATURE	326.90
05	PIND2	INLET PRESSURE	675.00
06	YIND2	INLET VAPOR QUALITY	0.000
07	YOUTD2	EXIT VAPOR QUALITY	0.000
08	SFD2	H.T. SAFETY FACTOR	1.000*
09	TSHD2	BOIL DEG SUP HEAT	0.00
10	TSCD2	BOIL DEG SUB COOL	0.00
11	RFD2	FOUL RESISTANCE	0.00050
12	FL2	FOUL LAYER THICK	0.0000
13	HCO	H.T. COEFFICIENT	0.00

CARD 25 DP, VELOCITY, NOZZLE INFO

D1	PHD1	HOT ALLOWABLE DP	5.00
02	PNMD11	HOT MAXDP IN--NOZ	0.00
03	PNMD21	HOT MAXDP OUT--NOZ	0.00
04	PD1	HOT DESIGN PRESS	90.77

07	PHD2	COLD ALLOWABLE DP	10.00
08	PNMD12	COLD MAXDP IN--NOZ	0.00
09	PNMD22	COLD MAXDP OUT--NOZ	0.00
10	PD2	COLD DESIGN PRESS	675.00
11	VHAXD2	COLD MAX VELOCITY	0.00
12	VHIND2	COLD MIN VELOCITY	0.00
13	PHAXD	TOTAL DP	0.00

HOT FLUID (GEOSTEAM) PHYSICAL PROPERTIES
CARD 31 PHYSICAL PROPERTY CONTROL

COMPONENT 1
NAME GEOSTEAM

04	HMMND	0.0000
05	ZNCG	0.
06	APC	1.
07	API	0.00
08	HCF	0.00
09	AMWL	0.00
10	AMW	0.00
11	ZD	0.00000
12	OPCD	0.00
13	OTCD	0.00
14	OZCD	0.00000
15	HLGD	0.00
16	PZERO	0.

COLD FLUID (ISOB+NHEX) PHYSICAL PROPERTIES PROFILE

40	PXP	ISOBARS	(K=1)	670.000	FPC	0.00	0.00	0.00	0.00			
41	TXP	(K)	I=1	I=2	I=3	I=4	I=5	I=6	I=7	I=8	I=9	I=10
42	QXFP	1	330.00	320.00	310.00	300.00	280.00	250.00	220.00	180.00	140.00	80.00
43	YXP											
44	ROVP											
45	XHUVF											
46	XKVP											
47	HVXP											
48	CPVP											
50	ROLF	1	11.2900	13.4070	16.1400	19.0790	23.2490	26.5230	28.6410	30.7780	32.5290	34.7920
51	XHULF	1	.0201	.0251	.0338	.0403	.0502	.0627	.0745	.0914	.1110	.1489
52	KLFP	1	.0265	.0289	.0325	.0347	.0376	.0408	.0434	.0467	.0503	.0565
53	HLXP	1	211.5700	197.3300	181.8900	166.6100	142.3200	115.7500	93.3300	66.4100	41.5700	6.9900
54	CLFP	1	1.3114	1.5088	1.5687	1.4503	1.0211	.7957	.7082	.6436	.6008	.5544
55	SIGP											
56	PCLP											

** INTEGRAL CONDENSING FLUID FLASH. CONDENSING FLUID -- GEOSTEAM **

	---TEMPERATURE---			WEIGHT FRACTION VAPOR			--MOLE FRACTIONS IN VAPOR PHASE--					--MOLE FRACTIONS IN LIQUID PHASE--				
1	336.90	336.90	336.90	1.0000	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000
2	336.01	336.09	336.17	1.0000	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000
3	336.01	336.09	336.17	.8571	.8571	.8571	1.0000	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000
4	336.01	336.09	336.17	.7143	.7143	.7143	1.0000	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000
5	336.01	336.09	336.17	.5714	.5714	.5714	1.0000	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000
6	336.01	336.09	336.17	.4286	.4286	.4286	1.0000	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000
7	336.01	336.09	336.17	.2857	.2857	.2857	1.0000	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000
8	336.01	336.09	336.17	.1429	.1429	.1429	1.0000	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000
9	336.01	336.09	336.17	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000
10	333.60	333.60	333.60	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000

PRESSURE = 112.01 112.13 112.25

DEW POINT TEMPERATURE = 336.01
BUBBLE POINT TEMPERATURE = 336.01

NOTE--THE BUBBLE AND DEW POINTS, AND LIQUID AND VAPOR MOLE FRACTIONS ARE AT THE LOWEST PRESSURE (112.01).

COMPONENT GEOSTEAM
FEED FRACT 1.0000 0.0000 0.0000 0.0000 0.0000

COLD FLUID (ISOB+NHX) - 1 PHYSICAL PROPERTIES PROFILE

FXP	ISOBARS	(K=1)	670.00														
	(K)	I=1	I=2	I=3	I=4	I=5	I=6	I=7	I=8	I=9	I=10						
TXP	1	330.00	320.00	310.00	300.00	280.00	250.00	220.00	180.00	140.00	80.00						
OXFP	1	204.5800	190.3400	174.9000	159.6200	135.3300	108.7600	86.3400	59.4200	34.5800	0.0000						
YXP	1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000						
ROVP	1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000						
XHVP	1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000						
XKVP	1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000						
CVVP	1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000						
RDLP	1	11.2900	13.4070	16.1400	19.0790	23.2490	26.5230	28.6410	30.7780	32.5290	34.7920						
XHULP	1	.0201	.0251	.0338	.0403	.0502	.0627	.0745	.0914	.1110	.1489						
XKLP	1	.0265	.0289	.0325	.0347	.0376	.0408	.0434	.0467	.0503	.0563						
HLXP	1	211.5700	197.3300	181.8900	166.6100	142.3200	115.7500	93.3300	66.4100	41.5700	6.9900						
CPLP	1	1.3114	1.5088	1.5687	1.6505	1.0211	.7957	.7382	.6436	.6008	.5544						
SLP	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00						
PCLP	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00						
XLATP	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00						

PXP	ISOBARS	(K=1)	112.01	(K=2)	112.13	(K=3)	112.25
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	(K)	1-1	1-2	1-3	1-4	1-5	1-6	1-7	1-8	1-9	1-10
TXP	1	336.90	336.01	336.01	336.01	336.01	336.01	336.01	336.01	336.01	336.01
	2	336.90	336.09	336.09	336.09	336.09	336.09	336.09	336.09	336.09	336.09
	3	336.90	336.17	336.17	336.17	336.17	336.17	336.17	336.17	336.17	336.17
QXFP	1	0.0000	0.5224	125.6866	250.8508	376.0150	501.1792	626.3435	751.5077	876.6719	879.1794
	2	0.0000	0.4766	125.6308	250.7851	375.9394	501.0937	626.2480	751.4023	876.5565	879.1449
	3	0.0000	0.4308	125.5751	250.7195	375.8638	501.0082	626.1525	751.2969	876.4413	879.1104
YXP	1	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	2	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	3	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
ROVP	1	2496	2499	2499	2499	2499	2499	2499	2499	2499	2499
	2	2499	2501	2501	2501	2501	2501	2501	2501	2501	2501
	3	2501	2504	2504	2504	2504	2504	2504	2504	2504	2504
XHVP	1	0.151	0.151	0.151	0.151	0.151	0.151	0.151	0.151	0.151	0.151
	2	0.151	0.151	0.151	0.151	0.151	0.151	0.151	0.151	0.151	0.151
	3	0.151	0.151	0.151	0.151	0.151	0.151	0.151	0.151	0.151	0.151
XKVP	1	0.186	0.186	0.186	0.186	0.186	0.186	0.186	0.186	0.186	0.186
	2	0.186	0.186	0.186	0.186	0.186	0.186	0.186	0.186	0.186	0.186
	3	0.186	0.186	0.186	0.186	0.186	0.186	0.186	0.186	0.186	0.186
HVXP	1	0.0000	0.5224	125.6866	250.8508	376.0150	501.1792	626.3435	751.5077	876.6719	879.1794
	2	0.0000	0.4766	125.6308	250.7851	375.9394	501.0937	626.2480	751.4023	876.5565	879.1449
	3	0.0000	0.4308	125.5751	250.7195	375.8638	501.0082	626.1525	751.2969	876.4413	879.1104
CPVP	1	5908	5905	5905	5905	5905	5905	5905	5905	5905	5905
	2	5909	5906	5906	5906	5906	5906	5906	5906	5906	5906
	3	5901	5907	5907	5907	5907	5907	5907	5907	5907	5907
ROLP	1	56.2537	56.2845	56.2845	56.2845	56.2845	56.2845	56.2845	56.2845	56.2845	56.2845
	2	56.2537	56.2818	56.2818	56.2818	56.2818	56.2818	56.2818	56.2818	56.2818	56.2818
	3	56.2537	56.2791	56.2791	56.2791	56.2791	56.2791	56.2791	56.2791	56.2791	56.2791
XHULP	1	1.594	1.594	1.594	1.594	1.594	1.594	1.594	1.594	1.594	1.594
	2	1.589	1.593	1.593	1.593	1.593	1.593	1.593	1.593	1.593	1.593
	3	1.589	1.593	1.593	1.593	1.593	1.593	1.593	1.593	1.593	1.593
XKLP	1	3896	3896	3896	3896	3896	3896	3896	3896	3896	3896
	2	3896	3896	3896	3896	3896	3896	3896	3896	3896	3896
	3	3896	3896	3896	3896	3896	3896	3896	3896	3896	3896
HLXP	1	0.0000	0.5224	125.6866	250.8508	376.0150	501.1792	626.3435	751.5077	876.6719	879.1794
	2	0.0000	0.4766	125.6308	250.7851	375.9394	501.0937	626.2480	751.4023	876.5565	879.1449
	3	0.0000	0.4308	125.5751	250.7195	375.8638	501.0082	626.1525	751.2969	876.4413	879.1104
CPLP	1	1.0394	1.0390	1.0390	1.0390	1.0390	1.0390	1.0390	1.0390	1.0390	1.0390
	2	1.0394	1.0390	1.0390	1.0390	1.0390	1.0390	1.0390	1.0390	1.0390	1.0390
	3	1.0394	1.0390	1.0390	1.0390	1.0390	1.0390	1.0390	1.0390	1.0390	1.0390
SIGP	1	44.01	44.12	44.12	44.12	44.12	44.12	44.12	44.12	44.12	44.12
	2	44.01	44.11	44.11	44.11	44.11	44.11	44.11	44.11	44.11	44.11
	3	44.01	44.10	44.10	44.10	44.10	44.10	44.10	44.10	44.10	44.10
PCLP	1	3208.20	3208.20	3208.20	3208.20	3208.20	3208.20	3208.20	3208.20	3208.20	3208.20
	2	3208.20	3208.20	3208.20	3208.20	3208.20	3208.20	3208.20	3208.20	3208.20	3208.20
	3	3208.20	3208.20	3208.20	3208.20	3208.20	3208.20	3208.20	3208.20	3208.20	3208.20
XLATP	1	876.15	876.15	876.15	876.15	876.15	876.15	876.15	876.15	876.15	876.15
	2	876.08	876.08	876.08	876.08	876.08	876.08	876.08	876.08	876.08	876.08
	3	876.01	876.01	876.01	876.01	876.01	876.01	876.01	876.01	876.01	876.01

HTRI SHELL AND TUBE CONDENSER PROGRAM CST-1 MOD 1.1

FINAL RESULTS PROBLEM DESCRIPTION-MX STUDY
COOLANT DESIGN- TUBESIDE HOT COUNTERCURRENT

HTRI VERSION

PAGE NO- 22

CASE-HX3/C11
ALT. SOLN- 1

HORIZONTAL TEMA AEL SHELL WITH N.T.I.W. BUNDLE

**** PROCESS DATA ****

	COLD SHELLSIDE	HOT TUBESIDE
01 FLUID NAME	ISOB+NHX	GEOSTEAM
02 FLUID CONDITION	SENS. LIQUID	COND. VAPOR
03 TOTAL FLOW RATE (1.0E+3)(LB/HR)	2512.000	121.000
04 WEIGHT FRACTION VAPOR, IN/OUT (--)	0.000+ / 0.000	1.000 / 0.000
05 TEMPERATURE, IN/OUT (DEG F)	298.5+ / 326.9	336.9 / 333.6
06 TEMPERATURE, AVERAGE/SKIN (DEG F)	312.7 / 321.2	335.3 / 332.8
07 PRESSURE, INLET/AVERAGE (PSIA)	675.00 / 670.61	113.10 / 112.55
08 PRESSURE DROP, TOTAL/ALLOW (PSI)	8.79 / 10.00	1.09 / 5.00
09 VELOCITY, MID/MAX ALLOW (FT/SEC)	5.38 / 0.00	20.17 / 0.00
10 AVERAGE FILM COEF (BTU/HR-FT ² -F)	450.78	3369.09
11 HEAT TRANSFER SAFETY FACTOR (--)	1.000	1.000
12 FOULING RESISTANCE (HR-FT ² -F/BTU)	.000500	.001000

13 OVERALL COEF, REQD/CLEAN/ACTUAL (BTU/HR-FT ² -F)	137.61 / 296.07 / 138.08
14 HEAT DUTY, REQUIRED/SPECIFIED (1.0E+6)(BTU/HR)	106.38076 / 0.00000
15 EFFECTIVE OVERALL TEMPERATURE DIFFERENCE (DEG F)	20.32

**** CONDENSER PERFORMANCE CRITERIA ****

16 PRESSURE DROP RATIOS BASED ON SPECIFIED/REQUIRED AREAS, SHELLSIDE/TUBESIDE	1.001 / 1.001
17 RATIO OF AREA SPECIFIED TO AREA REQUIRED	1.0034

18
19
20 ----- SEE NEXT PAGE FOR WARNING MESSAGES -----

**** SHELL CONSTRUCTION INFORMATION ****

21 SHELL TYPE E	REAR HEAD FXTS	SHELL ID (IN)	63.000
22 SHELLS SERIES 1	PARALLEL	TOTAL AREA (FT ²)	38522
23 PASSES SHELL 1	TUBE	EFF. AREA (FT ² /SHELL)	38052.2
24 SHELL ORIENTATION ANGLE	0	(DEGREES FROM HORIZONTAL)	
25 PAIRS OF SEALING DEVICES	0	IMPINGEMENT PLATE INCLUDED	NO
26 WEIGHT ESTIMATION (LB/SHELL)	WET	140460	DRY 73822

**** BAFFLE INFORMATION ****

27 TYPE	VERT	N.T.I.W.	BAFFLE CUT (PCT DIA)	17.434
28 CROSSPASSES/SHELLPASS	8		NO. (PCT AREA) (IN TO C.L.)	20.517
29 CENTRAL SPACING (IN)	62.454			
30 INLET SPACING (IN)	62.454			
31 OUTLET SPACING (IN)	62.454			
32 BAFFLE THICKNESS (IN)	.500			

**** TUBE INFORMATION ****

33 TUBE TYPE	(FINS/IN)	19	TUBECOUNT PER SHELL	1315
34 OVERALL LENGTH (FT)	43.000		PCT TUBES REMOVED (BOTH)	23.16
35 EFFECTIVE LENGTH (FT)	41.636		OUTSIDE DIAMETER (IN)	1.0000
36 TOTAL TUBESHEET THICK (IN)	16.4		INSIDE DIAMETER (IN)	1.7890
37 AREA RATIO (OUT/IN)	3.363		PITCH (IN)	1.3120
38			RATIO	1.432
			LAYOUT ANGLE (DEGREES)	90

**** SHELLSIDE PERFORMANCE ****

01 NOM. VEL, X-FLOW/WINDOW	6.01 / 19.48
02 FILM COEF, X-FLOW/WINDOW	490.8 / 0.0
03 FLOW FRACTIONS FOR HEAT TRANSFER	.814
04 A = .123 B = .769 C = .043 E = .065 F = 0.000	

**** SHELLSIDE HEAT TRANSFER CORRECTIONS ****

05 TOTAL	BETA	GAMMA	END	FIN
.920	.920	1.000	.998	1.000

**** PRESSURE DROPS **** (PERCENT OF TOTAL)

06 CROSS WINDOW ENDS	NOZZLE SHELL	TUBE
36.38 50.20 10.76	INLET	1.01 77.03
07 RECOVERY	0.00	OUTLET 1.64 1.08

**** CONDENSATION PARAMETERS ****

08 METHOD	INLET	CENTER	OUTLET
09 PRORATION MODE	SHEAR	TRANS	GRAVITY
09 AVG MULTICOMPONENT H.T. CORR FACTOR			.9062

**** H.T. PARAMETERS ****

	SHELL	TUBE
10 MIDPOINT REYNOLDS NO	323874	9125
11 BUNDLE INLET REYNOLDS NO	216746	48660
12 BUNDLE OUTLET REYNOLDS NO	411292	4621
13 FOULING LAYER (IN)	0.00000	0.00000

**** THERMAL RESISTANCES **** (PCT OVERALL)

14 SHELL	TUBE	FOULING	METAL	OVER DES
30.63	13.79	53.36	2.115	.342
15 TOTAL FOULING RESISTANCE				.003865

**** SHELLSIDE NOZZLES ****

	INLET	OUTLET
16 NUMBER AT EACH POSITION	1	1
17 DIAMETER (IN)	35.30	35.30
18 VELOCITY (FT/SEC)	5.30	8.59
19 PRESSURE DROP (PSI)	.09	.14
20 HEIGHT UNDER NOZZLE (IN)	10.98	10.98
21 NOZZLE R-V-SQ (LB/FT-S ²)	543	882
22 SHELL R-V-SQ (LB/FT-S ²)	353	574

**** TUBESIDE NOZZLES ****

	INLET	OUTLET
23 DIAMETER (IN)	12.10	8.10
24 VELOCITY (FT/SEC)	168.26	1.67
25 PRESSURE DROP (PSI)	.84	.01

**** DIAMETRAL CLEARANCES (IN) ****

29 BAFFLE-ID-SHELL BUNDLE-ID-SHELL TUBE-TO-BAFFLEHOLE	.2763	.7500	.0246
---	-------	-------	-------

HTRI - CST-1 MOD 1.1		HTRI VERSION		PAGE NO- 25	
PROBLEM DESCRIPTION-HX STUDY				CASE-HX3/C11	
FLOW INDUCED VIBRATION ANALYSIS		SENS. LIQUID SHELLSIDE			
01 LOG DECREMENT .0300 AXIAL STRESS LOADING		0.0 (KPSI)			
02 BETA 2.679 ADDED MASS FACTOR 2.9604		POSITION IN BUNDLE			
		INLET	CENTER	OUTLET	
03 LENGTH FOR NATURAL FREQUENCY (FT)		2.602	2.602	2.602	
04 LENGTH/TEMA MAXIMUM SPAN (---)		.595	.595	.595	
05 NUMBER OF SPANS (---)		16	16	16	
06 NATURAL FREQUENCY(FUBE) (HZ)		48.26	49.96	50.73	
FLOW VELOCITIES					
08 WINDOW (PARALLEL FLOW) (FT/SEC)		12.47	17.10	20.25	
10 C-STREAM VELOCITY (FT/SEC)		4.88	6.69	7.92	
11 E-STREAM VELOCITY (FT/SEC)		16.90	23.16	27.42	
13 CROSSFLOW VELOCITY (FT/SEC)		3.81	5.22	6.18	
14 CRITICAL VELOCITY (FT/SEC)		4.67	5.46	5.94	
15 CROSSFLOW REYNOLDS NUMBER (---)		204479.	305544.	388015.	
16 CROSSFLOW RHO-V-SQ (LB/FT-SQ)		282.	386.	457.	
FREQUENCY RATIOS					
17 (FVXSD)/(FUBE) (---)		.323	.442	.523	
DAMAGE NUMBERS					
21 BAFFLE (---)		.0356	.0488	.0578	
22 COLLISION (---)		.0096	.0132	.0156	
23 RHO/SQRT(MU) (SEE STV-1, FIG 9-6)		61.5222	54.8631	52.2177	
VIBRATION AMPLITUDES					
25 CROSSFLOW-INDUCED (IN)		.00489	.00735	.00946	
SHELL PARAMETERS AT NOZZLES		ENTRANCE		EXIT	
26 IMPINGEMENT PLATE		NO		---	
27 FLOW AREA (FT2)		8.4238		8.4238	
28 VELOCITY (FT/SEC)		4.27		6.93	
29 RHO-V-SQ (LB/FT-SQ)		353		574	
30 TEMA E SHELL WITH VERT. N.T.I.W. BAFFLES AND FXTS-BUNDLE					
31 NUMBER OF INTERMEDIATE SUPPORT PLATES PER SPAN 1					
32 FINNED ADMIRALTY TUBES 1.0000 DIAMETER (IN) 90 DEGREE LAYOUT					
33 PITCH RATIO 1.432					
* FREQUENCY RATIOS ARE BASED ON THE LOWEST NATURAL FREQUENCY					

APPENDIX D

HX#4 RUN SUMMARY, 400°F RESOURCE

(Page D-1 to D-5)

HTRI SHELL AND TUBE CONDENSER PROGRAM
INPUT DATA REPRINT US UNITS

CST-1 MOD 1.1
PROBLEM DESCRIPTION-MX CONDENSER

HTRI VERSION

PAGE NO- 1
CASE-CX1/C19

CARD 1 CONTROL INFORMATION
01 CIN INPUT UNITS CODE 0.
02 COUT OUTPUT UNITS CODE 0.
03 CCI CALCULATION TYPE 1.
04 CHS FLUID ALLOCATION 2.
05 CH8 HEAT DUTY CODE 4.
06 QDUTY HEAT DUTY(1.0E6) 0.00000

07 CCM CALCULATION METHOD 0.
08 FLASH RIGOROUS FLASH CODE 0.
09 PURE PURE CONDENSABLE 0.
10 POOL POOL BOILING 0.
11 CVIB VIBRATION CODE 1.
12 EOA SHELL ORIENTATION 0.

13
14
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16
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18
19
20 CMON MONITOR CODE 9.
21 COP1 PRINTOUT CODE 0.
22 CPROF PROFILE CODE 0.
23

CARD 6 BASIC BAFFLE GEOMETRY
01 CB2 BAFFLE TYPE 4.
02 BCC BAFFLE ORIENTATION 0.
03 BCD BAFFLE CUT (PCT) 0.00
04 FNW8 FRACT WINDOW AREA 0.00
05 RVDW NTIW RHO-V-SQUARED 5000.0*
06 HOVD TUBE ROWS OVERLAP 0.00
07 ZCPD1 NO OF CROSSPASSES 0.
08 XLBCD1 CENTRAL BAF SPACE 0.000
09 XLBD1 INLET BAF SPACE 0.000
10 XLBD2 OUTLET BAF SPACE 0.000
11 XLBD BAFFLE THICKNESS 0.000
12 XLBD TUBEHOLE BAF THICK 0.000
13 CEBS EQUAL END SPACING 0.0
14 CB3MX MAX BAF SPACING 0.00
15 CB3 BAFFLE WINDOW 0.
16
17
18
19

CARD 8 VARIABLE BAFFLE SPACING
01 ZCPD2 CROSSPASSES REG-2 0.
02 XLBCD2 BAF SPACING REG-2 0.000
03 ZCPD3 CROSSPASSES REG-3 0.
04 XLBCD3 BAF SPACING REG-3 0.000
05 ZCPD4 CROSSPASSES REG-4 0.
06 XLBCD4 BAF SPACING REG-4 0.000
07 ZCPD5 CROSSPASSES REG-5 0.
08 XLBCD5 BAF SPACING REG-5 0.000

CARD 5 BASIC SHELL DESCRIPTION
01 TEMA TEMA SHELL STYLE AEL
02 CS1 SHELL CONSTRUCTION 1.*
03 CB1 REAR HEAD TYPE 1.*
04 DSD SHELL ID 96.000
05
06
07 CTP TUBEPASS CODE 0.
08 ZTPD NO OF TUBEPASSES 1.1
09 ZNSD PAIRS SEAL DEVICES 0.
10 ZNSRD NO OF SEAL RODS 0.
11 DRSD SEAL ROD DIAMETER 0.0000
12 SFFMD SHELL FRICT MULT 1.0000*
13
14

CARD 7 CONSTRUCTION INFORMATION
01 SFHSD1 INLET H.T. PENALTY 1.000*
02 SFHSD2 OUTLET H.T. PENALTY 1.000*
03 SFHSD U-BEND H.T. PENALTY 0.000
04 HNTD1 INLET NOZ HEIGHT 0.000
05 HNTD2 OUTLET NOZ HEIGHT 0.000
06 DBDK CLEARANCE CODE 0.
07 CED BAFFLE-SHELL CLEAR 0.0000
08 CAD TUBE-BAFFLE CLEAR 0.0000
09 COTLD BUNDLE-SHELL CLEAR 0.0000
10 TS10 TUBESHEET THICK 0.0000
11 STRES ALLOWABLE STRESS 0.00
12 CS3 DOUBLE TUBESHEET 0.
13 CS2 EXP JOINT CODE 0.
14 PPVN NO VERT PASS LANE 0.
15 PPHN NO HORIZ PASS LANE 0.
16 WPPV WIDTH VERT LANES 0.000
17 WPPH WIDTH HORIZ LANES 0.000

CARD 10 NOZZLE INFORMATION
01 DNZDS1 SHELL-INLET NOZ ID 36.000
02 DNZDS2 SHELL-OUTLET NOZ ID 36.000
03 DNZDS3 SHELL-LIQUID NOZ ID 0.000
04 DNZDT1 TUBE-INLET NOZ ID 36.000
05 DNZDT2 TUBE-OUTLET NOZ ID 12.000
06 DNZDT3 TUBE-LIQUID NOZ ID 0.000
07 ADCD ANNULAR DISTRIBUTOR 0.
08 ALCD ANN-DIST CLEARANCE 0.000
09 ADLD ANN-DIST LENGTH 0.000
10 ADSA1 IN-DIST SLOT AREA 0.000
11 ADSA2 OUT-DIST SLOT AREA 0.000
12 ZNOZ1 NO NOZ SHELL INLET 1.*
13 ZNOZ2 NO NOZ SHELL OUTLET 1.*
14 CNOZ NOZZLE ORIENTATION 0.
15 CFTC IMPINGEMENT CODE 0.
16 RVD RHO-V-SQUARED 1500.0*
17 CAXAL TUBESIDE AXIAL NOZ 0.

CARD 12 TUBEFIELD DESCRIPTION
01 ZNTD NO OF TUBES/SHELL 0.
02 DTD TUBE OD 0.7500
03 TTB TUBE THICKNESS 0.0650
04 TLOV TUBE LENGTH 45.000
05 PT TUBE PITCH 1.0620
06 TLA TUBEFIELD PATTERN 90.
07 CHAT TUBE MATERIAL CODE 41.
08 CTK THERMAL CONDUCT 0.000
09 CFIN TUBE TYPE 0.
10
11 TLMAX MAX TUBE LENGTH 51.000
12 TLINC INCREMENT LENGTH 1.000
13 TFFMD TUBE FRICT MULT 1.0000*
14 TFFTD TUBE FRICT CODE 0.
15

CARD 13 EXTERNAL TUBE GEOMETRY
01 XNF NO OF FINS/LENGTH 0.00
02 XFH FIN HEIGHT 0.0000
03 DFR FIN ROOT DIAMETER 0.0000
04 XLF FIN THICKNESS 0.0000
05 FARP SURF AREA/LENGTH 0.000
06 TRTH THICKNESS UNDER FIN 0.0000

CARD 18 VIBRATION INFORMATION
01 EMOD TUB ELAST MODULUS 0.00
02 DTMT TUBE DENSITY 0.00
03 AXLD AXIAL STRESS LOAD 0.
04 AMFD ADDED MASS FACTOR 2.1353*
05 SUPPD SUP PLATE/BAF SPACE 0.
06 CLDCO VIB LOG DECREMENT 0.0300*
07 CBFD STABILITY CONSTANT 2.8622*
08

** A * INDICATES **
** A DEFAULT VALUE **

HTRI SHELL AND TUBE CONDENSER PROGRAM
INPUT DATA REPRINT

CST-1 MOD 1.1
PROBLEM DESCRIPTION-MX CONDENSER

HTRI VERSION

PAGE NO- 2
CASE-CX1/C19

HOT FLUID NAME--ISOB+NHEX
CARD 20 PROCESS INFORMATION
01 FCON1 FLUID CONDITION 2.*
02 WD1 FLOW RATE(1.OE3) 628.00
03 TIND1 INLET TEMPERATURE 145.10
04 TOUTD1 OUTLET TEMPERATURE 86.50
05 PIND1 INLET PRESSURE 11.40
06 YIND1 INLET VAPOR QUALITY 1.000
07 YOUTD1 EXIT VAPOR QUALITY 0.000*
08 SFD1 H.T. SAFETY FACTOR 1.700
09 TSHD1 COND DEG SUP HEAT 0.00
10 TSCD1 COND DEG SUB COOL 0.00
11 RFD1 FOUL RESISTANCE 0.00090
12 FL1 FOUL LAYER THICK 0.00060
13 HSUBD SUBCOOL H.T. COEF 0.00
14 HTPZD 2-PHASE H.T. COEF 0.00

COLD FLUID NAME--WATER
CARD 22 PROCESS INFORMATION
01 FCON2 FLUID CONDITION 0.
02 WD2 FLOW RATE(1.OE3) 4924.00
03 TIND2 INLET TEMPERATURE 70.00
04 TOUTD2 OUTLET TEMPERATURE 0.00
05 PIND2 INLET PRESSURE 50.00
06 YIND2 INLET VAPOR QUALITY 0.000
07 YOUTD2 EXIT VAPOR QUALITY 0.000
08 SFD2 H.T. SAFETY FACTOR 1.000*
09 TSHD2 BOIL DEG SUP HEAT 0.35
10 TSCD2 BOIL DEG SUB COOL 0.00
11 RFD2 FOUL RESISTANCE 0.00100
12 FL2 FOUL LAYER THICK 0.00000
13 HCD H.T. COEFFICIENT 0.00

CARD 25 DP, VELOCITY, NOZZLE INFO
01 PMD1 HOT ALLOWABLE DP 0.00
02 PNMD11 HOT MAXDP IN--NOZ 0.00
03 PNMD21 HOT MAXDP OUT--NOZ 0.00
04 PD1 HOT DESIGN PRESS 150.00*
05
06 PMD2 COLD ALLOWABLE DP 10.00
07 PNMD12 COLD MAXDP IN--NOZ 0.00
08 PNMD22 COLD MAXDP OUT--NOZ 0.00
09 PD2 COLD DESIGN PRESS 150.00*
10 VMAXD2 COLD MAX VELOCITY 0.00
11 VMIND2 COLD MIN VELOCITY 0.00
12
13 PMAXD TOTAL DP 0.00

COLD FLUID (WATER) PHYSICAL PROPERTIES
CARD 31 PHYSICAL PROPERTY CONTROL
COMPONENT 1
NAME WATER
04 HMMND 1.0000
05 ZNCG 0.
06 APC 1.
07 API 0.00
08 HCF 0.00
09 AMWL 0.00
10 APW 0.00
11 ZD 0.00000
12 DPCD 0.00
13 OTCD 0.00
14 OZCD 0.00000
15 HLGD 0.00
16 PZERO 0.

HOT FLUID (ISOB+NHX) PHYSICAL PROPERTIES PROFILE

40 PXP	ISOBARS	(K-1)	48.000	(K-2)	50.000	(K-3)	52.000	FPC	0.00	0.00	0.00	0.00
	(K)	I=1	I=2	I=3	I=4	I=5	I=6	I=7	I=8	I=9	I=10	
41 TXP	1	150.00	136.00	120.00	111.85	92.00	86.00	82.00	80.81	80.00	70.00	
	2	150.00	136.00	120.00	114.16	94.00	88.00	86.00	83.38	80.00	70.00	
	3	150.00	140.00	130.00	116.39	96.00	90.00	88.00	83.88	80.00	70.00	
42 QXFP	1	0.0000	6.4400	13.7000	17.3500	60.4320	91.1580	141.6200	172.9800	173.4600	179.0400	
	2	0.0000	6.4600	13.7300	16.3600	61.2080	94.6890	115.3200	171.3400	173.2500	178.8400	
	3	0.0000	4.6200	9.2100	15.3900	61.9990	98.0420	122.3000	169.6900	173.0400	178.6200	
43 YXP	1	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	
	2	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	
	3	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	
44 ROVP	1	.4728	.4870	.5045	.6023	.5750	.5627	.5533	.5503	.5503	.5503	
	2	.4941	.5091	.5276	.6254	.5964	.5836	.5788	.5722	.5722	.5722	
	3	.5158	.5267	.5358	.6483	.6179	.6046	.5996	.5941	.5941	.5941	
45 XMUVP	1	.0085	.0083	.0081	.0080	.0078	.0077	.0077	.0076	.0076	.0076	
	2	.0085	.0083	.0081	.0080	.0078	.0077	.0077	.0076	.0076	.0076	
	3	.0085	.0084	.0083	.0081	.0079	.0078	.0078	.0077	.0077	.0077	
46 XKVP	1	.0125	.0119	.0114	.0111	.0105	.0103	.0102	.0102	.0102	.0102	
	2	.0125	.0119	.0114	.0112	.0106	.0104	.0104	.0103	.0103	.0103	
	3	.0125	.0121	.0117	.0113	.0107	.0105	.0104	.0104	.0104	.0104	
47 HVXP	1	.4639	.4573	.4499	.4463	.4369	.4342	.4324	.4319	.4319	.4319	
	2	.4649	.4583	.4511	.4486	.4391	.4364	.4358	.4346	.4346	.4346	
	3	.4658	.4612	.4537	.4508	.4413	.4387	.4378	.4369	.4369	.4369	
50 ROLP	1	36.2560	36.2560	36.2560	36.2560	35.2940	34.8260	34.4540	34.3350	34.3640	34.7466	
	2	36.1350	36.1350	36.1350	36.1350	35.1470	34.6740	34.4920	34.2360	34.3670	34.7480	
	3	36.0180	36.0180	36.0180	36.0180	35.0080	34.5300	34.3480	34.1400	34.3680	34.7490	
51 XMULP	1	.1694	.1694	.1694	.1694	.1540	.1467	.1411	.1393	.1399	.1474	
	2	.1667	.1667	.1667	.1667	.1512	.1439	.1412	.1374	.1399	.1474	
	3	.1641	.1641	.1641	.1641	.1485	.1413	.1386	.1356	.1399	.1474	
52 XKLP	1	.0569	.0569	.0569	.0569	.0560	.0553	.0548	.0546	.0547	.0559	
	2	.0566	.0566	.0566	.0566	.0556	.0550	.0547	.0543	.0547	.0559	
	3	.0563	.0563	.0563	.0563	.0553	.0546	.0543	.0540	.0547	.0559	
53 HLXP	1	.5733	.5733	.5733	.5733	.5660	.5642	.5631	.5627	.5621	.5547	
	2	.5750	.5750	.5750	.5750	.5677	.5659	.5654	.5647	.5621	.5546	
	3	.5766	.5766	.5766	.5766	.5694	.5677	.5672	.5667	.5621	.5546	
55 SIGP												
56 PCLP												

HTRI SHELL AND TUBE CONDENSER PROGRAM CST-1 MOD 1.1				HTRI VERSION		PAGE NO- 60	
FINAL RESULTS PROBLEM DESCRIPTION-MX CONDENSER						CASE-CX1/C19	
COOLANT DESIGN- TUBESIDE HOT		COUNTERCURRENT		HORIZONTAL TEMA AEL SHELL WITH N.T.I.W. BUNDLE		ALT. SOLN- 5	
**** PROCESS DATA ****				**** SHELLSIDE PERFORMANCE ****			
01 FLUID NAME	COLD SHELLSIDE	HOT TUBESIDE		01 NOM VEL, X-FLOW/WINDOW	3.38/	4.66	
02 FLUID CONDITION	WATER	ISOBNHEX		02 FILM COEF, X-FLOW/WINDOW	1253.7/	0.0	
03 TOTAL FLOW RATE (1.0E+3)(LB/HR)	SENS. LIQUID 4924.000	COND. VAPOR 628.003		03 FLOW FRACTIONS FOR HEAT TRANSFER		.571	
04 WEIGHT FRACTION VAPOR, IN/OUT (--)	0.000 / 0.000	1.000 / 0.000		04 A=.413 B=.432 C=.011 E=.144 F=0.000			
05 TEMPERATURE, IN/OUT (DEG F)	70.0 / 91.8	145.1 / 80.5		**** SHELLSIDE HEAT TRANSFER CORRECTIONS ****			
06 TEMPERATURE, AVERAGE/SKIN (DEG F)	80.9 / 81.7	112.8 / 87.5		05 TOTAL	BETA .920	GAMMA .920	END FIN
07 PRESSURE, INLET/AVERAGE (PSIA)	50.00 / 45.24	51.40 / 50.88					
08 PRESSURE DROP, TOTAL/ALLOW (PSI)	9.51 / 10.00	1.05 / 0.00		**** PRESSURE DROPS **** (PERCENT OF TOTAL)			
09 VELOCITY, MID/MAX ALLOW (FT/SEC)	1.66 / 0.00	14.43 / 0.00		06 CROSS WINDOW ENDS	70.65 / 17.55	10.00	SHELL TUBE
10 AVERAGE FILM COEF (BTU/HR-FT ² -F)	1141.20	451.60		07 RECOVERY	0.00	OUTLET .90	13.44
11 HEAT TRANSFER SAFETY FACTOR (--)	1.000	1.700		**** CONDENSATION PARAMETERS ****			
12 FOULING RESISTANCE (HR-FT ² -F/BTU)	.001000	.000900		08 METHOD	INLET CENTER	OUTLET	
13 OVERALL COEF, REQD/CLEAN/ACTUAL (BTU/HR-FT ² -F)	175.03 / 275.89 / 175.03			09 PRORATION	MODE ANN-MIST	TRANS GRAVITY	
14 HEAT DUTY, REQUIRED/SPECIFIED (1.0E+6)(BTU/HR)	107.17407 / 0.00000			09 AVG MULTICOMPONENT H.T. CORR FACTOR .6150			
15 EFFECTIVE OVERALL TEMPERATURE DIFFERENCE (DEG F)	12.57			**** H.T. PARAMETERS ****			
**** CONDENSER PERFORMANCE CRITERIA ****				10 MIDPOINT	REYNOLDS NO	SHELL	TUBE
16 PRESSURE DROP RATIOS BASED ON				11 BUNDLE INLET	REYNOLDS NO	14608	14341
SPECIFIED/REQUIRED AREAS, SHELLSIDE/TUBESIDE	1.000 / 1.000			12 BUNDLE OUTLET	REYNOLDS NO	9057	149354
17 RATIO OF AREA SPECIFIED TO AREA REQUIRED	1.0000	1.0000		13 FOULING LAYER (IN)		0.00000	0.00000
18				**** THERMAL RESISTANCES **** (PCT OVERALL)			
19				14 SHELL	TUBE	FOULING	METAL
20				15 TOTAL FOULING RESISTANCE			.002089
**** SHELL CONSTRUCTION INFORMATION ****				**** SHELLSIDE NOZZLES ****			
21 SHELL TYPE E	REAR HEAD FXTS	SHELL ID (IN)	96.000	16 NUMBER AT EACH POSITION	INLET	OUTLET	
22 SHELLS SERIES 1	PARALLEL 1	TOTAL AREA (FT ²)	49667	17 DIAMETER (IN)	36.00	36.00	
23 PASSES SHELL 1	TUBE 1	EFF. AREA (FT ² /SHELL)	48693.3	18 VELOCITY (FT/SEC)	3.11	3.12	
24 SHELL ORIENTATION ANGLE	0	(DEGREES FROM HORIZONTAL)		19 PRESSURE DROP (PSI)	.09	.09	
25 PAIRS OF SEALING DEVICES	0	IMPINGEMENT PLATE INCLUDED NO		20 HEIGHT UNDER NOZZLE (IN)	14.40	14.40	
26 WEIGHT ESTIMATION (LB/SHELL)	WET 376013	DRY 165649		21 NOZZLE R-V-SQ (LB/FT-S2)	601	603	
**** BAFFLE INFORMATION ****				22 SHELL R-V-SQ (LB/FT-S2)	208	209	
27 TYPE	VERT N.T.I.W.	BAFFLE CUT (PCT DIA)	15.000	**** TUBESIDE NOZZLES ****			
28 CROSSPASSES/SHELLPASS	17	NO. (PCT AREA) (IN TO C.L.)	33.600	23 DIAMETER (IN)	36.00	12.00	
29 CENTRAL SPACING (IN)	33.257			24 VELOCITY (FT/SEC)	47.96	6.49	
30 INLET SPACING (IN)	47.630			25 PRESSURE DROP (PSI)	.14	.11	
31 OUTLET SPACING (IN)	41.752			**** DIAMETRAL CLEARANCES (IN) ****			
32 BAFFLE THICKNESS (IN)	.500			29 BAFFLE-TO-SHELL BUNDLE-TO-SHELL TUBE-TO-BAFFLEHOLE	.4237	.8750	.0313
**** TUBE INFORMATION ****							
33 TUBE TYPE	PLAIN	TUBECOUNT PER SHELL	5059				
34 OVERALL LENGTH (FT)	50.000	PCT TUBES REMOVED (BOTH)	18.44				
35 EFFECTIVE LENGTH (FT)	49.020	OUTSIDE DIAMETER (IN)	.7500				
36 TOTAL TUBESHEET THICK (IN)	11.8	INSIDE DIAMETER (IN)	.6200				
37 AREA RATIO (OUT/IN)	1.210	PITCH (IN)	1.0620				
38		LAYOUT ANGLE (DEGREES)	90				

HTRI CST-1 PNC 1.1		HTRI VERSION		PAGE NO- 63	
PROBLEM DESCRIPTION-MX CONDENSER		-		CASE-CX1/C19	
FLOW INDUCED VIBRATION ANALYSIS			SENS. LIQUID SHELLSIDE		
C1 LOG DECREMENT .0300 AXIAL STRESS LOADING			J.C (KPSI)		
C2 BETA 2.662 ADDED MASS FACTOR 2.1353			POSITION IN BUNDLE		
			INLET	CENTER	OUTLET
C3	LENGTH FOR NATURAL FREQUENCY (FT)		3.969	2.771	3.479
C4	LENGTH/TEMA MAXIMUM SPAN (---)		.916	.640	.803
C5	NUMBER OF SPANS (---)		17	17	17
C6	NATURAL FREQUENCY (FTUBE) (HZ)		17.67*	36.25	23.02
FLOW VELOCITIES					
C8	WINDOW (PARALLEL FLOW) (FT/SEC)		2.73	2.73	2.74
C9					
C10	C-STREAM VELOCITY (FT/SEC)		.84	1.20	.96
C11	E-STREAM VELOCITY (FT/SEC)		6.69	9.60	7.66
C12					
C13	CROSSFLOW VELOCITY (FT/SEC)		1.16	1.66	1.33
C14	CRITICAL VELOCITY (FT/SEC)		1.07	2.19	1.39
C15	CROSSFLOW REYNOLDS NUMBER (---)		6849.	11047.	10104.
C16	CROSSFLOW RHO-V-SQ (LB/FT-SQ)		83.	171.	109.
FREQUENCY RATIOS					
C17	(FVXSD)/(FTUBE) (---)		.332	.476	.380
C18					
C19					
C20					
DAMAGE NUMBERS					
C21	BAFFLE (---)		.0277	.0278	.0278
C22	COLLISION (---)		.0665	.0325	.0513
C23	R/D/SQRT(MU)(SEE STV-1, FIG 9-6)		40.4634	42.8656	45.8277
VIBRATION AMPLITUDES					
C24					
C25	CROSSFLOW-INDUCED (IN)		.00778	.00357	.00584
SHELL PARAMETERS AT NOZZLES					
C26	IMPINGEMENT PLATE		ENTRANCE	EXIT	
C27	FLOW AREA (FT2)		12.0058	12.0058	
C28	VELOCITY (FT/SEC)		1.83	1.84	
C29	RHO-V-SQ (LB/FT-SQ)		208		209
C30	TEMA E SHELL WITH VERT N.T.I.W. BAFFLES AND FXTS BUNDLE				
C31	NUMBER OF INTERMEDIATE SUPPORT PLATES PER SPAN		0		
C32	PLAIN ADMIRALTY TUBES .7500 DIAMETER (IN)			90 DEGREE LAYOUT	
C33	PITCH RATIO 1.416				
* FREQUENCY RATIOS ARE BASED ON THE LOWEST NATURAL FREQUENCY					

APPENDIX E

HX#1 RUN SUMMARY, 365⁰F RESOURCE

(Page E-1 to E-4)

CARD 1 CONTROL INFORMATION				*CARD 2* SHELLSIDE INFORMATION				*CARD 3* SHELL, BUNDLE AND BAFFLE			
01	CIN	INPUT UNITS CODE	0.	01	CNSD	SEAL STRIP CODE	0.	01	DSO	SHELL ID	0.000
02	COUT	OUTPUT UNITS CODE	0.	02	ZNSD	PAIRS OF STRIPS	0.	02	BCD	BAFFLE CUT (PCT)	0.00
03	CCI	CALCULATION TYPE	1.*	03	DSMAX	MAX SHELL SIZE	200.000	03	FNWB	FRACT WINDOW AREA	0.000
04	CHS	FLUID ALLOCATION	2.	04	DSMIN	MIN SHELL SIZE	0.000	04	HUVD	TUBE ROWS OVERLAP	0.00
05	CHB	HEAT DUTY CODE	3.	05	UMAX	MAX OVERALL COEF	0.00	05	ZCPD	NO OF CROSSPASSES	0.
06	QDUTY	HEAT DUTY (1.0E6)	0.00000	06	RVD	RHO-V-SQUARED	1500.000*	06	XLBCD	CENTRAL BAF SPACE	0.0000
07	CTP	TUBE PASS CODE	0.	07	CFTC	TUBE COUNT CODE	0.	07	XLB1D	INLET BAF SPACING	0.0000
08	ZTPD	NO OF TUBE PASSES	1.	08	HNTD1	INLET HEIGHT	0.000	08	XLB2D	OUTLET BAF SPACE	0.0000
09	ZMSD	SHELLS IN SERIES	2.	09	HNTD2	OUTLET HEIGHT	0.000	09	PPVN	NO VERT PASS LANE	0.
10	ZMPD	SHELLS IN PARALLEL	1.*	10	SFMS1	INLET PENALTY	1.000*	10	PPHN	NO HOKZ PASS LANE	0.
11	CS1	SHELL CONSTRUCTION	1.*	11	SFMS2	OUTLET PENALTY	1.000*	11	WPPV	WIDTH VERT LANES	0.000
12	CTBH	EXCHANGER TYPE	0.	12	CEBS	EQUAL END SPACING	0.	12	WPPH	WIDTH HOKZ LANES	0.000
13	CB1	REAR HEAD TYPE	1.	13	CNOZ	NOZZLE ORIENTATION	0.	13	XLBD	BAFFLE THICKNESS	0.0000
14	CB2	BAFFLE TYPE	4.	14	CB3	WINDOW CONSTRUCT	0.	14	XLBDT	TUBEHOLE BAF THK	0.0000
15	BCC	BAFFLE ORIENTATION	0.	15	DRDK	CLEARANCE CODE	0.	15	GUF3	LONG BAFFLE CODE	0.
16	GOUTS	TUBESIDE STEPWISE	1.	16	CEB	BAF-SHELL CLEAR	0.0000	16	GODEL	DELTA LMTD CORR	0.
17				17	CAU	TUBE-BAF CLEAR	0.0000	17	DUBNZ	MULTIPLE NOZ CODE	1.*
18	GOMEX	SERIES STEP EVAL	0.	18	COTLD	BUND-SHELL CLEAR	0.0000	18			
19	COPI	OUTPUT CODE	0.	19	GDOPS	SHELLSIDE DP USE	1.	19	TEMA	TEMA SHELL STYLE	AEL*
20	CMON	MONITOR CODE	1.	20	CBMSX	MAX BAF SPACING	0.000	20	CAXAL	TUBESIDE AXIAL NOZ	0.
21	CARR	AUTO REKATE CODE	0.	21	PMAX	TOTAL DP	0.00				
CARD 4 TUBESIDE INFORMATION				**HOT FLUID NAME -GEOFLUID -**				**COLD FLUID NAME -ISOB+MHX -**			
01	TLOW	TUBE LENGTH	20.000	*CARD 6* PROCESS INFORMATION				*CARD 8* PROCESS INFORMATION			
02	TLMAX	MAXIMUM LENGTH	60.000	01	FCO1	FLUID CONDITION	0.	01	FCO2	FLUID CONDITION	0.
03	TLINC	LENGTH INCREMENT	5.000	02				02			
04	PT	TUBE PITCH	1.3120	03	WD1	FLOW RATE (1.0E3)	2225.00	03	WD2	FLOW RATE (1.0E3)	2521.00
05	TLA	LAYOUT ANGLE	90.	04	TIND1	INLET TEMPERATURE	308.20	04	TIND2	INLET TEMPERATURE	84.20
06	ZNTD	NO OF TUBES/SHELL	0.	05	TOUT1	OUTLET TEMPERATURE	0.00	05	TOUT2	OUTLET TEMPERATURE	283.20
07	DTU	TUBE OD	1.0000	06	P11	INLET PRESSURE	75.60	06	P12	INLET PRESSURE	530.00
08	TTB	TUBE THICKNESS	0.0650	07	RFD1	FOUL RESISTANCE	0.00100	07	RFD2	FOUL RESISTANCE	0.00050
09	CMAT	TUBE MATERIAL CODE	41.	08	FL1	FOUL LAYER THICK	0.0000	08	FL2	FOUL LAYER THICK	0.0000
10	CTK	THERMAL CONDUCT	0.000	09	HC1	HEAT TRANS COEF	0.00	09	HC2	HEAT TRANS COEF	0.00
11	CFIN	FINNED TUBE CODE	1.	10	SF1	SAFETY FACTOR	1.000*	10	SF2	SAFETY FACTOR	1.000*
12	XNF	NO OF FINS/LENGTH	19.00	11	YIN1	INLET VAPOR QUAL	0.000	11	YIN2	INLET VAPOR QUAL	0.000
13	XHF	FIN HEIGHT	0.0570	12	YEX1	EXIT VAPOR QUALITY	0.000	12	YEX2	EXIT VAPOR QUALITY	0.000
14	DFR	FIN ROOT DIAMETER	0.8770	13	TSH1	COND DEG SUP HEAT	0.00	13	TSH2	BOIL DEG SUP HEAT	0.00
15	XLF	FIN THICKNESS	0.0180	14	TSC1	COND DEG SUB COOL	0.00	14	TSC2	BOIL DEG SUB COOL	0.00
16	FARP	SURF AREA/LENGTH	0.695								
17	TRTH	THICKNESS UNDER FIN	0.0440								
CARD 5 TUBESHEET AND VIBRATION				*CARD 7* MAXIMUM DP AND VELOCITY				*CARD 9* MAXIMUM DP AND VELOCITY			
01	TSID	TUBESHEET THICK	0.0000	01	PM1	ALLOWABLE DP	10.00	01	PM2	ALLOWABLE DP	10.00
02	CS2	EXP JOINT CODE	0.	02	VM1	MAXIMUM VELOCITY	0.00	02	VM2	MAXIMUM VELOCITY	0.00
03	CS3	DOUBLE TUBESHEET	0.	03	PNM1	MAX NOZZLE DP (PCT)	0.00	03	PNM2	MAX NOZZLE DP (PCT)	0.00
04	STRES	ALLOWABLE STRESS	0.00	04	DNZ11	INLET NOZZLE ID	0.000	04	DNZ12	INLET NOZZLE ID	0.000
05	CVIB	VIBRATION CODE	1.	05	DNZ21	OUTLET NOZZLE ID	0.000	05	DNZ22	OUTLET NOZZLE ID	0.000
06	EMOD	ELASTIC MODULUS	0.000	06	PD1	DESIGN PRESSURE	0.00	06	PD2	DESIGN PRESSURE	0.00
07	DTMAT	TUBE DENSITY	0.00	07				07			
10	RE1	0.300*	11 RE2	08	VMIN1	MINIMUM VELOCITY	0.00	08	VMIN2	MINIMUM VELOCITY	0.00
12	CJ1	0.	13 CJ2					09	F12	PH	0.0
14	CF1	2.6791*	15 CF2					10	F22	TOTAL ALKALINITY	0.
								11	F32	CALCIUM HARDNESS	0.
								12	F42	TOT DISSOLVED SOLID	0.

** A * INDICATES **
 ** A DEFAULT VALUE **

HOT FLUID (GEOFLUID) PHYSICAL PROPERTIES
 COMPONENT 1
 NAME GEOFLUID

CARD 10 PHYSICAL PROPERTY CONTROL

03 HMMN 0.0000
 04 APC 1.
 05 API 0.00
 06 AMW 0.00
 07 HCF 0.00
 08 PZERO 0.

CALCULATED PHYSICAL PROPERTY CONSTANTS

D.B. NAME WATER
 MOL FRACT 1.0000
 WT. FRACT 1.0000
 MOL WT. 18.02
 CRIT TEMP 1165.20
 CRIT PRES 3208.20
 TEMPERATURE LIMITS
 UPPER 1165.20
 LOWER 494.69

CALCULATED MIXTURE VALUES

MOLECULAR WEIGHT 18.02
 CRITICAL VALUES-TEMPERATURE 1165.20 PRESSURE 3208.20
 TEMPERATURE LIMITS-UPPER 1165.20 LOWER 494.69

COLD FLUID (ISOB+NHX) PHYSICAL PROPERTIES PROFILE

40 PXP	ISOBARS	(K-1)	520.000	(K-2)	540.000	0.00						
FPC		0.00	0.00	0.00	0.00	0.00						
41 TXP	(K)	1-1	1-2	1-3	1-4	1-5	1-6	1-7	1-8	1-9	1-10	
	1	330.00	320.00	310.00	300.00	280.00	250.00	220.00	180.00	140.00	80.00	
	2	330.00	320.00	310.00	300.00	280.00	250.00	220.00	180.00	140.00	80.00	
43 YXP												
44 ROVP												
45 XMUVP												
46 XKVP												
47 HVXP												
48 CPVP												
50 ROLP	1	6.0728	6.5134	7.1301	8.1599	20.1950	25.7750	28.2440	30.5460	32.3730	34.6950	
	2	6.5527	7.1038	7.9334	9.6015	20.9420	25.8890	28.3010	30.5780	32.3940	34.7080	
51 XMULP	1	.0144	.0145	.0148	.0153	.0438	.0590	.0718	.0891	.1088	.1467	
	2	.0147	.0150	.0154	.0166	.0449	.0595	.0721	.0894	.1091	.1470	
52 XKLP	1	.0226	.0223	.0220	.0222	.0353	.0396	.0426	.0461	.0497	.0561	
	2	.0228	.0225	.0226	.0231	.0357	.0398	.0427	.0461	.0498	.0561	
53 HLXP	1	235.7500	227.4300	218.2500	207.1200	151.0200	117.3500	93.8500	66.4300	41.3700	6.6400	
	2	233.2300	224.3800	214.2200	200.3700	148.8200	117.0900	93.7700	66.4200	41.3900	6.6800	
54 CPLP	1	.8037	.8658	.9849	1.3084	1.8726	.8593	.7285	.6513	.6046	.5560	
	2	.8452	.9341	1.1267	1.8350	1.5533	.8480	.7254	.6502	.6040	.5558	

55 SIGP
 56 PCLP
 ** CARD 42 (QXF) AND CARD 49 (PCVP) ARE NOT USED IN THE ST-4 PROGRAM **

HTRI SHELL AND TUBE HEAT EXCHANGER PROGRAM ST-4 MOD 5.2
 FINAL RESULTS PROBLEM DESCRIPTION-MX STUDY
 DESIGN CASE COUNTERCURRENT FLOW IN A T.E.M.A. AEL SHELL WITH N.T.I.W. BUNDLE

HTRI VERSION

PAGE NO- 49
 CASE-BHX1/RJ
 ALT. SOLN.- 7

**** PROCESS DATA ****				COLD SHELLSIDE		HOT TUBESIDE		**** SHELLSIDE PERFORMANCE ****			
01 FLUID NAME				ISOB+MHFX		GEOLUID		01 NOM. VEL, X-FLOW/WINDOW	1.62/	8.68	
02 FLUID CONDITION				SENS. LIQUID		SENS. LIQUID		02 FILM COEF, X-FLOW/WINDOW	250.3/	0.0	
03 TOTAL FLOW RATE	(1.0E+3)(LB/HR)			2521.000		2225.000		03 FLOW FRACTIONS FOR HEAT TRANSFER		.822	
								04 A = .115 B = .780 C = .042 E = .063 F = 0.000			
04 TEMPERATURE, IN/OUT	(DEG F)	84.2 /	283.2			308.2 /	138.4	**** SHELLSIDE HEAT TRANSFER CORRECTIONS ****			
05 TEMPERATURE, AVERAGE/SKIN	(DEG F)	183.7/	196.6			223.3/	208.9	05 TOTAL	BETA	GAMA	END
06 PRESSURE, INLET/AVERAGE	(PSIA)	530.00/	525.00			75.60/	70.60	06 .920	.920	1.000	.999
07 PRESSURE DROP, TOTAL/ALLOW	(PSI)	5.58/	10.00			1.47/	10.00				1.000
08 VELOCITY, CALC./MAX.ALLOW	(FT/SEC)	1.45/	0.00			1.67/	0.00	**** PRESSURE DROPS **** (PERCENT TOTAL DP)			
09 FILM COEF. (SAF. FACT) (BTU/HR-FT ² -F)		229.96	(1.00)			693.16	(1.00)	07 WIND 49.10	NOZZLE	SHELL	5.74/ 10.80
10 FOULING RESISTANCE (HR-FT ² -F/BTU)		.00050				.00100		08 END 8.92	(IN/OUT)	TUBE	26.48/ 15.73
11 DENSITY (LB/FT ³)		30.3416				59.5859		**** H.T. PARAMETERS ****			
12 THERMAL CONDUCTIVITY (BTU/HR-FT-F)		.0457				.3856		09 WALL CORRECTION		SHELL	TUBE
13 SPECIFIC HEAT CAPACITY (BTU/LB-F)		.6581				1.0041		10 PRANDTL NO.	1.009	.990	
14 VISCOSITY AT AVERAGE TEMP (CP)		.08753				.26518		11 AVERAGE REYNOLDS NO.	60331	36720	
15 VISCOSITY AT SKIN TEMP (CP)		.08198				.28921		12 BUNDLE INLET REYNOLDS NO.	36617	55102	
								13 BUNDLE OUTLET REYNOLDS NO.	134674	20061	
								14 FOULING LAYER (IN)	0.00000	0.00000	
**** OVERALL PERFORMANCE DATA **** (TUBESIDE STEPWISE)								**** THERMAL RESISTANCES **** (PCT. OVERALL)			
16 TOTAL HEAT DUTY REQUIRED (1.0E+6)(BTU/HR)						380.433018		15 SHELL TUBE FOULING METAL		OVER DES	
17 EFFECTIVE MTD, (LMTD)(F)(DELTA) = (DEG F)		37.73	(.98)(1.00)			37.0		16 32.52 36.30 28.40	2.288	1.156	
18 F FACTOR=(TUBE)(BAFFLES)(F/G)(HOT/COLD)=(1.000)(.983)(1.000)(.997)								17 TOTAL FOULING RESISTANCE		.003865	
19 OVERALL COEF, REQD/CLEAN/ACTUAL (BTU/HR-FT ² -F)		73.92/	105.17/	74.78				18 DIFFERENTIAL RESISTANCE		.000155	
**** CONSTRUCTION INFORMATION ****								**** SHELL NOZZLE INFO. ****			
20 NO. SHELLS SERIES 2 PARALLEL 1				TOTAL SURFACE AREA (FT ²)	139451			19 INSIDE DIAMETER (IN)	25.3	25.3	
21 NO. PASSES SHELL 1 TUBE 1				EFF. SURF. AREA (FT ² /SHELL)	69565.8			20 VELOCITY (FT/SEC)	5.83	11.02	
22 SHELL I.D. (IN)	72.000			TEMA SHELL TYPE	E	REAR HEAD FXTS		21 DENSITY (LB/FT ³)	34.539	18.269	
23 BAFFLE TYPE	VERT	N.T.I.W.		NO. CROSSPASSES/SHELL PASS	7			22 NOZZLE R-V-SO (LB/FT-S2)	1174	2220	
24 CENTRAL SPACING (IN)	93.714			BAFFLE CUT (PCT. DIA)	15.00			23 BUNDLE R-V-SO (LB/FT-S2)	350	662	
25 INLET SPACING (IN)	93.714			CUT AREA(PCT) 1) 14.4 2) 0.0 3) 0.0				24 HEIGHT UNDER NOZZLE (IN)	10.8	10.8	
26 OUTLET SPACING (IN)	93.714			CUT HEIGHT FROM CENTER LINE (IN)				**** TUBE NOZZLE INFO. ****			
27 BAFFLE THICKNESS (IN)	.750			PDS-1) 25.2 2) 0.0 3) 0.0				25 INSIDE DIAMETER (IN)	19.3	19.3	
28 NO. PAIRS SEAL DEVICES	0			IMPINGEMENT PLATE INCLUDED	NO			26 VELOCITY (FT/SEC)	5.34	4.99	
29 TOT. TUBESHEET THICK. (IN)	4.0			PERCENT TUBES REMOVED (HOTH)	18.408			27 DENSITY (LB/FT ³)	57.214	61.308	
30 TUBE TYPE (FINS/IN)	19			TUBECOUNT PER SHELL	1831			**** DIAMETRICAL CLEARANCES ****			
31 OVERALL LENGTH (FT)	55.000			TUBE PITCH (IN)	1.3120			28 BAFFLE-TO-SHELL (IN)		.3165	
32 EFFECTIVE LENGTH (FT)	54.667			OUTSIDE DIAMETER (IN)	1.000			29 BUNDLE-TO-SHELL (IN)		.8750	
33 LAYOUT ANGLE (DEG)	90			INSIDE DIAMETER (IN)	.789			30 TUBE-TO-BAFFLEHOLE (IN)		.0246	
34 PITCH RATIO	1.432			SURFACE AREA RATIO (OUT/IN)	3.365			31 MULTI-SEG. BAFFLE OVERLAP (IN)		0.000	
35 FIN TUBE EQ. DIA. (IN)	.916			FIN EQ.DIA. CONDENSING (IN)	0.0000			32 FIN EFFICIENCY= .962		FIN RESIST.= .00015	
36 WEIGHT ESTIMATION (LB/SHELL)	DRY	99319		WET	206927						

***** SEE FOLLOWING PAGES FOR CALCULATION WARNING MESSAGES *****

HTRI ST-4 MOD 5.2 HTRI VERSION PAGE NO- 51
 PROBLEM DESCRIPTION-MX STUDY CASE-HHX1/F3

***FLOW INDUCED VIBRATION ANALYSIS** SENS. LIQUID SHELLSIDE

01 LOG DECREMENT .0300 AXIAL STRESS LOADING 0.0 (KPSI)
 02 BETA 2.679 ADDED MASS FACTOR 2.5604 POSITION IN BUNDLE

	INLET	CENTER	OUTLET
03 LENGTH FOR NATURAL FREQUENCY (FT)	7.810	7.810	7.810
04 LENGTH/TEMA MAXIMUM SPAN (---)	1.784	1.784	1.784
05 NUMBER OF SPANS (---)	7	7	7
06 NATURAL FREQUENCY (FTUBE) (HZ)	4.70*	4.79	5.06

07 FLOW VELOCITIES

08 WINDOW (PARALLEL FLOW) (FT/SEC)	6.74	7.68	12.75
09 C-STREAM VELOCITY (FT/SEC)	1.50	1.71	2.84
10 E-STREAM VELOCITY (FT/SEC)	6.91	7.86	13.00
11 CROSSFLOW VELOCITY (FT/SEC)	1.27	1.45	2.41
12 CRITICAL VELOCITY (FT/SEC)	.41	.43	.56

15 CROSSFLOW REYNOLDS NUMBER (---)	34681.	57141.	127554.
16 CROSSFLOW RHO-V-SQ (LB/FT-SQ)	56.	64.	106.
17 FREQUENCY RATIOS (FVXSQ)/(FTUBE)	1.108	1.261	2.095

18 DAMAGE NUMBERS

21 BAFFLE (---)	.0418	.0476	.0791
22 COLLISION (---)	.1524	.1734	.2880
23 RHO/SQRT(MU) (SEE STV-1, FIG 9-6)	58.4645	65.9243	59.3065

19 VIBRATION AMPLITUDES

25 CROSSFLOW-INDUCED (IN)	(.30568)	(.14909)	(.04781)
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20 BUNDLE PARAMETERS AT NOZZLES

	ENTRANCE	EXIT
26 IMPINGEMENT PLATE NO	---	---
27 FLOW AREA (FT ²)	6.3666	6.3666
28 VELOCITY (FT/SEC)	3.18	6.02
29 RHO-V-SQ (LB/FT-SQ)	350.	662.

30 TEMA E SHELL WITH VERT N.T.I.W. BAFFLES AND FXTS BUNDLE
 31 NUMBER OF INTERMEDIATE SUPPORT PLATES PER SPAN 0
 32 FINNED ADMIRALTY TUBES 1.0000 DIAMETER (IN) 90 DEGREE LAYOUT
 33 PITCH RATIO 1.432

* FREQUENCY RATIOS ARE BASED ON THE LOWEST NATURAL FREQUENCY
 (1) FREQUENCY RATIOS ARE GREATER THAN ONE. VALUES OF THESE ITEMS ARE
 CALCULATED FOR THE FIRST MODE ONLY. CHECK HIGHER MODES

APPENDIX F

HX#2 RUN SUMMARY, 365⁰F RESOURCE

(Page F-1 to F-4)

CARD 1 CONTROL INFORMATION				*CARD 2* SHELLSIDE INFORMATION				*CARD 3* SHELL, BUNDLE AND BAFFLE			
01	CIN	INPUT UNITS CODE	0.	01	CNSD	SEAL STRIP CODE	0.	01	DSO	SHELL ID	0.000
02	CUUT	OUTPUT UNITS CODE	0.	02	ZNSD	PAIRS OF STRIPS	0.	02	BCD	BAFFLE CUT (PCT)	0.00
03	CCI	CALCULATION TYPE	1.*	03	DSMAX	MAX SHELL SIZE	200.000	03	FNWB	FRACT WINDOW AREA	0.000
04	CHS	FLUID ALLOCATION	2.	04	DSMIN	MIN SHELL SIZE	0.000	04	HOVD	TUBE ROWS OVERLAP	0.00
05	CHB	HEAT DUTY CODE	3.	05	UIAX	MAX OVERALL COEF	0.00	05	ZCPD	NO OF CROSSPASSES	0.
06	QDUTY	HEAT DUTY(1.OE6)	0.00000	06	RVD	RHO-V-SQUARED	1500.000*	06	XLBCD	CENTRAL BAF SPACE	0.0000
07	CTP	TUBEPASS CODE	0.	07	CFIC	TUBECOUNT CODE	0.	07	XLB1D	INLET BAF SPACING	0.0000
08	ZTPD	NO OF TUBEPASSES	1.	08	HNTD1	INLET HEIGHT	0.000	08	XLB2D	OUTLET BAF SPACE	0.0000
09	ZMSD	SHELLS IN SERIES	6.	09	HNTD2	OUTLET HEIGHT	0.000	09	PPVN	NO VERT PASS LANE	0.
10	ZMPD	SHELLS IN PARALLEL	1.*	10	SFHS1	INLET PENALTY	1.000*	10	PPHN	NO HORIZ PASS LANE	0.
11	CS1	SHELL CONSTRUCTION	1.*	11	SFHS2	OUTLET PENALTY	1.000*	11	WPPV	WIDTH VERT LANES	0.000
12	CTBH	EXCHANGER TYPE	0.	12	CEBS	EQUAL END SPACING	0.	12	WPPH	WIDTH HORIZ LANES	0.000
13	CR1	REAR HEAD TYPE	1.	13	CNOZ	NOZZLE ORIENTATION	0.	13	XLBD	BAFFLE THICKNESS	0.0000
14	CB2	BAFFLE TYPE	1.*	14	CB3	WINDOW CONSTRUCT	0.	14	XLBDT	TUBEHOLE BAF THIK	0.0000
15	BCC	BAFFLE ORIENTATION	0.	15	DBDK	CLEARANCE CODE	0.	15	GOF13	LONG BAFFLE CODE	0.
16	GOUTS	TUBESIDE STEPWISE	1.	16	CEO	BAF-SHELL CLEAR	0.0000	16	GODEL	DELTA LMTD CORR	0.
17				17	CAD	TUBE-BAF CLEAR	0.0000	17	DUBNZ	MULTIPLE NOZ CODE	1.*
18	GOMEX	SERIES STEP EVAL	0.	18	COTLO	BUND-SHELL CLEAR	0.0000	18			
19	CNP1	OUTPUT CODE	0.	19	GODPS	SHELLSIDE DP USE	1.	19	TEMA	TEMA SHELL STYLE	AEL*
20	CMCN	MONITOR CODE	1.	20	CISMX	MAX BAF SPACING	0.000	20	CAXAL	TUBESIDE AXIAL NOZ	0.
21	CARR	AUTO RERATE CODE	0.	21	PHAX	TOTAL DP	0.00				

CARD 4 TUBESIDE INFORMATION				**HOT FLUID NAME -GENFLUID				**COLD FLUID NAME -ISOB+NHX			
CARD 6 PROCESS INFORMATION				*CARD 8* PROCESS INFORMATION							
01	TLCV	TUBE LENGTH	16.000	01	FCON1	FLUID CONDITION	0.	01	FCON2	FLUID CONDITION	0.
02	TLMAX	MAXIMUM LENGTH	24.000	02				02			
03	TLINC	LENGTH INCREMENT	1.000	03	WD1	FLOW RATE(1.OE3)	141.00	03	WD2	FLOW RATE(1.OE3)	160.00
04	PT	TUBE PITCH	1.3120	04	TIND1	INLET TEMPERATURE	308.20	04	TIND2	INLET TEMPERATURE	84.20
05	TLA	LAYOUT ANGLE	90.	05	TOUT1	OUTLET TEMPERATURE	0.00	05	TOUT2	OUTLET TEMPERATURE	283.20
06	ZNTD	NO OF TUBES/SHELL	0.	06	P11	INLET PRESSURE	75.60	06	P12	INLET PRESSURE	530.00
07	DTQ	TUBE OD	1.0000	07	RFD1	FOUL RESISTANCE	0.00100	07	RFD2	FOUL RESISTANCE	0.00030
08	TTB	TUBE THICKNESS	0.0650	08	FL1	FOUL LAYER THICK	0.0000	08	FL2	FOUL LAYER THICK	0.0000
09	CMAT	TUBE MATERIAL CODE	41.	09	HC1	HEAT TRANS COEF	0.00	09	HC2	HEAT TRANS COEF	0.00
10	CTK	THERMAL CONDUCT	0.000	10	SF1	SAFETY FACTOR	1.000*	10	SF2	SAFETY FACTOR	1.000*
11	CFIN	FINNED TUBE CODE	1.	11	YIN1	INLET VAPOR QUAL	0.000	11	YIN2	INLET VAPOR QUAL	0.000
12	XNF	NO OF FINS/LENGTH	19.00	12	YEX1	EXIT VAPOR QUALITY	0.000	12	YEX2	EXIT VAPOR QUALITY	0.000
13	XFH	FIN HEIGHT	0.0570	13	TSH1	COND DEG SUP HEAT	0.00	13	TSH2	BOIL DEG SUP HEAT	0.00
14	DFR	FIN ROOT DIAMETER	0.8770	14	TSC1	COND DEG SUB COOL	0.00	14	TSC2	BOIL DEG SUB COOL	0.00
15	XLF	FIN THICKNESS	0.0180								
16	FAKP	SURF AREA/LENGTH	0.695								
17	TRTH	THICKNESS UNDER FIN	0.0440								

CARD 5 TUBESHEET AND VIBRATION				*CARD 7* MAXIMUM DP AND VELOCITY				*CARD 9* MAXIMUM DP AND VELOCITY			
01	TS1D	TUBESHEET THICK	0.0000	01	PM1	ALLOWABLE DP	10.00	01	PM2	ALLOWABLE DP	15.00
02	CS2	EXP JOINT CODE	0.	02	VM1	MAXIMUM VELOCITY	0.00	02	VM2	MAXIMUM VELOCITY	0.00
03	CS3	DOUBLE TUBESHEET	0.	03	PNM1	MAX NOZZLE DP(PCT)	0.00	03	PNM2	MAX NOZZLE DP(PCT)	0.00
04	STRES	ALLOWABLE STRESS	0.00	04	DNZ11	INLET NOZZLE ID	0.000	04	DNZ12	INLET NOZZLE ID	0.000
05	CVIB	VIBRATION CODE	1.	05	DNZ21	OUTLET NOZZLE ID	0.000	05	DNZ22	OUTLET NOZZLE ID	0.000
06	EMOD	ELASTIC MODULUS	0.000	06	PD1	DESIGN PRESSURE	0.00	06	PD2	DESIGN PRESSURE	0.00
07	OTMAT	TUBE DENSITY	0.00	07				07			
10	RE1	0.0300*	11 RE2	08	VMIN1	MINIMUM VELOCITY	0.00	08	VMIN2	MINIMUM VELOCITY	0.00
12	CJ1	0.	13 CJ2	09	F12	PH	0.0	09	F12	PH	0.0
14	CF1	2.6791*	15 CF2	10	F22	TOTAL ALKALINITY	0.	10	F22	TOTAL ALKALINITY	0.
				11	F32	CALCIUM HARDNESS	0.	11	F32	CALCIUM HARDNESS	0.
				12	F42	TOT DISSOLVED SOLID	0.	12	F42	TOT DISSOLVED SOLID	0.

** A * INDICATES **

** A DEFAULT VALUE **

** A * INDICATES **
 ** A DEFAULT VALUE **

HOT FLUID (GEOLUID) PHYSICAL PROPERTIES

COMPONENT 1
 NAME GEOLUID

CARD 10 PHYSICAL PROPERTY CONTROL

03 HMPN 0.0000
 04 APC 1.
 05 API 0.00
 06 AM 0.00
 07 HCF 0.00
 08 PZERO 0.

CALCULATED PHYSICAL PROPERTY CONSTANTS

D.B. NAME WATER
 MOL FRACT 1.0000
 WT. FRACT 1.0000
 MOL WT. 18.02
 CRIT TEMP 1165.20
 CRIT PRES 3208.20
 TEMPERATURE LIMITS
 UPPER 1165.20
 LOWER 494.69

CALCULATED MIXTURE VALUES

MOLECULAR WEIGHT 18.02
 CRITICAL VALUES-TEMPERATURE 1165.20 PRESSURE 3208.20
 TEMPERATURE LIMITS-UPPER 1165.20 LOWER 494.69

COLD FLUID (ISOB+NHX) PHYSICAL PROPERTIES PROFILE

40 PXP FPC	ISOBARS	(K=1) 520.000 0.00	(K=2) 540.000 0.00	(K=3) 560.000 0.00	(K=4) 580.000 0.00	(K=5) 600.000 0.00	(K=6) 620.000 0.00	(K=7) 640.000 0.00	(K=8) 660.000 0.00	(K=9) 680.000 0.00	(K=10) 700.000 0.00
41 TXP	(K)	1-1 330.00	1-2 320.00	1-3 310.00	1-4 300.00	1-5 280.00	1-6 250.00	1-7 220.00	1-8 180.00	1-9 140.00	1-10 80.00
43 YXP	2	330.00	320.00	310.00	300.00	280.00	250.00	220.00	180.00	140.00	80.00
44 ROVP											
45 XMVVP											
46 XKVP											
47 HVXP											
48 CPVP											
50 ROLP	1	6.0278	6.5134	7.1301	8.1599	20.1950	25.7750	28.2440	30.5460	32.3730	34.6950
	2	6.5527	7.1038	7.9334	9.6013	20.9420	25.8890	28.3010	30.5780	32.3940	34.7040
51 XMULP	1	.0144	.0145	.0148	.0153	.0438	.0590	.0718	.0891	.1088	.1467
	2	.0147	.0150	.0154	.0166	.0449	.0595	.0721	.0894	.1091	.1470
52 XKLP	1	.0226	.0223	.0220	.0222	.0353	.0396	.0426	.0461	.0497	.0561
	2	.0228	.0225	.0226	.0231	.0357	.0398	.0427	.0461	.0498	.0561
53 HLXP	1	235.7500	227.4300	218.2500	207.1200	151.0200	117.3500	93.8500	66.4300	41.3700	6.6400
	2	233.2300	224.3800	214.2200	200.3700	148.8200	117.0900	93.7700	66.4200	41.3900	6.6800
54 CPLP	1	.8037	.8658	.9849	1.3084	1.8726	.8593	.7285	.6513	.6046	.5580
	2	.8452	.9341	1.1267	1.8350	1.5533	.8480	.7254	.6502	.6040	.5558
55 SIGP											
56 PCLP											

** CARD 42 (QXF) AND CARD 49 (PCVP) ARE NOT USED IN THE ST-4 PROGRAM **

FINAL RESULTS

PROBLEM DESCRIPTION-MX STUDY

AEL

SHELL WITH

SEGMENTAL BAFFLES

CASE-BHX2/R4

ALT. SOLN.- 4

**** PROCESS DATA ****

COLD SHELLSIDE

HOT TUBESIDE

**** SHELLSIDE PERFORMANCE ****

01 FLUID NAME	ISOB+NHX	GEOLUID	01 NOM. VEL. X-FLOW/WINDOW	1.95/	6.10
02 FLUID CONDITION	SENS. LIQUID	SENS. LIQUID	02 FILM COEF. X-FLOW/WINDOW	301.9/	958.9
03 TOTAL FLOW RATE (1.0E+3)(LB/HR)	160.000	141.000	03 FLOW FRACTIONS FOR HEAT TRANSFER	.938	
04 TEMPERATURE, IN/OUT (DEG F)	84.2 / 283.2	308.2 / 137.3*	04 A=.030 B=.871 C=.063 E=.036 F=0.000		
05 TEMPERATURE, AVERAGE/SKIN (DEG F)	183.7/ 193.1	222.7/ 208.3	**** SHELLSIDE HEAT TRANSFER CORRECTIONS ****		
06 PRESSURE, INLET/AVERAGE (PSIA)	530.00/ 522.50	75.60/ 70.60	05 TOTAL BETA GAMMA END FIN	.920 .920 1.000 .968 1.000	
07 PRESSURE DROP, TOTAL/ALLOW (PSI)	10.80/ 15.00	2.46/ 10.00	**** PRESSURE DROPS **** (PERCENT TOTAL DP)		
08 VELOCITY, CALC./MAX.ALLOW (FT/SEC)	1.94/ 0.00	2.25/ 0.00	07 WIND 71.79 NOZZLE SHELL 4.50/ 8.19		
09 FILM COEF (SAF.FACT) (BTU/HR-FT ² -F)	388.95 (1.00)	893.86 (1.00)	08 END 3.36 (IN/OUT) TUBE 19.29/ 11.45		
10 FOULING RESISTANCE (HR-FT ² -F/BTU)	.00050	.00100	**** H.T. PARAMETERS ****		
11 DENSITY (LB/FT ³)	30.3374	59.5995	09 WALL CORRECTION SHELL TUBE	1.007 .990	
12 THERMAL CONDUCTIVITY (BTU/HR-FT-F)	.0457	.3855	10 PRANDTL NO.	3.0 1.7	
13 SPECIFIC HEAT CAPACITY (BTU/LB-F)	.6583	1.0040	11 AVERAGE REYNOLDS NO.	82496 49402	
14 VISCOSITY AT AVERAGE TEMP (CP)	.08749	.26593	12 BUNDLE INLET REYNOLDS NO.	50047 74344	
15 VISCOSITY AT SKIN TEMP (CP)	.08343	.29032	13 BUNDLE OUTLET REYNOLDS NO.	185386 26825	
			14 FOULING LAYER (IN)	0.00000 0.00000	

**** OVERALL PERFORMANCE DATA **** (TUBESIDE STEPWISE)

16 TOTAL HEAT DUTY REQUIRED (1.0E+6)(BTU/HR)	24.262016		**** THERMAL RESISTANCES **** (PCT. OVERALL)		
17 EFFECTIVE MTD, (LMTD)(F)(DELTA) = (DEG F)	37.30(1.00)(1.00) = 37.2		15 SHELL TUBE FOULING METAL OVER DES		
18 F FACTOR=(TUBE)(BAFFLES)(F/G)(HOT/COLD)=(1.000)(1.000)(1.000)(.999)			16 24.07 36.89 36.18 2.852 1.774		
19 OVERALL COEF, REQD/CLEAN/ACTUAL(BTU/HR-FT ² -F)	91.99/ 146.71/ 93.63		17 TOTAL FOULING RESISTANCE	.003865	
			18 DIFFERENTIAL RESISTANCE	.000189	

**** CONSTRUCTION INFORMATION ****

20 NO. SHELLS SERIES 6 PARALLEL 1	TOTAL SURFACE AREA (FT ²)	7116	**** SHELL NOZZLE INFO. ****	INLET	OUTLET
21 NO. PASSES SHELL 1 TUBE 1	EFF. SURF. AREA (FT ² /SHELL)	1180.2	19 INSIDE DIAMETER (IN)	10.2	10.2
22 SHELL I.D. (IN)	TEMA SHELL TYPE E REAR HEAD FXTS		20 VELOCITY (FT/SEC)	2.27	4.34
23 BAFFLE TYPE VERT SEGMENTAL	NO. CROSSPASSES/SHELL PASS	10	21 DENSITY (LB/FT ³)	34.537	18.055
24 CENTRAL SPACING (IN)	BAFFLE CUT (PCT. DIA)	32.73	22 NOZZLE R-V-SQ (LB/FT-SQ)	178	341
25 INLET SPACING (IN)	CUT AREA(PCT)1) 29.7 2) 0.0 3) 0.0		23 BUNDLE R-V-SQ (LB/FT-SQ)	1021	1953
26 OUTLET SPACING (IN)	CUT HEIGHT FROM CENTER LINE (IN)	0.0	24 HEIGHT UNDER NOZZLE (IN)	.3	.3
27 BAFFLE THICKNESS (IN)	POS-1) 2.6 2) 0.0 3) 0.0		**** TUBE NOZZLE INFO. ****	INLET	OUTLET
28 NO. PAIRS SEAL DEVICES	IMPINGEMENT PLATE INCLUDED	NO	25 INSIDE DIAMETER (IN)	6.1	6.1
29 TOT. TUBESHEET THICK. (IN)	PERCENT TUBES REMOVED (NONE)	0.000	26 VELOCITY (FT/SEC)	3.41	3.18
30 TUBE TYPE (FINS/IN)	TUBECOUNT PER SHELL	86	27 DENSITY (LB/FT ³)	57.214	61.327
31 OVERALL LENGTH (FT)	TUBE PITCH (IN)	1.3120	**** DIAMETRAL CLEARANCES ****		
32 EFFECTIVE LENGTH (FT)	OUTSIDE DIAMETER (IN)	1.000	28 BAFFLE-TO-SHELL (IN)	.1130	
33 LAYOUT ANGLE (DEG)	INSIDE DIAMETER (IN)	.789	29 BUNDLE-TO-SHELL (IN)	.5000	
34 PITCH RATIO	SURFACE AREA RATIO (OUT/IN)	3.365	30 TUBE-TO-BAFFLEHOLE (IN)	.0246	
35 FIN TUBE EQ. DIA. (IN)	FIN EQ.DIA. CONDENSING (IN)	0.0000	31 MULTI-SEG. BAFFLE OVERLAP (IN)	0.000	
36 WEIGHT ESTIMATION (LB/SHELL)	DRY 2755 WET 4481		32 FIN EFFICIENCY=.941 FIN RESIST.=	.00019	

L-3

HTRI ST-4 MOD 5.2
PROBLEM DESCRIPTION-MX STUDY

HTRI VERSION

PAGE NO- 28
CASE-BHX2/R4

FLOW INDUCED VIBRATION ANALYSIS

SENS. LIQUID SHELLSIDE

01 LOG DECREMENT .0300 AXIAL STRESS LOADING 0.0 (KPSI)
02 BETA 2.679 ADDED MASS FACTOR 2.5604 POSITION IN BUNDLE

	INLET	CENTER	OUTLET
03 LENGTH FOR NATURAL FREQUENCY (FT)	3.949	3.949	3.949
04 LENGTH/TEMA MAXIMUM SPAN (---)	.902	.902	.902
05 NUMBER OF SPANS (---)	5	5	5
06 NATURAL FREQUENCY (FTUBE) (HZ)	19.10*	19.47	20.68

07 FLOW VELOCITIES

	INLET	CENTER	OUTLET
08 WINDOW (PARALLEL FLOW) (FT/SEC)	5.20	5.92	9.94
09 WINDOW (CROSSFLOW) (FT/SEC)	1.61	1.70	1.17
10 C-STREAM VELOCITY (FT/SEC)	1.00	1.14	1.91
11 E-STREAM VELOCITY (FT/SEC)	4.08	4.65	7.81
13 CROSSFLOW VELOCITY (FT/SEC)	1.71	1.94	3.26
14 CRITICAL VELOCITY (FT/SEC)	1.66	1.77	2.29

	INLET	CENTER	OUTLET
15 CROSSFLOW REYNOLDS NUMBER (---)	46387.	76464.	171831.
16 CROSSFLOW RHO-V-SQ (LB/FT-SQ)	100.	114.	192.
17 FREQUENCY RATIOS (FVXSD)/(FTUBE) (---)	.131	.149	.251

18 DAMAGE NUMBERS

	INLET	CENTER	OUTLET
21 BAFFLE (---)	.0383	.0436	.0732
22 COLLISION (---)	.0178	.0203	.0341
23 RHC/SQRT(MU) (SEE STV-1, FIG 9-6)	58.4614	65.9303	58.8200
24 VIBRATION AMPLITUDES (IN)	.001860	.002118	.003561
25 PARALLEL FLOW (IN)	.00828	.00947	.01646

BUNDLE PARAMETERS AT NOZZLES

	ENTRANCE	EXIT
26 IMPINGEMENT PLATE NO	NO	---
27 FLOW AREA (FT2)	.2367	.2367
28 VELOCITY (FT/SEC)	5.44	10.40
29 RHO-V-SQ (LB/FT-SQ)	1021.	1953.

30 TEMA E SHELL WITH VERT SEGMENTAL BAFFLES AND FXTS BUNDLE
31 NUMBER OF INTERMEDIATE SUPPORT PLATES PER SPAN 0
32 FINNED ADMIRALTY TUBES 1.0000 DIAMETER (IN) 90 DEGREE LAYOUT
33 PITCH RATIO 1.432

* FREQUENCY RATIOS ARE BASED ON THE LOWEST NATURAL FREQUENCY

APPENDIX G

HX#3 RUN SUMMARY, 365⁰F RESOURCE

(Page G-1 to G-6)

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*****
**          A * INDICATES          **
**          A DEFAULT VALUE        **
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HTRI SHELL AND TUBE CONDENSER PROGRAM				CST-1 MOD 1.1				HTRI VERSION				PAGE NO- 2			
INPUT DATA REPRINT				US UNITS				PROBLEM DESCRIPTION-MX STUDY				CASE-BHX3/R3			
HOT FLUID NAME--GEOSTEAM				**COLD FLUID NAME--ISOB+NHX**				**CARD 25* DP, VELOCITY, NOZZLE INFO							
CARD 20 PROCESS INFORMATION				*CARD 22* PROCESS INFORMATION				C1 PMD1 HOT ALLOWABLE DP				5.00			
01	FCON1	FLUID CONDITION	2.	01	FCON2	FLUID CONDITION	0.	C2	PNMD11	HOT	MAXDP IN--NOZ	0.00			
02	WDI	FLOW RATE(1.OE3)	141.00	02	WDI	FLOW RATE(1.OE3)	2680.00	03	PNMD21	HOT	MAXDP OUT--NOZ	0.00			
03	TIND1	INLET TEMPERATURE	310.20	03	TIND2	INLET TEMPERATURE	0.00	04	PD1	HOT	DESIGN PRESS	77.60			
04	TOUTD1	OUTLET TEMPERATURE	308.20	04	TOUTD2	OUTLET TEMPERATURE	300.20	C5							
05	PIND1	INLET PRESSURE	77.60	05	PIND2	INLET PRESSURE	525.00	C6							
06	YIND1	INLET VAPOR QUALITY	1.000	06	YIND2	INLET VAPOR QUALITY	0.000	C7	PMHD2	COLD	ALLOWABLE DP	10.00			
07	YOUTD1	EXIT VAPOR QUALITY	0.000	07	YOUTD2	EXIT VAPOR QUALITY	0.000	C8	PNMD12	COLD	MAXDP IN--NOZ	0.00			
08	SFD1	H.T. SAFETY FACTOR	1.000*	08	SFD2	H.T. SAFETY FACTOR	1.000*	C9	PNMD22	COLD	MAXDP OUT--NOZ	0.00			
09	TSHD1	COND DEG SUP HEAT	0.00	09	TSHD2	BOIL DEG SUP HEAT	0.00	10	PD2	COLD	DESIGN PRESS	525.00			
10	TSCD1	COND DEG SUB COOL	0.00	10	TSCD2	BOIL DEG SUB COOL	0.00	11	VMAXD2	COLD	MAX VELOCITY	0.00			
11	RFD1	FOUL RESISTANCE	0.00100	11	RFD2	FOUL RESISTANCE	0.00050	12	VMIND2	COLD	MIN VELOCITY	0.00			
12	FL1	FOUL LAYER THICK	0.00000	12	FL2	FOUL LAYER THICK	0.00000	13	PHAXD	TOTAL DP			0.00		
13	HSUBD	SUBCOOL H.T. COEF	0.00	13	HCD	H.T. COEFFICIENT	0.00								
14	HTPZD	2-PHASE H.T. COEF	0.00												

HOT FLUID (GEOSTEAM) PHYSICAL PROPERTIES										
CARD 31 PHYSICAL PROPERTY CONTROL										
COMPONENT 1										
NAME GEOSTEAM										
04 HMMND	0.0000									
05 ZNCG	0.									
06 APC	1.									
07 API	0.00									
08 HCF	0.00									
09 AMWL	0.00									
10 AMW	0.00									
11 ZD	0.0000									
12 DPCD	0.00									
13 OTCD	0.00									
14 OZCD	0.0000									
15 HLG0	0.00									
16 PZERO	0.									

HTRI SHELL AND TUBE CONDENSER PROGRAM			CST-1 MOD 1.1			HTRI VERSION			PAGE NO- 3		
INPUT DATA REPRINT			US UNITS			PROBLEM DESCRIPTION-MX STUDY			CASE-BHX3/R3		
COLD FLUID (ISOB+NHX) PHYSICAL PROPERTIES PROFILE											
40 PXP	ISOBARS	(K=1)	520.000				FPC	0.00	0.00	0.00	0.00
	(K)	I=1	I=2	I=3	I=4	I=5	I=6	I=7	I=8	I=9	I=10
41 TXP	1	330.00	320.00	310.00	300.00	280.00	250.00	220.00	180.00	140.00	80.00
42 QXFP											
43 YXP											
44 RDVP											
45 XMUVP											
46 XKVP											
47 HVXP											
48 CPVP											
50 ROLP	1	6.0728	6.5134	7.1301	8.1599	20.1950	25.7750	28.2440	30.5460	32.3730	34.6950
51 XMULP	1	.0144	.0145	.0148	.0153	.0438	.0590	.0718	.0891	.1088	.1467
52 XKLP	1	.0266	.0223	.0220	.0222	.0353	.0396	.0426	.0461	.0497	.0561
53 HLXP	1	235.7500	227.4300	218.2500	207.1200	151.0200	117.3500	93.8500	66.4300	41.3700	6.6400
54 CPLP	1	.8037	.8658	.9849	1.3084	1.8726	.8593	.7285	.6513	.6046	.5560
55 SIGP											
56 PCLP											

** INTEGRAL CONDENSING FLUID FLASH. CONDENSING FLUID -- GEOSTEAM **

	TEMPERATURE	WEIGHT FRACTION	FRACTION VAPOR	MOLE FRACTIONS IN VAPOR PHASE	MOLE FRACTIONS IN LIQUID PHASE
1	310.20	1.0000	1.0000	1.0000	0.0000
2	308.31	1.0000	1.0000	1.0000	0.0000
3	308.31	0.8571	0.8571	0.0000	0.0000
4	308.31	0.7143	0.7143	0.0000	0.0000
5	308.31	0.5714	0.5714	0.0000	0.0000
6	308.31	0.4286	0.4286	0.0000	0.0000
7	308.31	0.2857	0.2857	0.0000	0.0000
8	308.31	0.1429	0.1429	0.0000	0.0000
9	308.31	0.0000	0.0000	0.0000	0.0000
10	308.20	0.0000	0.0000	0.0000	0.0000

PRESSURE = 75.72 75.83 75.94

DEW POINT TEMPERATURE = 308.31
 BUBBLE POINT TEMPERATURE = 308.31

NOTE--THE BUBBLE AND DEW POINTS, AND LIQUID AND VAPOR MOLE FRACTIONS ARE AT THE LOWEST PRESSURE (75.72).

COMPONENT GEOSTEAM
 FEED FRACT 1.0000 0.0000 0.0000 0.0000 0.0000

COLD FLUID (ISOBARS+NMIX) PHYSICAL PROPERTIES PROFILE

PXP ISOBARS (K=1) 520.00

	(K)	I=1	I=2	I=3	I=4	I=5	I=6	I=7	I=8	I=9	I=10
TXP	1	330.00	320.00	310.00	300.00	280.00	250.00	220.00	180.00	140.00	80.00
QXFP	1	229.1100	220.7900	211.6100	200.4800	144.3800	110.7100	87.2100	59.7900	34.7300	0.0000
YXP	1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ROVP	1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
XMVUP	1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
XKVP	1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
HVXP	1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
CPVP	1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ROLP	1	6.0728	6.5134	7.1301	8.1599	20.1950	25.7750	28.2440	30.5460	32.3730	34.6950
XMULP	1	0.0144	0.0145	0.0148	0.0153	0.0438	0.0590	0.0718	0.0891	0.1088	0.1467
XKLP	1	0.0266	0.0223	0.0220	0.0222	0.0353	0.0396	0.0426	0.0461	0.0497	0.0561
HLXP	1	235.7500	227.4300	218.2500	207.1200	151.0200	117.3500	93.8500	66.4300	41.3700	6.6400
CPLP	1	0.8037	0.8658	0.9849	1.3084	1.8726	0.8593	0.7285	0.6513	0.6046	0.5560
SIGP	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PCLP	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
XLATP	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

PXP	ISOBARS	(K=1)	75.72	(K=2)	75.83	(K=3)	75.94	(K=4)	76.05	(K=5)	76.16	(K=6)	76.27	(K=7)	76.38	(K=8)	76.49	(K=9)	76.60	(K=10)	76.71	(K=11)	76.82	(K=12)	76.93	(K=13)	77.04	(K=14)	77.15	(K=15)	77.26	(K=16)	77.37	(K=17)	77.48	(K=18)	77.59	(K=19)	77.70	(K=20)	77.81	(K=21)	77.92	(K=22)	78.03	(K=23)	78.14	(K=24)	78.25	(K=25)	78.36	(K=26)	78.47	(K=27)	78.58	(K=28)	78.69	(K=29)	78.80	(K=30)	78.91	(K=31)	79.02	(K=32)	79.13	(K=33)	79.24	(K=34)	79.35	(K=35)	79.46	(K=36)	79.57	(K=37)	79.68	(K=38)	79.79	(K=39)	79.90	(K=40)	80.01	(K=41)	80.12	(K=42)	80.23	(K=43)	80.34	(K=44)	80.45	(K=45)	80.56	(K=46)	80.67	(K=47)	80.78	(K=48)	80.89	(K=49)	81.00	(K=50)	81.11	(K=51)	81.22	(K=52)	81.33	(K=53)	81.44	(K=54)	81.55	(K=55)	81.66	(K=56)	81.77	(K=57)	81.88	(K=58)	81.99	(K=59)	82.10	(K=60)	82.21	(K=61)	82.32	(K=62)	82.43	(K=63)	82.54	(K=64)	82.65	(K=65)	82.76	(K=66)	82.87	(K=67)	82.98	(K=68)	83.09	(K=69)	83.20	(K=70)	83.31	(K=71)	83.42	(K=72)	83.53	(K=73)	83.64	(K=74)	83.75	(K=75)	83.86	(K=76)	83.97	(K=77)	84.08	(K=78)	84.19	(K=79)	84.30	(K=80)	84.41	(K=81)	84.52	(K=82)	84.63	(K=83)	84.74	(K=84)	84.85	(K=85)	84.96	(K=86)	85.07	(K=87)	85.18	(K=88)	85.29	(K=89)	85.40	(K=90)	85.51	(K=91)	85.62	(K=92)	85.73	(K=93)	85.84	(K=94)	85.95	(K=95)	86.06	(K=96)	86.17	(K=97)	86.28	(K=98)	86.39	(K=99)	86.50	(K=100)	86.61	(K=101)	86.72	(K=102)	86.83	(K=103)	86.94	(K=104)	87.05	(K=105)	87.16	(K=106)	87.27	(K=107)	87.38	(K=108)	87.49	(K=109)	87.60	(K=110)	87.71	(K=111)	87.82	(K=112)	87.93	(K=113)	88.04	(K=114)	88.15	(K=115)	88.26	(K=116)	88.37	(K=117)	88.48	(K=118)	88.59	(K=119)	88.70	(K=120)	88.81	(K=121)	88.92	(K=122)	89.03	(K=123)	89.14	(K=124)	89.25	(K=125)	89.36	(K=126)	89.47	(K=127)	89.58	(K=128)	89.69	(K=129)	89.80	(K=130)	89.91	(K=131)	90.02	(K=132)	90.13	(K=133)	90.24	(K=134)	90.35	(K=135)	90.46	(K=136)	90.57	(K=137)	90.68	(K=138)	90.79	(K=139)	90.90	(K=140)	91.01	(K=141)	91.12	(K=142)	91.23	(K=143)	91.34	(K=144)	91.45	(K=145)	91.56	(K=146)	91.67	(K=147)	91.78	(K=148)	91.89	(K=149)	92.00	(K=150)	92.11	(K=151)	92.22	(K=152)	92.33	(K=153)	92.44	(K=154)	92.55	(K=155)	92.66	(K=156)	92.77	(K=157)	92.88	(K=158)	92.99	(K=159)	93.10	(K=160)	93.21	(K=161)	93.32	(K=162)	93.43	(K=163)	93.54	(K=164)	93.65	(K=165)	93.76	(K=166)	93.87	(K=167)	93.98	(K=168)	94.09	(K=169)	94.20	(K=170)	94.31	(K=171)	94.42	(K=172)	94.53	(K=173)	94.64	(K=174)	94.75	(K=175)	94.86	(K=176)	94.97	(K=177)	95.08	(K=178)	95.19	(K=179)	95.30	(K=180)	95.41	(K=181)	95.52	(K=182)	95.63	(K=183)	95.74	(K=184)	95.85	(K=185)	95.96	(K=186)	96.07	(K=187)	96.18	(K=188)	96.29	(K=189)	96.40	(K=190)	96.51	(K=191)	96.62	(K=192)	96.73	(K=193)	96.84	(K=194)	96.95	(K=195)	97.06	(K=196)	97.17	(K=197)	97.28	(K=198)	97.39	(K=199)	97.50	(K=200)	97.61	(K=201)	97.72	(K=202)	97.83	(K=203)	97.94	(K=204)	98.05	(K=205)	98.16	(K=206)	98.27	(K=207)	98.38	(K=208)	98.49	(K=209)	98.60</
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HTRI SHELL AND TUBE CONDENSER PROGRAM				CST-1 MOD 1.1		HTRI VERSION		PAGE NO- 66		
FINAL RESULTS				PROBLEM DESCRIPTION-MX STUDY				CASE-BHX3/R3		
COOLANT DESIGN- TUBESIDE HOT				COUNTERCURRENT		HORIZONTAL TEMA AEL SHELL WITH N.T.I.W. BUNDLE				
**** PROCESS DATA ****				COLD SHELLSIDE		HOT TUBESIDE		**** SHELLSIDE PERFORMANCE ****		
01	FLUID NAME			SUB+HEX		GEOSTEAM		01	NOM. VEL, X-FLOW/WINDOW	5.61/ 21.44
02	FLUID CONDITION			SENS. LIQUID		COND. VAPOR		02	FILM COEF, X-FLOW/WINDOW	391.8/ 0.0
03	TOTAL FLOW RATE (1.0E+3)(LB/HR)			2080.000		141.000		03	FLOW FRACTIONS FOR HEAT TRANSFER	.785
04	WEIGHT FRACTION VAPOR, IN/OUT (--)			0.000/ 0.000		1.000 / 0.000		04	A= .150 B= .730 C= .043 E= .077 F=0.000	
05	TEMPERATURE, IN/OUT (DEG F)			283.2/ 300.2		310.2 / 308.2		**** SHELLSIDE HEAT TRANSFER CORRECTIONS ****		
06	TEMPERATURE, AVERAGE/SKIN (DEG F)			291.7/ 298.0		309.2/ 306.1		TOTAL BETA GAMMA END FIN		
07	PRESSURE, INLET/AVERAGE (PSIA)			525.00/ 520.84		77.60/ 76.65		05	.420 .920 1.000 .998 1.000	
08	PRESSURE DROP, TOTAL/ALLOW (PSI)			8.32/ 10.00		1.89/ 5.00		**** PRESSURE DROPS **** (PERCENT OF TOTAL)		
09	VELOCITY, MID/MAX ALLOW (FT/SEC)			4.93/ 0.00		21.38/ 0.00		CROSS WINDOW ENDS NOZZLE SHELL TUBE		
10	AVERAGE FILM COEF (BTU/HR-FT ² -F)			359.92		3243.36		06	34.7 51.01 10.26 INLET 1.23 87.29	
11	HEAT TRANSFER SAFETY FACTOR (--)			1.000		1.000		07	RECOVERY 0.00 OUTLET 2.76 .84	
12	FOULING RESISTANCE (HR-FT ² -F/BTU)			.000500		.001000		**** CONDENSATION PARAMETERS ****		
13	OVERALL COEF, REQD/CLEAN/ACTUAL (BTU/HR-FT ² -F)			126.87/ 251.56/ 127.55				08	METHOD INLET CENTER OUTLET	
14	HEAT DUTY, REQUIRED/SPECIFIED (1.0E+6)(BTU/HR)			127.11500/ 0.00000				09	PRODRATION MODE SHEAR TRANS GRAVITY	
15	EFFECTIVE OVERALL TEMPERATURE DIFFERENCE (DEG F)			15.28				AVG MULTICOMPONENT H.T. CORR FACTOR .8561		
**** CONDENSER PERFORMANCE CRITERIA ****										
16	PRESSURE DROP RATIOS BASED ON							**** F.T. PARAMETERS ****		
17	SPECIFIED/REQUIRED AREAS, SHELLSIDE/TUBESIDE			1.002 / 1.001				10	MIDPOINT REYNOLDS NO	SHELL 282517 TUBE 6113
17	RATIO OF AREA SPECIFIED TO AREA REQUIRED			1.0054				11	BUNDLE INLET REYNOLDS NO	172697 39205
----- SEE NEXT PAGE FOR WARNING MESSAGES -----										
**** SHELL CONSTRUCTION INFORMATION ****										
21	SHELL TYPE E REAR HEAD FXTS			SHELL ID (IN) 75.000				**** SHELLSIDE NOZZLES ****		
22	SHELLS SERIES 1 PARALLEL			TOTAL AREA (FT ²) 66301				16	NUMBER AT EACH POSITION	INLET 1 OUTLET 1
23	PASSES SHELL 1 TUBE			EFF. AREA (FT ² /SHELL) 65557.4				17	DIAMETER (IN)	35.30 35.30
24	SHELL ORIENTATION ANGLE 0			(DEGREES FROM HORIZONTAL)				18	VELOCITY (FT/SEC)	5.99 13.46
25	PAIRS OF SEALING DEVICES 0			IMPINGEMENT PLATE INCLUDED NO				19	PRESSURE DROP (PSI)	.10 .23
26	WEIGHT ESTIMATION (LB/SHELL)			WET 218894 DRY 113423				20	HEIGHT UNDER NOZZLE (IN)	11.38 11.38
**** BAFFLE INFORMATION ****										
27	TYPE VERT			N.T.I.W. BAFFLE CUT (PCT DIA) 15.169				21	NOZZLE R-V-S (LB/FT-S ²)	656 1474
28	CROSSPASSES/SHELLPASS 8			NU. (PCT AREA) (IN TO C.L.) 26.124				22	SHELL R-V-S (LB/FT-S ²)	365 820
29	CENTRAL SPACING (IN) 71.352							**** TUBESIDE NOZZLES ****		
30	INLET SPACING (IN) 71.352							23	DIAMETER (IN)	12.10 8.10
31	OUTLET SPACING (IN) 71.352							24	VELOCITY (FT/SEC)	283.40 1.91
32	BAFFLE THICKNESS (IN) .500							25	PRESSURE DROP (PSI)	1.65 .02
**** TUBE INFORMATION ****										
33	TUBE TYPE (FINS/IN) 19			TUBECOUNT PER SHELL 1983				**** DIAMETRAL CLEARANCES (IN) ****		
34	OVERALL LENGTH (FT) 49.000			PCT TUBES REMOVED (30TH) 18.74				BAFFLE-TO-SHELL BUNDLE-TO-SHELL TUBE-TO-BAFFLEHOLE		
35	EFFECTIVE LENGTH (FT) 47.568			OUTSIDE DIAMETER (IN) 1.0000				29	.3299 .8750 .0246	
36	TOTAL TUBESHEET THICK (IN) 17.2			INSIDE DIAMETER (IN) .7890						
37	AREA RATIO (OUT/IN) 3.365			PITCH (IN) 1.3120 RATIO 1.432						
38				LAYOUT ANGLE (DEGREES) 90						

HTRI CSI-1 MOD 1.1 HTRI VERSION PAGE NO- 69
 PROBLEM DESCRIPTION-MX STUDY CASE-BHX3/R3

---**FLOW INDUCED VIBRATION ANALYSIS**--- SENS. LIQUID SHELLSIDE

01 LOG DECREMENT .0300 AXIAL STRESS LOADING U.O (KPSI)
 02 BETA 2.679 ADDED MASS FACTOR 2.5604 POSITION IN BUNDLE---

	INLET	CENTER	OUTLET
03 LENGTH FOR NATURAL FREQUENCY (FT)	2.973	2.973	2.973
04 LENGTH/TEMA MAXIMUM SPAN (---)	.679	.679	.679
05 NUMBER OF SPANS (---)	16	16	16
06 NATURAL FREQUENCY (FTUBE) (HZ)	37.56*	39.24	40.30

07 FLOW VELOCITIES
 08 WINDOW (PARALLEL FLOW) (FT/SEC) 11.80 18.25 26.52

10 C-STREAM VELOCITY (FT/SEC) 4.13 6.39 9.29
 11 E-STREAM VELOCITY (FT/SEC) 15.54 24.03 34.91

13 CROSSFLOW VELOCITY (FT/SEC) 3.03 4.69 6.82
 14 CRITICAL VELOCITY (FT/SEC) 3.71 4.62 5.57

15 CROSSFLOW REYNOLDS NUMBER (---) 160590. 262710. 411265.
 16 CROSSFLOW RHO-V-SQ (LB/FT-S2) 108. 260. 378.

17 FREQUENCY RATIOS (FVXSD)/(FTUBE) (---) .330 .510 .742

18
 19

20 DAMAGE NUMBERS
 21 BAFFLE (---) .0272 .0422 .0614
 22 COLLISION (---) .0096 .0149 .0216

23 RHO/SQRT(MU) (SEE STV-1, FIG 9-6) 59.3329 49.0730 42.2602

24 VIBRATION AMPLITUDES

25 CROSSFLOW-INDUCED (IN) .00493 .00892 .01889

SHELL PARAMETERS AT NOZZLES ENTRANCE EXIT
 26 IMPINGEMENT PLATE NO

27 FLOW AREA (FT2) 9.1097 9.1097
 28 VELOCITY (FT/SEC) 4.47 10.04
 29 RHO-V-SQ (LB/FT-S2) 365 820

30 TEMA E SHELL WITH VERT. N.T.I.W. BAFFLES AND FXTS BUNDLE

31 NUMBER OF INTERMEDIATE SUPPORT PLATES PER SPAN 1
 32 FINNED ADMIRALTY TUBES 1.0000 DIAMETER (IN) 90 DEGREE LAYOUT

33 PITCH RATIO 1.432

* FREQUENCY RATIOS ARE BASED ON THE LOWEST NATURAL FREQUENCY

APPENDIX H

HX#4 RUN SUMMARY, 365⁰F RESOURCE

(Page H-1 to H-5)

HTRI SHELL AND TUBE CONDENSER PROGRAM
INPUT DATA REPRINT

US UNITS
CST-1 MOD 1.1
PROBLEM DESCRIPTION-MA CONDENSER

HTRI VERSION

PAGE NO- 1
CASE-00A1/RJA

CARD 1 CONTROL INFORMATION

01	CIN	INPUT UNITS CODE	0.
02	COUT	OUTPUT UNITS CODE	0.
03	CCI	CALCULATION TYPE	1.
04	CHS	FLUID ALLOCATION	2.
05	CHB	HEAT DUTY CODE	4.
06	QDUTY	HEAT DUTY(1.0E6)	0.00000
07			
08			
09	CCM	CALCULATION METHOD	0.
10	FLASH	RIGOROUS FLASH CODE	0.
11	PURE	PURE CONDENSABLE	0.
12	POOL	POOL BOILING	0.
13			
14	CVIB	VIBRATION CODE	1.
15	EOA	SHELL ORIENTATION	0.

CARD 5 BASIC SHELL DESCRIPTION

01	TEMA	TEMA SHELL STYLE	AEL
02	CSI	SHELL CONSTRUCTION	1.*
03	CB1	REAR HEAD TYPE	1.*
04	DSO	SHELL ID	96.000
05			
06			
07	CTP	TUBE PASS CODE	0.
08	ZTPD	NO OF TUBE PASSES	1.
09	ZNSD	PAIRS SEAL DEVICES	0.
10	ZNSRD	NO OF SEAL RINGS	0.
11	DRDD	SEAL ROD DIAMETER	0.0000
12	SFFMD	SHELL FRICT MULT	1.0000*
13			
14			

CARD 12 TUBEFIELD DESCRIPTION

01	ZNTD	NO OF TUBES/SHELL	0.
02	DTU	TUBE OD	.7500
03	TTB	TUBE THICKNESS	.0650
04	TLOV	TUBE LENGTH	49.000
05	PT	TUBE PITCH	1.0620
06	TLA	TUBEFIELD PATTERN	90.
07	CMAT	TUBE MATERIAL CODE	41.
08	CTR	THERMAL CONDUCT	0.000
09	CFIN	TUBE TYPE	0.
10			
11	TLMAX	MAX TUBE LENGTH	55.000
12	TLINC	INCREMENT LENGTH	1.000
13	TFEFD	TUBE FRICT MULT	1.0000*
14	TFEFD	TUBE FRICT CODE	0.
15			

CARD 7 CONSTRUCTION INFORMATION

01	SFHS01	INLET H.T. PENALTY	1.000*
02	SFHS02	OUTLET H.T. PENALTY	1.000*
03	SFHS0	U-BEND H.T. PENALTY	0.000
04	HNT01	INLET NOZ HEIGHT	0.000
05	HNT02	OUTLET NOZ HEIGHT	0.000
06	DBDK	CLEARANCE CODE	0.
07	CEB	BAFFLE-SHELL CLEAR	0.0000
08	CAD	TUBE-BAFFLE CLEAR	0.0000
09	CUTLD	BUNDLE-SHELL CLEAR	0.0000
10	TSID	TUBESHEET THICK	0.0000
11	STRES	ALLOWABLE STRESS	0.00
12	CS3	DOUBLE TUBESHEET	0.
13	CS2	EXP JOINT CODE	0.
14	PPVN	NO VERT PASS LANE	0.
15	PPHN	NO HORIZ PASS LANE	0.
16	WPPV	WIDTH VERT LANES	0.000
17	WPPH	WIDTH HORIZ LANES	0.000

CARD 13 EXTERNAL TUBE GEOMETRY

01	XNF	NO OF FINS/LENGTH	0.00
02	XFH	FIN HEIGHT	0.0050
03	DFH	FIN ROOT DIAMETER	0.0000
04	XLF	FIN THICKNESS	0.0000
05	FARP	SURF AREA/LENGTH	0.000
06	TRTH	THICKNESS UNDER FIN	0.0000

CARD 16 VIBRATION INFORMATION

01	EMOD	TUB ELAST MODULUS	0.00
02	DTMAT	TUBE DENSITY	0.00
03	AXLD	AXIAL STRESS LOAD	0.
04	AMFD	ADDED MASS FACTOR	2.1353*
05	SUPPD	SUP PLATE/BAF SPACE	0.
06	CLDCO	VIB LOG DECREMENT	.0300*
07	CBFD	STABILITY CONSTANT	2.8622*
08			

CARD 6 BASIC BAFFLE GEOMETRY

01	CB2	BAFFLE TYPE	4.
02	BCC	BAFFLE ORIENTATION	0.
03	BCD	BAFFLE CUT (PCT)	0.00
04	FNWB	FRACT WINDOW AREA	0.00
05	RVDW	NTW RHO-V-SQUARED	5000.0*
06	HOVD	TUBE ROWS OVERLAP	0.00
07	ZCPD1	NO OF CROSSPASSES	0.
08	XLBCD1	CENTRAL BAF SPACE	0.000
09	XLBD1	INLET BAF SPACE	0.000
10	XLBD2	OUTLET BAF SPACE	0.000
11	XLBD	BAFFLE THICKNESS	0.0000
12	XLRTD	TUBEHOLE BAF THICK	0.0000
13	CEBS	EQUAL END SPACING	0.
14	CBSMX	MAX BAF SPACING	0.00
15	CB3	BAFFLE WINDOW	0.

CARD 10 NOZZLE INFORMATION

01	UNZDS1	SHELL-INLET NOZ ID	36.000
02	UNZDS2	SHELL-OUTLET NOZ ID	36.000
03	UNZDS3	SHELL-LIQUID NOZ ID	0.000
04	UNZUT1	TUBE-INLET NOZ ID	36.000
05	UNZUT2	TUBE-OUTLET NOZ ID	12.000
06	UNZUT3	TUBE-LIQUID NOZ ID	0.000
07	ADCC	ANGULAR DISTRIBUTION	0.
08	ALCD	ANN-DIST CLEARANCE	0.000
09	ADLD	ANN-DIST LENGTH	0.000
10	ADSA1	IN-DIST SECT AREA	0.000
11	ADSA2	OUT-DIST SECT AREA	0.000
12	ZNUZ1	NO NOZ SHELL INLET	1.*
13	ZNUZ2	NO NOZ SHELL OUTLET	1.*
14	CNUZ	NOZZLE ORIENTATION	0.
15	CFIC	IMPINGEMENT CODE	0.
16	RVD	RHO-V-SQUARED	1500.0*
17	CAXAL	TUBESIDE AXIAL NOZ	0.

** A * INDICATES **
** A DEFAULT VALUE **

CARD 8 VARIABLE BAFFLE SPACING

01	ZCPD2	CROSSPASSES REG-2	0.
02	XLBCD2	BAF SPACING REG-2	0.000
03	ZCPD3	CROSSPASSES REG-3	0.
04	XLBCD3	BAF SPACING REG-3	0.000
05	ZCPD4	CROSSPASSES REG-4	0.
06	XLBCD4	BAF SPACING REG-4	0.000
07	ZCPD5	CROSSPASSES REG-5	0.
08	XLBCD5	BAF SPACING REG-5	0.000

HTRI SHELL AND TUBE CONDENSER PROGRAM
INPUT DATA PERKINT US UNITS

EST-1 MOD 1.1
PROBLEM DESCRIPTION-MX CONDENSER

HTRI VERSION

PAGE NO- 2
CASE-BEX1/KJA

HOT FLUID NAME--ISOB+NHX				**COLD FLUID NAME--WATER**				*CARD 25* DP, VELOCITY, NOZZLE INFO			
CARD 20 PROCESS INFORMATION				*CARD 22* PROCESS INFORMATION							
01 FCON1	FLUID CONDITION	2.*		01 FCON2	FLUID CONDITION	0.		01 PMD1	HOT	ALLOWABLE DP	0.00
02 WOI	FLOW RATE(1.0E3)	670.00		02 WOI	FLOW RATE(1.0E3)	5245.00		02 PNMU11	HOT	MAXDP IN--NOZ	0.00
03 TIND1	INLET TEMPERATURE	142.60		03 TIND2	INLET TEMPERATURE	70.00		03 PNMU21	HOT	MAXDP OUT--NOZ	0.00
04 TOUTD1	OUTLET TEMPERATURE	60.50		04 TOUTD2	OUTLET TEMPERATURE	0.00		04 PD1	HOT	DESIGN PRESS	150.00*
05 PIND1	INLET PRESSURE	51.40		05 PIND2	INLET PRESSURE	50.00		06			
06 YIND1	INLET VAPOR QUALITY	1.000		06 YIND2	INLET VAPOR QUALITY	0.000		07 PMD2	COLD	ALLOWABLE DP	10.00
07 YOUTD1	EXIT VAPOR QUALITY	0.000*		07 YOUTD2	EXIT VAPOR QUALITY	0.000		08 PNMU12	COLD	MAXDP IN--NOZ	0.00
08 SFD1	H.T. SAFETY FACTOR	1.700		08 SFD2	H.T. SAFETY FACTOR	1.000*		09 PNMU22	COLD	MAXDP OUT--NOZ	0.00
09 TSHD1	COND. DEG. SUP. HEAT	0.00		09 TSHD2	COND. DEG. SUP. HEAT	0.00		10 PD2	COLD	DESIGN PRESS	150.00*
10 TSCD1	COND. DEG. SUB. COOL	0.00		10 TSCD2	COND. DEG. SUB. COOL	0.00		11 VHAXD2	COLD	MAX VELOCITY	0.00
11 RFD1	FOUL RESISTANCE	.00090		11 RFD2	FOUL RESISTANCE	.00100		12 VMIND2	COLD	MIN VELOCITY	0.00
12 FL1	FOUL LAYER THICK	0.0000		12 FL2	FOUL LAYER THICK	0.0000		13 PMAXD	TOTAL DP		0.00
13 HSUBD	SUBCOOL H.T. COEF	0.00		13 HCD	H.T. COEFFICIENT	0.00					
14 HTP2D	2-PHASE H.T. COEF	0.00									

COLD FLUID (WATER) 1 PHYSICAL PROPERTIES *CARD 31* PHYSICAL PROPERTY CONTROL	
COMPONENT	1
NAME	WATER
04 HMMND	1.0000
05 ZNCG	0.
06 APC	1.
07 API	0.00
08 HCF	0.00
09 AMAL	0.00
10 AMK	0.00
11 ZD	0.0000
12 UPCD	0.00
13 UTCO	0.00
14 UZCD	0.0000
15 HLCD	0.00
16 PZER0	0.

**HOT FLUID (ISOF+HCL) PHYSICAL PROPERTIES PROFILES*

40 PXP	ISOBARS	(K-1)	45.000	(K-2)	50.000	(K-3)	55.000	FPC	0.00	0.00	0.00	0.00
	(K)	I=1	I=2	I=3	I=4	I=5	I=6	I=7	I=8	I=9	I=10	
41 TXP	1	150.00	136.00	120.00	111.86	92.00	68.00	82.00	66.81	60.00	70.00	
	2	150.00	136.00	120.00	114.16	94.00	68.00	85.00	63.38	60.00	70.00	
	3	150.00	136.00	130.00	116.39	96.00	90.00	88.00	65.88	60.00	70.00	
42 QXFP	1	0.0000	6.4400	13.7000	17.3500	60.4320	91.1500	141.6200	172.9800	173.4600	179.0400	
	2	0.0000	6.4600	13.7300	16.3600	61.2900	94.6890	116.3200	171.3400	173.2500	178.8400	
	3	0.0000	4.6200	9.2100	15.3900	61.9990	98.0420	122.3000	169.6900	173.0400	178.6200	
43 YXP	1	1.0000	1.0000	1.0000	1.0000	.7588	.5610	.2176	0.0000	0.0000	0.0000	
	2	1.0000	1.0000	1.0000	1.0000	.7459	.5264	.1815	0.0000	0.0000	0.0000	
	3	1.0000	1.0000	1.0000	1.0000	.7339	.4967	.1306	0.0000	0.0000	0.0000	
44 ROVP	1	.4728	.4870	.5045	.6023	.5750	.5627	.5533	.5503	.5503	.5503	
	2	.4941	.5091	.5276	.6254	.5964	.5836	.5783	.5722	.5722	.5722	
	3	.5158	.5267	.5358	.6483	.6179	.6046	.5996	.5941	.5941	.5941	
45 XMUVP	1	.0085	.0083	.0081	.0080	.0078	.0077	.0077	.0076	.0076	.0076	
	2	.0085	.0083	.0081	.0080	.0078	.0077	.0077	.0077	.0077	.0077	
	3	.0085	.0084	.0083	.0081	.0079	.0078	.0078	.0077	.0077	.0077	
46 XKVP	1	.0125	.0119	.0114	.0111	.0105	.0103	.0102	.0102	.0102	.0102	
	2	.0125	.0119	.0114	.0111	.0106	.0104	.0104	.0103	.0103	.0103	
	3	.0125	.0121	.0117	.0113	.0107	.0105	.0104	.0104	.0104	.0104	
47 HVXP												
48 CPVP	1	.4639	.4573	.4499	.4463	.4369	.4342	.4324	.4319	.4319	.4319	
	2	.4649	.4583	.4511	.4486	.4391	.4364	.4358	.4346	.4346	.4346	
	3	.4658	.4612	.4567	.4508	.4413	.4387	.4378	.4369	.4369	.4369	
50 ROLP	1	36.2560	36.2560	36.2560	36.2560	35.2950	34.8260	34.4540	34.3350	34.3640	34.7460	
	2	36.1350	36.1350	36.1350	36.1350	35.1470	34.6790	34.4920	34.2360	34.3670	34.7460	
	3	36.0180	36.0180	36.0180	36.0180	35.0380	34.5300	34.3480	34.1400	34.3680	34.7490	
51 XMULP	1	.1694	.1694	.1694	.1694	.1546	.1467	.1411	.1393	.1399	.1474	
	2	.1667	.1667	.1667	.1667	.1512	.1439	.1412	.1374	.1399	.1474	
	3	.1641	.1641	.1641	.1641	.1485	.1413	.1386	.1356	.1399	.1474	
52 XKLP	1	.0569	.0569	.0569	.0569	.0560	.0553	.0548	.0546	.0547	.0559	
	2	.0566	.0566	.0566	.0566	.0556	.0550	.0547	.0543	.0547	.0559	
	3	.0563	.0563	.0563	.0563	.0553	.0546	.0543	.0540	.0547	.0559	
53 HLXP												
54 CPLP	1	.5733	.5733	.5733	.5733	.5660	.5642	.5631	.5627	.5621	.5547	
	2	.5750	.5750	.5750	.5750	.5677	.5659	.5654	.5647	.5621	.5546	
	3	.5766	.5766	.5766	.5766	.5694	.5677	.5672	.5667	.5621	.5546	
55 SIGP												
56 PCLP												

HTRI SHELL AND TUBE CONDENSER PROGRAM EST-1 MOD 1.1
 FINAL RESULTS PROBLEM DESCRIPTION-PA CONDENSER
 COOLANT DESIGN- TUBESIDE HOT COUNTERCURRENT

HTRI VERSION

PAGE NO- 00

CASE-CCAL/PA

ALT-5000

HORIZONTAL TEMA AEL SHELL WITH N.T.I.W. BUNDLE

**** PROCESS DATA ****

	COLD SHELLSIDE	HOT TUBESIDE
01 FLUID NAME	WATER	ISOBUTANE
02 FLUID CONDITION	SING. LIQUID	COND. VAPOR
03 TOTAL FLOW RATE (1.0E+3)(LB/HR)	5245.000	670.000
04 WEIGHT FRACTION VAPOR, IN/OUT (---)	0.000 / 0.000	1.000 / 0.000
05 TEMPERATURE, IN/OUT (DEG F)	70.0 / 71.0	142.6 / 80.5
06 TEMPERATURE, AVERAGE/SKIN (DEG F)	80.8 / 81.7	111.6 / 87.5
07 PRESSURE, INLET/AVERAGE (PSIA)	50.00 / 45.02	51.40 / 50.76
08 PRESSURE DROP, TOTAL/ALLOW (PSI)	9.95 / 10.00	1.28 / 0.00
09 VELOCITY, MID/MAX ALLOW (FT/SEC)	1.87 / 0.00	15.45 / 0.00
10 AVERAGE FILM COEF (BTU/HR-FT ² -F)	1097.34	474.38
11 HEAT TRANSFER SAFETY FACTOR (---)	1.000	1.700
12 FOULING RESISTANCE (HR-FT ² -F/BTU)	.00100	.000900

**** SHELLSIDE PERFORMANCE ****

01 NOM. VEL, X-FLOW/WINDUP	2.42	4.96
02 FILM COEF, X-FLOW/WINDUP	1193.57	0.0
03 FLOW FRACTIONS FOR HEAT TRANSFER	.727	
04 A = .159 B = .073 C = .017 E = .152 F = 0.000		

**** SHELLSIDE HEAT TRANSFER CORRECTIONS ****

	BETA	GAMMA	END	FIN
05 TOTAL	.920	.920	1.000	.999

**** PRESSURE DROPS **** (PERCENT OF TOTAL)

	CROSS WINDOW	ENDS	NOZZLE	SHELL	TUBE
06 TOTAL	62.05	25.33	10.06	.90	12.43
07 RECOVERY	0.00	0.00	0.00	.90	9.00

**** CONDENSATION PARAMETERS ****

	METHOD	INLET	CENTER	OUTLET
08 PROXIMATION	MODL ANN-MIST	TRANS	GRAVITY	
09 AVG MULTICOMPONENT H.T. CORR FACTOR				.6351

**** CONDENSER PERFORMANCE CRITERIA ****

13 OVERALL COEF, REQ'D/CLEAN/ACTUAL (BTU/HR-FT ² -F)	174.75 / 283.07 / 177.69
14 HEAT DUTY, REQ'D/SPECIFIED (1.0E+6)(BTU/HR)	113.58242 / 0.00000
15 EFFECTIVE OVERALL TEMPERATURE DIFFERENCE (DEG F)	12.34

**** H.T. PARAMETERS ****

	SHELL	TUBE
10 MIDPOINT REYNOLDS NO	13982	15301
11 BUNDLE INLET REYNOLDS NO	11969	16011
12 BUNDLE OUTLET REYNOLDS NO	15400	9832
13 FOULING LAYER (IN)	0.00000	0.00000

**** THERMAL RESISTANCES **** (PLT OVERALL)

	SHELL	TUBE	FOULING	METAL	OVER DES
14	16.71	45.36	37.16	1.578	1.779
15 TOTAL FOULING RESISTANCE					.002089

**** SHELL CONSTRUCTION INFORMATION ****

21 SHELL TYPE	E	REAR HEAD FXIS	SHELL ID (IN)	96.000
22 SHELLS SERIES	1	PARALLEL	TOTAL AREA (FT ²)	53640
23 PASSES SHELL	1	TUBE	EFF. AREA (FT ² /SHELL)	52666.6
24 SHELL ORIENTATION ANGLE	0	(DEGREES FROM HORIZONTAL)		
25 PAIRS OF SEALING DEVICES	0	IMPINGEMENT PLATE INCLUDED	NO	
26 WEIGHT ESTIMATION (LB/SHELL)	WLT	399648	DRY	198173

**** BAFFLE INFORMATION ****

	VERT	N.T.I.W.	BAFFLE CUT (PCT DIA)	15.000
27 TYPE			NO. (PCT AREA) (IN TO C.L.)	
28 CROSSPASSES/SHELLPASS	13		13.608	33.600
29 CENTRAL SPACING (IN)	48.942			
30 INLET SPACING (IN)	48.942			
31 OUTLET SPACING (IN)	48.942			
32 BAFFLE THICKNESS (IN)	.750			

**** SHELLSIDE NOZZLES ****

	INLET	OUTLET
16 NUMBER AT EACH POSITION	1	1
17 DIAMETER (IN)	36.00	36.00
18 VELOCITY (FT/SEC)	3.31	3.32
19 PRESSURE DROP (PSI)	.10	.10
20 HEIGHT UNDER NOZZLE (IN)	14.40	14.40
21 NOZZLE R-V-SO (LB/FT-S ²)	602	602
22 SHELL R-V-SO (LB/FT-S ²)	220	227

**** TUBESIDE NOZZLES ****

	INLET	OUTLET
23 DIAMETER (IN)	36.00	12.00
24 VELOCITY (FT/SEC)	50.89	6.92
25 PRESSURE DROP (PSI)	.16	.12

**** TUBE INFORMATION ****

33 TUBE TYPE	PLAIN	TUBE COUNT PER SHELL	5059
34 OVERALL LENGTH (FT)	54.000	PCT TUBES REMOVED (BOUN)	10.44
35 EFFECTIVE LENGTH (FT)	53.020	OUTSIDE DIAMETER (IN)	.7500
36 TOTAL TUBESHEET THICK (IN)	11.8	INSIDE DIAMETER (IN)	.6250
37 AREA RATIO (OUT/IN)	1.210	PITCH (IN)	1.0620
38		LAYOUT ANGLE (DEGREES)	90

**** DIAMETRAL CLEARANCES (IN) ****

29	.4237	.8750	.0150
----	-------	-------	-------

HTRI CST-1 MOD 1.1 HTRI VERSION PAGE NO- 63
 PROBLEM DESCRIPTION-MX CONDENSER CASE-BLX17FJA

FLOW INDUCED VIBRATION ANALYSIS SENS. LIQUID SHELLSIDE

01 LOG DECREMENT .0300 AXIAL STRESS LOADING 0.0 (KPSI)
 02 BETA 2.862 ADDED MASS FACTOR 2.1353 POSITION IN BUNDLE

	INLET	CENTER	OUTLET
03 LENGTH FOR NATURAL FREQUENCY (FT)	4.078	4.078	4.078
04 LENGTH/TEMA MAXIMUM SPAN (---)	.941	.941	.941
05 NUMBER OF SPANS (---)	13	13	13
06 NATURAL FREQUENCY (FTUBE) (HZ)	17.08*	17.08	17.09

07 FLOW VELOCITIES

08 WINDOW (PARALLEL FLOW) (FT/SEC)	4.16	4.17	4.18
09 C-STREAM VELOCITY (FT/SEC)	1.38	1.38	1.38
10 E-STREAM VELOCITY (FT/SEC)	10.70	10.72	10.74
11 CROSSFLOW VELOCITY (FT/SEC)	1.87	1.87	1.88
12 CRITICAL VELOCITY (FT/SEC)	1.03	1.03	1.03

15 CROSSFLOW REYNOLDS NUMBER (---)	11056	12456	14283
16 CROSSFLOW RHO-V-SQ (LB/FT-SQ)	217	218	218
17 FREQUENCY RATIOS (FVXSD)/(FTUBE) (---)	.555	.556	.557

18 DAMAGE NUMBERS

21 RAFFLE (---)	.0407	.0407	.0408
22 COLLISION (---)	.0791	.0793	.0795
23 RHO/SORTIMU (SEE STV-1, FIG 9-6)	40.4634	42.8701	45.8007

24 VIBRATION AMPLITUDES

25 CROSSFLOW-INDUCED (IN)	.02902	.02911	.02922
---------------------------	--------	--------	--------

26 SHELL PARAMETERS AT NOZZLES

	ENTRANCE	EXIT
27 IMPINGEMENT PLATE NO		
28 FLOW AREA (FT ²)	12.0058	12.0058
29 VELOCITY (FT/SEC)	1.95	1.96
29 RHO-V-SQ (LB/FT-SQ)	236	237

30 TEMA E SHELL WITH VERT N.T.I.W. BAFFLES AND FATS BUNDLE
 31 NUMBER OF INTERMEDIATE SUPPORT PLATLS PER SPAN 0
 32 PLAIN ADMIRALTY TUBES .7500 DIAMETER (IN) 90 DEGREE LAYOUT
 33 PITCH RATIO 1.416

* FREQUENCY RATIOS ARE BASED ON THE LOWEST NATURAL FREQUENCY

APPENDIX I

HX#1 RUN SUMMARY, 450⁰F RESOURCE

(Page I-1 to I-4)

HTRI SHELL AND TUBE HEAT EXCHANGER PROGRAM ST-4 MOD 5.2
 INPUT DATA REPRINT US UNITS PROBLEM DESCRIPTION-MX STUDY

HTRI VERSION

PAGE NO- 1
 CASEI-AH71/P4

CARD 1 CONTROL INFORMATION			*CARD 2* SHELLSIDE INFORMATION			*CARD 3* SHELL, BUNDLE AND BAFFLE		
01 CIN	INPUT UNITS CODE	0.	01 CUSD	SEAL STRIP CODE	0.	01 BSD	SHELL ID	0.000
02 COUT	OUTPUT UNITS CODE	0.	02 ZNSD	PAIRS OF STRIPS	0.	02 BCD	BAFFLE CUT (PCT)	0.00
03 CCI	CALCULATION TYPE	1.*	03 USMAX	MAX SHELL SIZE	200.000	03 ENBR	FRACL VINDOS AREA	0.000
04 CHS	FLUID ALLOCATION	2.	04 USMIN	MIN SHELL SIZE	0.000	04 ROVD	TUBE PASS OVERLAP	0.0
05 CHE	HEAT DUTY CODE	3.	05 UMAX	MAX OVERALL CUEF	0.00	05 ZCPD	NO OF CROSS-PASSES	0.
06 QDUTY	HEAT DUTY(1.0E6)	0.00000	06 RVD	RHO-V-SQUARED	1500.000*	06 XLBCD	CENTRAL BAF SPACE	0.0000
07 CIP	TUBE PASS CODE	0.	07 CFTC	TUBE COUNT CODE	0.	07 XLBID	INLET BAF SPACING	0.0000
08 ZTPD	NO OF TUBE PASSES	1.	08 HNTD1	INLET HEIGHT	0.000	08 XLB2D	OUTLET BAF SPACING	0.0000
09 ZMSD	SHELLS IN SERIES	5.	09 HNTD2	OUTLET HEIGHT	0.000	09 PPHN	NO VERT PASS LANE	0.
10 ZMPD	SHELLS IN PARALLEL	1.*	10 SFHS1	INLET PENALTY	1.00*	10 PPHN	NO HORIZ PASS LANE	0.
11 CSI	SHELL CONSTRUCTION	1.*	11 SFHS2	OUTLET PENALTY	1.00*	11 WPPV	WIDTH VERT LINES	0.00
12 CTRH	EXCHANGER TYPE	0.	12 CEBS	EQUAL END SPACING	0.	12 WPPH	WIDTH HORIZ LINES	0.00
13 CH1	REAR HEAD TYPE	1.	13 CNUZ	NOZZLE ORIENTATION	0.	13 XLBD	BAFFLE THICKNESS	0.0000
14 CB2	BAFFLE TYPE	4.	14 CB3	WINDOW CONSTRUCT	0.	14 XLBID	TUBEHOLE BAF THIN	0.0000
15 RCC	BAFFLE ORIENTATION	0.	15 DBDK	CLEARANCE CODE	0.	15 GHEF3	LONG BAFFLE CODE	0.
16 GOUTS	TUBESIDE STEPWISE	1.	16 CED	BAF-SHELL CLEAR	0.0000	16 GDDIC	DELTA LMT CORR	1.
17			17 CAD	TUBE-BAF CLEAR	0.0000	17 DUBNZ	MULTIPLE NOZ CODE	1.*
18 GOMEX	SERIES STEP EVAL	0.	18 COTLD	BUND-SHELL CLEAR	0.0000	18		
19 CQPI	OUTPUT CODE	0.	19 GDDPS	SHELLSIDE DP USE	1.	19 TEMA	TEMA SHELL STYLE	ALL*
20 CMON	MONITOR CODE	1.	20 GDSMX	MAX BAF SPACING	0.000	20 CAXAC	TUBESIDE AXIAL REV	1.
21 CARR	AUTO REKATE CODE	0.	21 PMAX	TOTAL DP	0.00			
CARD 4 TUBESIDE INFORMATION			*HOT FLUID NAME -GEOLFLUID			*COLD FLUID NAME -ISOL*PM*		
01 TLOV	TUBE LENGTH	20.000	*CARD 6* PROCESS INFORMATION			*CARD 8* PROCESS INFORMATION		
02 TLMAX	MAXIMUM LENGTH	60.000	01 FCON1	FLUID CONDITION	0.	01 FCON2	FLUID CONDITION	0.
03 TLINC	LENGTH INCREMENT	5.000	02			02		
04 PT	TUBE PITCH	1.3120	03 WDI	FLOW RATE(1.0E3)	1202.00	03 WDI	FLOW RATE(1.0E3)	2103.00
05 TLA	LAYOUT ANGLE	90.	04 TIND1	INLET TEMPERATURE	333.60	04 TIND2	INLET TEMPERATURE	333.60
06 ZTUD	NO OF TUBES/SHELL	0.	05 TOUT1	OUTLET TEMPERATURE	0.00	05 TOUT2	OUTLET TEMPERATURE	273.00
07 TID	TUBE ID	1.0000	06 PII	INLET PRESSURE	111.10	06 PII	INLET PRESSURE	609.00
08 TID	TUBE THICKNESS	0.050	07 FFD1	FUOL RESISTANCE	0.00100	07 FFD2	FUOL RESISTANCE	0.00000
09 CMAT	TUBE MATERIAL CODE	41.	08 FL1	FUOL LAYER THICK	0.0000	08 FL2	FUOL LAYER THICK	0.0000
10 CTX	THERMAL CONDUCT	0.000	09 HCT	HEAT TRANS CUEF	0.0	09 HCT	HEAT TRANS CUEF	0.00
11 CFIN	FINNED TUBE CODE	1.	10 SF1	SAFETY FACTOR	1.000*	10 SF2	SAFETY FACTOR	1.000*
12 XNF	NO OF FINS/LENGTH	19.00	11 YIN1	INLET VAPOR QUAL	0.000	11 YIN2	INLET VAPOR QUAL	0.000
13 XFH	FIN HEIGHT	0.0570	12 YEX1	EXIT VAPOR QUALITY	0.000	12 YEX2	EXIT VAPOR QUALITY	0.000
14 PER	FIN ROOT DIAMETER	0.8770	13 TSH1	COND DEG SUB HEAT	0.00	13 TSH2	COND DEG SUB HEAT	0.00
15 XLF	FIN THICKNESS	0.0180	14 TSC1	COND DEG SUB COOL	0.00	14 TSC2	COND DEG SUB COOL	0.00
16 FAPP	SURF AREA/LENGTH	0.695						
17 TRTH	THICKNESS UNDER FIN	0.0440						
CARD 5 TUBESHEET AND VIBRATION			*CARD 7* MAXIMUM DP AND VELOCITY			*CARD 9* MAXIMUM DP AND VELOCITY		
01 TSID	TUBESHEET THICK	0.0000	01 PM1	ALLOWABLE DP	10.00	01 PM2	ALLOWABLE DP	15.00
02 CS2	EXP JOINT CODE	0.	02 VML	MAXIMUM VELOCITY	0.00	02 VM2	MAXIMUM VELOCITY	0.0
03 CS3	DOUBLE TUBESHEET	0.	03 PMM1	MAX NOZZLE DP(PCT)	0.00	03 PMT	MAX NOZZLE DP(PCT)	0.00
04 STRES	ALLOWABLE STRESS	0.00	04 DNZ11	INLET NOZZLE ID	0.000	04 DNZ12	INLET NOZZLE ID	0.000
05 CVIB	VIBRATION CODE	1.	05 DNZ21	OUTLET NOZZLE ID	0.000	05 DNZ22	OUTLET NOZZLE ID	0.000
06 EMOD	ELASTIC MODULUS	0.000	06 PD1	DESIGN PRESSURE	0.00	06 PD2	DESIGN PRESSURE	0.0
07 DTMAT	TUBE DENSITY	0.00	07			07		
10 RE1	0.0300*	11 RE2	08 VMIN1	MINIMUM VELOCITY	0.00	08 VMIN2	MINIMUM VELOCITY	0.00
12 CJ1	0.	13 CJ2				09 F12	FM	0.0
14 CF1	2.6791*	15 CF2				10 F22	TOTAL ALKALINITY	0.
						11 F12	CALCIUM HARDNESS	0.
						12 F42	TOT DISSOLVED SOLID	0.

** A * INDICATES **
 ** A DEFAULT VALUE **

HTRI SHELL AND TUBE HEAT EXCHANGER PROGRAM ST-4 MOD 5.2
 INPUT DATA REPRINT US UNITS PROBLEM DESCRIPTION-MX STUDY

HTRI VERSION -

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 CASE-AHX1/P4

HOT FLUID (GEOFLUID) PHYSICAL PROPERTIES

COMPONENT 1
 NAME GEOFLUID

CARD 10 PHYSICAL PROPERTY CONTROL

03 HMMN 0.0000
 04 APC 1.
 05 API 0.00
 06 AMW 0.00
 07 HCF 0.00
 08 PZERO 0.

CALCULATED PHYSICAL PROPERTY CONSTANTS

D.B. NAME WATER
 MOL FRACT 1.0000
 WT. FRACT 1.0000
 MOL WT. 18.02
 CRIT TEMP 1165.20
 CRIT PRES 3208.20
 TEMPERATURE LIMITS
 UPPER 1165.20
 LOWER 494.69

CALCULATED MIXTURE VALUES

MOLECULAR WEIGHT 18.02
 CRITICAL VALUES-TEMPERATURE 1165.20 PRESSURE 3208.20
 TEMPERATURE LIMITS-UPPER 1165.20 LOWER 494.69

HTRI SHELL AND TUBE HEAT EXCHANGER PROGRAM ST-4 MOD 5.2
 INPUT DATA REPRINT US UNITS PROBLEM DESCRIPTION-MX STUDY

HTRI VERSION -

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COLD FLUID (ISOB+NHX) PHYSICAL PROPERTIES PROFILE

40 PXP FPC	ISOBARS	(K=1) 670.000 0.00	(K=2) 680.000 0.00	(K=3) 690.000 0.00	(K=4) 700.000 0.00	(K=5) 710.000 0.00	(K=6) 720.000 0.00	(K=7) 730.000 0.00	(K=8) 740.000 0.00	(K=9) 750.000 0.00	(K=10) 760.000 0.00
41 TXP	(K)	1-1 330.00	1-2 320.00	1-3 310.00	1-4 300.00	1-5 280.00	1-6 250.00	1-7 220.00	1-8 180.00	1-9 140.00	1-10 80.00
43 YXP	2	330.00	320.00	310.00	300.00	280.00	250.00	220.00	180.00	140.00	80.00
44 RQVP											
45 XQVVP											
46 XKVP											
47 HXVP											
48 CPVP											
50 FBLP	1	11.2900	13.4070	16.1400	19.0790	23.2490	26.5230	28.6410	30.7780	32.6290	34.7220
	2	11.7550	13.8950	16.5880	19.3910	23.3590	26.5660	28.6660	30.7930	32.5370	34.7280
51 XMULP	1	.0201	.0251	.0338	.0403	.0502	.0627	.0745	.0914	.1110	.1400
	2	.0209	.0267	.0347	.0409	.0505	.0629	.0747	.0916	.1111	.1401
52 XKLP	1	.0265	.0289	.0325	.0347	.0376	.0408	.0434	.0467	.0503	.0560
	2	.0270	.0296	.0328	.0349	.0378	.0407	.0434	.0467	.0503	.0560
53 HLXP	1	211.5700	197.3300	181.8900	164.6100	142.3200	115.7500	93.3300	66.4100	41.5700	6.2900
	2	207.7100	195.6300	180.4600	165.6800	142.0300	115.6600	93.3100	66.4100	41.5800	7.0700
54 CPLP	1	1.3114	1.5088	1.9687	1.4905	1.0211	.7957	.7082	.6436	.6098	.5544
	2	1.3288	1.4868	1.5243	1.3989	1.0062	.7927	.7071	.6431	.6095	.5543
55 SIGP											
56 PCLP											

** CARD 42 (OXF) AND CARD 49 (PCVP) ARE NOT USED IN THE ST-4 PROGRAM **

FINAL RESULTS PROBLEM DESCRIPTION-MX STUDY

CASE-447184

DESIGN CASE COUNTERCURRENT FLOW IN A T.E.M.A. AEL SHELL WITH N.T.I.W. BUNDLE

ALT. SHELL-4

*** PROCESS DATA ***				*** SHELLSIDE PERFORMANCE ***			
01 FLUID NAME	ISOB*NMEX	COLD SHELLSIDE	HOT TUBESIDE	01 NOM. VEL, X=FLOW/AREA	1.097	12.75	
02 FLUID CONDITION	SENS. LIQUID	ISOB*NMEX	SENS. LIQUID	02 FILM COEF, X=FLOW/AREA	284.07	3.	
03 TOTAL FLOW RATE (1.0E+3)(LB/HR)	2163.000		1202.000	03 FLOW FRACTIONS	FOR HEAT TRANSFER	0.70	
04 TEMPERATURE, IN/OUT (DEG F)	90.6 / 278.9		333.6 / 104.5	04 A=.071 B=.848 C=.043 D=.038 E=.000			
05 TEMPERATURE, AVERAGE/SKIN (DEG F)	184.8 / 194.9		219.1 / 206.0	*** SHELLSIDE HEAT TRANSFER CORRECTIONS ***			
06 PRESSURE, INLET/AVERAGE (PSIA)	680.00 / 672.50		111.10 / 106.10	05 TOTAL	BETA	GAMA	END
07 PRESSURE DROP, TOTAL/ALLOW (PSI)	14.90 / 15.00		2.57 / 10.00	06 .920	.920	1.000	.998 1.000
08 VELOCITY, CALC./MAX.ALLOW (FT/SEC)	1.83 / 0.00		1.79 / 0.00	*** PRESSURE DROPS *** (PERCENT TOTAL DP)			
09 FILM COEF (SAF.FACT) (BTU/HR-FT ² -F)	261.24 (1.00)		682.82 (1.00)	07 WIND	65.72	NOZZLE	SHELL
10 FOULING RESISTANCE (HR-FT ² -F/BTU)	.00050		.00100	08 END	8.73	(IN/OUT)	TUBE
11 DENSITY (LB/FT ³)	30.5283		59.6813	*** H.T. PARAMETERS ***			
12 THERMAL CONDUCTIVITY (BTU/HR-FT-F)	.0463		.3850	09 WALL CORRECTION		SHELL	TUBE
13 SPECIFIC HEAT CAPACITY (BTU/LB-F)	.6511		1.0036	10 PRANDTL NO.		3.0	1.7
14 VISCOSITY AT AVERAGE TEMP (CP)	.03945		.27267	11 AVERAGE REYNOLDS NO.		73322	38451
15 VISCOSITY AT SKIN TEMP (CP)	.08516		.29366	12 BUNDLE INLET REYNOLDS NO.		46664	65269
*** OVERALL PERFORMANCE DATA *** (TUBESIDE STEPPED)				13 BUNDLE OUTLET REYNOLDS NO.		130011	15862
16 TOTAL HEAT DUTY REQUIRED (1.0E+6)(BTU/HR)	277.645925			14 FOULING LAYER		0.0000	0.0000
17 EFFECTIVE MD, (LMTD)(F)(DELTA) = (DEG F)	29.81(1.00)(1.00) = 29.8			*** THERMAL RESISTANCES *** (PCI. OVERALL)			
18 F FACTOR=(TUBE)(BAFFLES)(F/G)(HOT/COLD)=(1.000)(1.000)(1.000)(1.000)				15 SHELL TUBE FOULING		METAL	OVERALL
19 OVERALL COEF, REQ/CLEAN/ACTUAL(BTU/HR-FT ² -F)	73.61 / 110.42 / 77.39			16 29.63	38.14	29.91	2.32
*** CONSTRUCTION INFORMATION ***				17 TOTAL FOULING RESISTANCE			.10365
20 NO. SHELLS SERIES 5 PARALLEL 1				18 DIFFERENTIAL RESISTANCE			.00006
21 NO. PASSES SHELL 1 TUBE 1				*** SHELL NOZZLE INFO. ***			
22 SHELL I.D. (IN) 52.000				19 INSIDE DIAMETER		(IN)	29.3
23 BAFFLE TYPE VERT N.T.I.W.				20 VELOCITY		(FT/SEC)	3.74
24 CENTRAL SPACING (IN) 95.200				21 DENSITY		(LB/FT ³)	34.399
25 INLET SPACING (IN) 95.200				22 NOZZLE R-V-SQ		(LP/FT-SQ)	402
26 OUTLET SPACING (IN) 95.200				23 BUNDLE R-V-SQ		(LP/FT-SQ)	370
27 BAFFLE THICKNESS (IN) .625				24 HEIGHT UNDER NOZZLE		(IN)	5.4
28 NO. PAIRS SEAL DEVICES 0				*** TUBE NOZZLE INFO. ***			
29 TOT.TUBESHEET THICK.(IN) 4.0				25 INSIDE DIAMETER		(IN)	17.3
30 TUBE TYPE (FINS/IN) 19				26 VELOCITY		(FT/SEC)	3.69
31 OVERALL LENGTH (FT) 40.000				27 DENSITY		(LB/FT ³)	56.304
32 EFFECTIVE LENGTH (FT) 39.667				*** DIAMETRAL CLEARANCE S ***			
33 LAYOUT ANGLE (DEG) 90				28 BAFFLE-TO-SHELL		(IN)	.2272
34 PITCH RATIO 1.432				29 BUNDLE-TO-SHELL		(IN)	.6255
35 FIN TUBE EQ. DIA. (IN) .916				30 TUBE-TO-BAFFLEHOLE		(IN)	.0246
36 WEIGHT ESTIMATION (LB/SHELL)				31 MULTI-SEG. BAFFLE OVERLAP		(IN)	0.000
				32 FIN EFFICIENCY=.950		FIN RESIST.=	.00015

***** SEE FOLLOWING PAGES FOR CALCULATION WARNING MESSAGES *****

HTRI ST-4 MOD 5.2
 PROBLEM DESCRIPTION-MX STUDY

HTRI VERSION

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 CASE-AHX1/R4

FLOW INDUCED VIBRATION ANALYSIS		SENS. LIQUID SHELLSIDE		
01	LOG DECREMENT .0300 AXIAL STRESS LOADING	0.0 (KPSI)		
02	BETA 2.679 ADDED MASS FACTOR 2.5604	POSITION IN BUNDLE		
		INLET	CENTER	OUTLET
03	LENGTH FOR NATURAL FREQUENCY (FT)	7.933	7.933	7.933
04	LENGTH/TEMA MAXIMUM SPAN (---)	1.813	1.813	1.813
05	NUMBER OF SPANS (---)	5	5	5
06	NATURAL FREQUENCY(FTUBE) (HZ)	4.70*	4.78	4.95
07	FLOW VELOCITIES			
08	WINDOW (PARALLEL FLOW) (FT/SEC)	10.51	11.85	15.51
09				
10	C-STREAM VELOCITY (FT/SEC)	1.83	2.06	2.70
11	E-STREAM VELOCITY (FT/SEC)	7.04	7.93	10.59
12				
13	CROSSFLOW VELOCITY (FT/SEC)	1.62	1.83	2.39
14	CRITICAL VELOCITY (FT/SEC)	.41	.43	.50
15	CROSSFLOW REYNOLDS NUMBER (---)	44542.	70901.	125717.
16	CROSSFLOW RHG-V-SQ (LB/FT-SQ)	91.	102.	134.
17	FREQUENCY RATIOS (FVX50)/(FTUBE) (---)	1.411	1.590	2.012
18				
19				
20	DAMAGE NUMBERS			
21	BAFFLE (---)	.0850	.0958	.1255
22	COLLISION (---)	.2663	.3001	.3929
23	RHG/SQRT(MU) (SEE STV-1, FIG 9-6)	58.6026	65.6166	66.7303
24	VIBRATION AMPLITUDES			
25	CROSSFLOW-INDUCED (IN)	(.12259)	(.09504)	(.06172)
BUNDLE PARAMETERS AT NOZZLES		ENTRANCE	EXIT	
26	IMPIINGEMENT PLATE (FT2)	5.3270	4.7715	
27	FLOW AREA (FT2)	3.28	5.40	
28	VELOCITY (FT/SEC)	370.	680.	
29	RHG-V-SQ (LB/FT-SQ)			
30	TEMA E SHELL WITH VERT N.T.I.W. BAFFLES AND EXTS BUNDLE			
31	NUMBER OF INTERMEDIATE SUPPORT PLATES PER SPAN	0		
32	FINNED ADMIRALTY TUBES 1.0000 DIAMETER (IN)	90 DEGREE LAYOUT		
33	PITCH RATIO 1.432			

* FREQUENCY RATIOS ARE BASED ON THE LOWEST NATURAL FREQUENCY
 () FREQUENCY RATIOS ARE GREATER THAN ONE. VALUES OF THESE ITEMS ARE
 CALCULATED FOR THE FIRST MODE ONLY. CHECK HIGHER MODES

APPENDIX J

HX#2 RUN SUMMARY, 450°F RESOURCE

(Page J-1 to J-4)

CARD 1 CONTROL INFORMATION			*CARD 2* SHELLSIDE INFORMATION			*CARD 3* SHELL, BUNDLE AND BAFFLE		
01 CIN	INPUT UNITS CODE	0.	01 CSD	SHELL STRIP CODE	0.	01 DSD	SHELL ID	0.000
02 COUT	OUTPUT UNITS CODE	0.	02 ZASD	PAIRS OF STRIPS	0.	02 BCD	BAFFLE CUT (PCT)	0.00
03 CCI	CALCULATION TYPE	1.	03 DSMAX	MAX SHELL SIZE	200.000	03 FNXB	FRACT WINDOW AREA	0.000
04 CDS	FLUIDS ALLOCATION	2.	04 DSMIN	MIN SHELL SIZE	0.000	04 HNOV	TUBE ROWS OVERLAP	0.00
05 CHT	HEAT DUTY CODE	3.	05 DSMAX	MAX OVERALL CDEF	0.00	05 ZCPE	NO OF CROSSPASSES	0.
06 CHTY	HEAT DUTY (1.0E6)	0.00000	06 FVD	FHD-V-SQUARED	1500.000*	06 XLBCD	CENTRAL BAF SPACE	0.0000
07 CTP	TUBE PASS CODE	0.	07 CHTC	TUBE COUNT CODE	0.	07 XLBID	INLET BAF SPACING	0.0000
08 ZTPD	NO OF TUBE PASSES	1.	08 HHTL	INLET HEIGHT	0.000	08 XLB2D	OUTLET BAF SPACE	0.0000
09 ZNSD	SHELLS IN SERIES	5.	09 HHTC2	OUTLET HEIGHT	0.000	09 PPVN	NO VERT PASS LANE	0.
10 ZPPD	SHELLS IN PARALLEL	1.	10 SHS1	INLET PENALTY	1.000*	10 PPHN	NO HORIZ PASS LANE	0.
11 CSI	SHELL CONSTRUCTION	1.	11 SHS2	OUTLET PENALTY	1.000*	11 WPPV	WIDTH VERT LANES	0.000
12 CTH	EXCHANGER TYPE	0.	12 CBS	EQUAL END SPACING	0.	12 WPPH	WIDTH HORIZ LANES	0.000
13 CRI	FLAN HEAD TYPE	1.	13 CNUZ	NOZZLE ORIENTATION	0.	13 XLBD	BAFFLE THICKNESS	0.0000
14 CR2	BAFFLE TYPE	4.	14 CBJ	WINDOW CONSTRUCT	0.	14 XLBID	TUBEHOLE BAF THIK	0.0000
15 CRI	BAFFLE ORIENTATION	0.	15 CDBR	CLEARANCE CODE	0.	15 GRT3	LONG BAFFLE CODE	0.
16 CHTS	TUBESIDE STEPWISE	1.	16 CDB	BAF-SHELL CLEAR	0.0000	16 GDBL	DELTA LMBD CORR	0.
17			17 CDB	TUBE-BAF CLEAR	0.0000	17 DDBNZ	MULTIPLE NOZ CODE	1.
18 CDMX	SERIES STEP EVAL	0.	18 CDBL	BUND-SHELL CLEAR	0.0000	18		
19 CDB1	OUTPUT CODE	0.	19 CDBPS	SHELLSIDE DP USE	1.	19 TEMA	TEMA SHELL STYLE	ALL*
20 CDBN	MONITOR CODE	1.	20 CDBMX	MAX BAF SPACING	0.000	20 CAXAL	TUBESIDE AXIAL NOZ	0.
21 CDBR	AUTO RATE CODE	0.	21 PRAX	TOTAL DP	0.00			
CARD 4 TUBESIDE INFORMATION			*CARD 5* PROCESS INFORMATION			*CARD 6* PROCESS INFORMATION		
01 TLEV	TUBE LENGTH	20.000	01 FCON1	FLUID CONDITION	0.	01 FCON2	FLUID CONDITION	0.
02 TMAX	MAXIMUM LENGTH	60.000	02			02		
03 TTRC	LENGTH TOLERANCE	5.000	03 WRI	FLOW RATE (1.0E3)	187.00	03 WRI	FLOW RATE (1.0E3)	337.00
04 PI	TUBE PITCH	1.3120	04 TIND1	INLET TEMPERATURE	333.60	04 TIND2	INLET TEMPERATURE	75.00
05 TPA	LAYOUT ANGLE	90.	05 TOUT1	OUTLET TEMPERATURE	0.00	05 TOUT2	OUTLET TEMPERATURE	278.90
06 ZNSD	NO OF TUBE SHELL	0.	06 P11	INLET PRESSURE	111.10	06 P12	INLET PRESSURE	680.00
07 TID	TUBE ID	1.0000	07 RFD1	FOUL RESISTANCE	.00100	07 RFD2	FOUL RESISTANCE	.00050
08 TID	TUBE THICKNESS	.0050	08 FL1	FOUL LAYER THICK	0.0000	08 FL2	FOUL LAYER THICK	0.0000
09 CMT	TUBE MATERIAL CODE	41.	09 HCT	HEAT TRANS CDEF	0.00	09 HCT	HEAT TRANS CDEF	0.00
10 CFI	INTERNAL CONDUCT	0.000	10 SF1	SAFETY FACTOR	1.000*	10 SF2	SAFETY FACTOR	1.000*
11 CFIH	FINNED TUBE CODE	1.	11 YIN1	INLET VAPOR QUAL	0.000	11 YIN2	INLET VAPOR QUAL	0.000
12 CFI	NO OF FINNED LENGTH	19.00	12 YEX1	EXIT VAPOR QUALITY	0.000	12 YEX2	EXIT VAPOR QUALITY	0.000
13 FPH	FIN HEIGHT	.0570	13 TSH1	BOIL DEG SUP HEAT	0.00	13 TSH2	BOIL DEG SUP HEAT	0.00
14 FID	FIN ROOT DIAMETER	.8770	14 TSC1	COND DEG SUB COOL	0.00	14 TSC2	BOIL DEG SUB COOL	0.00
15 FID	FIN THICKNESS	.0160						
16 FASP	SHELL SPACING	.690						
17 T-TH	THICKNESS UNDER FIN	.0440						
CARD 7 TUBESIDE AND VIBRATION			*CARD 8* MAXIMUM DP AND VELOCITY			*CARD 9* MAXIMUM DP AND VELOCITY		
01 TSD1	TUBESIDE THICK	0.0000	01 PM1	ALLOWABLE DP	10.00	01 PM2	ALLOWABLE DP	15.00
02 CSD	EXP JOINT CODE	0.	02 VM1	MAXIMUM VELOCITY	0.00	02 VM2	MAXIMUM VELOCITY	0.00
03 CSD	COUPLER TUBESIDE	0.	03 PM1	MAX NOZZLE DP (PCT)	0.00	03 PM2	MAX NOZZLE DP (PCT)	0.00
04 STRES	ALLOWABLE STRESS	0.00	04 DNZ11	INLET NOZZLE ID	0.000	04 DNZ12	INLET NOZZLE ID	0.000
05 CSD	VIBRATION CODE	1.	05 DNZ21	OUTLET NOZZLE ID	0.000	05 DNZ22	OUTLET NOZZLE ID	0.000
06 CSD	ELASTIC MODULUS	0.000	06 PD1	DESIGN PRESSURE	0.00	06 PD2	DESIGN PRESSURE	0.00
07 DPMAT	TUBE DENSITY	0.00	07			07		
10 RFI	.0000*	2.5664*	08 VMIN1	MINIMUM VELOCITY	0.00	08 VMIN2	MINIMUM VELOCITY	0.00
12 CFI	0.	0.				09 F12	PH	0.0
14 CFI	2.6771*	1.0000*				10 F22	TOTAL ALKALINITY	0.
						11 F32	CALCIUM HARDNESS	0.
						12 F42	TOT DISSOLVED SOLID	0.

** A * INDICATES **
 ** A DEFAULT VALUE **

*COLD FLUID (GEOLUID) PHYSICAL PROPERTIES**

COMPONENT 1
 NAME GEOLUID

CARD 10 PHYSICAL PROPERTY CONTROL

01 HX% 0.000
 02 APC 1.
 03 API 0.00
 04 AM 0.00
 05 BCF 0.00
 06 PZERD 0.

CALCULATED PHYSICAL PROPERTY CONSTANTS

0.1 NAME WATER
 0.2 T-FACT 1.000
 0.3 P-FACT 1.000
 0.4 RT 1.00
 0.5 T-TEMP 1165.20
 0.6 P-PRIS 1.000
 0.7 TEMPERATURE LIMITS
 0.8 UPPER 1165.20
 0.9 LOWER 494.69

CALCULATED MIXTURE VALUES

0.1 NAME WATER 1.00
 0.2 CRITICAL VALUES-TEMPERATURE 1165.20 PRESSURE 3208.20
 0.3 TEMPERATURE LIMITS-UPPER 1165.20 LOWER 494.69

*COLD FLUID (ISOB+NHX) PHYSICAL PROPERTIES PROFILE**

01 PAP 1500ARS (K=1) 670.000 (K=2) 680.000
 02 FPC 0.00 0.00 0.00

	(K)	1=1	1=2	1=3	1=4	1=5	1=6	1=7	1=8	1=9	1=10
01 TYP	1	150.00	320.00	310.00	300.00	280.00	250.00	220.00	180.00	140.00	80.00
	2	330.00	320.00	310.00	300.00	280.00	250.00	220.00	180.00	140.00	80.00
03 YAP											
04 RUPP											
05 XHVP											
06 XHVP											
07 HXVP											
08 GPVP											
09 RUPP	1	11.2900	13.4070	10.1400	19.0790	23.2490	26.5230	28.6410	30.7780	32.5290	34.7920
	2	11.7550	13.4750	10.1630	19.3910	23.3590	26.5660	28.6560	30.7930	32.5390	34.7980
01 XHVP	1	.0201	.0251	.0338	.0403	.0502	.0627	.0745	.0914	.1110	.1489
	2	.0209	.0267	.0347	.0409	.0505	.0629	.0747	.0916	.1111	.1491
02 XHVP	1	.0205	.0269	.0325	.0347	.0376	.0408	.0434	.0467	.0503	.0565
	2	.0270	.0296	.0320	.0349	.0378	.0409	.0434	.0467	.0503	.0566
03 HXVP	1	211.5700	197.3360	181.8900	166.6100	142.3200	115.7500	93.3300	66.4100	41.5700	6.9900
	2	209.7100	195.6300	180.4600	165.6800	142.0300	115.6600	93.3100	66.4100	41.5800	7.0200
04 GPVP	1	1.3114	1.5053	1.5647	1.4505	1.0211	.7957	.7082	.6436	.6008	.5544
	2	1.3208	1.4868	1.5243	1.3989	1.0062	.7927	.7071	.6431	.6005	.5543
05 SIGP											
06 RUPP											

** CASE 42 (XAP) AND CARD 49 (GPVP) ARE NOT USED IN THE ST-4 PROGRAM **

HTRI SHELL AND TUBE HEAT EXCHANGER PROGRAM ST-4 MOD 5.2

FINAL RESULTS

DESIGN CASE

PROCESS DESCRIPTION-MX STUDY

COUNTERCURRENT FLOW IN A T.E.M.A.

AEL SHELL WITH

HTRI VERSION

N.T.I.W. BUNDLE

PAGE NO- 22

CASE-AHX2/R4

ALT. SOLN.- 3

*** PROCESS DATA ***				*** SHELLSIDE PERFORMANCE ***			
01 FLUID NAME	ISOPENTANE	COLD SHELLSIDE	HOT TUBESIDE	01 NOM. VEL, X-FLOW/WINDOW	1.18/	10.38	
02 FLUID CONDITION	SENS. LIQUID	SENS. LIQUID	SENS. LIQUID	02 FILM COEF, X-FLOW/WINDOW	217.5/	0.0	
03 TOTAL FLOW RATE	(1.00+3) (LB/HR)	337.000	187.000	03 FLOW FRACTIONS FOR HEAT TRANSFER	.868		
04 TEMPERATURE, IN/OUT	(100 F)	90.6 / 278.9	333.6 / 104.2*	04 A = .046 B = .846 C = .072 E = .036 F = 0.000			
05 TEMPERATURE, AVERAGE/SKIN	(DLG F)	184.8/ 196.0	218.9/ 205.4	*** SHELLSIDE HEAT TRANSFER CORRECTIONS ***			
06 PRESSURE, INLET/AVERAGE	(PSIA)	600.00/ 672.50	111.10/ 106.10	05 TOTAL BETA	.920	1.000	1.000
07 PRESSURE DROP, TOTAL/ALLOW	(PSI)	14.42/ 15.00	1.36/ 10.00	06 FIN	.979	1.000	
08 VELOCITY, CALC./MAX.ALLOW	(FT/SEC)	1.16/ 0.00	1.36/ 0.00	*** PRESSURE DROPS *** (PERCENT TOTAL DP)			
09 FILM COEF (CALC/FAC) (BTU/HR-FT ² -F)	199.82 (1.00)	562.71 (1.00)		07 WND	80.33	NOZZLE	4.11/ 6.01
10 FOULING RESISTANCE (HR-FT ² -F/BTU)	.00000	.00100		08 LND	1.78	(IN/OUT) TUBE	16.56/ 9.61
11 DENSITY (LB/FT ³)	50.5283	59.6853		*** H.T. PARAMETERS ***			
12 THERMAL CONDUCTIVITY (BTU/HR-FT-F)	.0463	.3850		09 WALL CORRECTION	1.008	.989	
13 SPECIFIC HEAT CAPACITY (BTU/LB-F)	.511	1.0035		10 PRANITL NO.	3.0	1.7	
14 VISCOSITY AT AVERAGE TEMP (CP)	.00945	.27314		11 AVERAGE REYNOLDS NO.	47117	29181	
15 VISCOSITY AT SKIN TEMP (CP)	.00469	.29476		12 BUNDLE INLET REYNOLDS NO.	29601	49582	
*** OVERALL PERFORMANCE DATA *** (TUBESIDE STEPWISE)				13 BUNDLE OUTLET REYNOLDS NO.	83546	11970	
16 TOTAL HEAT DUTY REQUIRED (1.01+0) (BTU/HR)	43.257E.6			14 FOULING LAYER (IN)	0.00000	0.00000	
17 EFFECTIVE MD, (LMD)(F)(DUELLA) = (DLG F)	29.521(1.00)(1.00) = 29.5			*** THERMAL RESISTANCES *** (PCT. OVERALL)			
18 F FACTOR = (LMD)(F)(DUELLA) / (LMD)(F)(DUELLA) = (1.00)(1.00) / (1.00)(1.00) = 1.000				15 SHELL TUBE FOULING METAL OVER LFS			
19 OVERALL COEF, X-FLOW/CELL/ACTUAL (BTU/HR-FT ² -F)	64.70/ 88.61/ 66.61			16 33.03 39.47 25.51 1.990			
*** CONSTRUCTION INFORMATION ***				17 TOTAL FOULING RESISTANCE	.003865		
20 NO. SHELLS SERIES 5 PARALLEL 1 TOTAL SURFACE AREA (FT ²)	22730			18 DIFFERENTIAL RESISTANCE	.000307		
21 NO. PASSES SHELL 1 TUBE 1 (FT. SURF. AREA (FT ² /SHELL))	4529.5			*** SHELL NOZZLE INFO. ***			
22 SHELL I.D. (IN)	24.000	TEMA SHELL TYPE L	FLASK HEAD FATS	19 INSIDE DIAMETER (IN)	10.2	10.2	
23 BAFLE TYPE VERT N.T.I.W.	NO. CROSSPASSES/SHELL PASS 8			20 VELOCITY (FT/SEC)	4.80	7.09	
24 CENTER SPACING (IN)	52.000	BAFLE CUT (PCT. DIA)	15.00	21 DENSITY (LB/FT ³)	34.399	23.315	
25 TUBE SPACING (IN)	52.000	CUT AREA (PCT. DIA)	13.8 2) 0.0 3) 0.0	22 NOZZLE R-V-SQ (LB/FT-SQ)	794	1171	
26 OUTLET SPACING (IN)	52.000	CUT HEIGHT FROM CENTER LINE (IN)		23 BUNDLE R-V-SQ (LB/FT-SQ)	357	527	
27 BAFLE THICKNESS (IN)	.500	PAS-1) 0.4 2) 0.0 3) 0.0		24 HEIGHT UNDER NOZZLE (IN)	3.6	3.6	
28 NO. PAIRS SEAL DEVICES 0	IMPINGEMENT PLATE INCLUDED NO			*** TUBE NOZZLE INFO. ***			
29 TUBE SHEET THICK. (IN)	4.0	PERCENT TUBES REMOVED (ROTH)	18.610	25 INSIDE DIAMETER (IN)	8.1	8.1	
30 TUBE TYPE (IN/IN)	19	TUBES COUNT PER SHELL	188	26 VELOCITY (FT/SEC)	2.59	2.36	
31 OVERALL LENGTH (FT)	35.000	TUBE PITCH (IN)	1.3120	27 DENSITY (LB/FT ³)	56.368	61.831	
32 EFFECTIVE LENGTH (FT)	34.667	OUTSIDE DIAMETER (IN)	1.000	*** DIAMETRAL CLEARANCES ***			
33 LAYOUT ANGLE (DEG)	90	INSIDE DIAMETER (IN)	.789	28 BAFLE-TO-SHELL (IN)		.1524	
34 PITCH RATIO	1.432	OUTSIDE DIAMETER (IN)	3.365	29 BUNDLE-TO-SHELL (IN)		.5000	
35 FIN TYP. CW. DIA. (IN)	.916	SURFACE AREA RATIO (OUT/IN)	0.0000	30 TUBE-TO-BAFLEHOLE (IN)		.0246	
36 WEIGHT ESTIMATION (LB/SHELL)	8107	FIN TO DIA. CONDENSING (IN)	0.0000	31 MULTI-SQ. BAFLE OVERLAP (IN)		0.0000	
		DAY	15241	32 FIN EFFICIENCY = .967	FIN RESIST. =	.00015	

J-3

HTRI 51-4 MOD 5.2 HTRI VERSION PAGE NO- 23
 PROBLEM DESCRIPTION-MX STUDY CASE-AHX2/R4

FLOW INDUCED VIBRATION ANALYSIS		SENS. LIQUID SHELLSIDE		
01 LOG DECREMENT .0300	AXIAL STRESS LOADING	0.0 (KPSI)		
02 BETA 2.579	ADDED MASS FACTOR 2.5604	POSITION IN BUNDLE		
		INLET	CENT. R	OUTLET
03 LENGTH FOR NATURAL FREQUENCY (FT)		4.333	4.333	4.333
04 LENGTH/SPAN RATIO	(--)	.996	.996	.996
05 NUMBER OF SPANS	(--)	8	8	8
06 NATURAL FREQUENCY (FT/SEC)	(Hz)	14.86*	15.12	15.65
07				
FLOW VELOCITIES				
08 21000 (PARALLEL FLOW) (FT/SEC)		8.79	9.90	12.97
09				
10 C-SHELL VELOCITY (FT/SEC)		1.49	1.24	1.63
11 U-SHELL VELOCITY (FT/SEC)		3.31	3.73	4.89
12				
13 C-SHELL VELOCITY (FT/SEC)		1.05	1.16	1.55
14 CRITICAL VELOCITY (FT/SEC)		1.29	1.37	1.57
15 CROSSFLOW REYNOLDS NUMBER (---)		28806.	45853.	81303.
16 CROSSFLOW PRANDTL NO. (LB/FT-SZ)		38.	43.	56.
17 FREQUENCY RATIO (FVSU)/(FT/SEC)	(--)	.289	.325	.426
18				
19				
20				
DAMAGE NUMBERS				
21 RAFFLE (---)		.0133	.0149	.0196
22 COLLISION (---)		.0079	.0112	.0146
23 RHO/SUBST (MIL/SEC STV-1, FIG 9-6)		53.6026	65.6166	66.7303
VIBRATION AMPLITUDES				
24				
25 CROSSFLOW-1000C10 (IN)		.00495	.00568	.00799
BUNDLE PARAMETERS AT NOZZLES		INLET	EXIT	
26 TYPICAL PLATE				
27 FLOW AREA (FT2)		.8449	.8449	
28 VELOCITY (FT/SEC)		3.22	4.75	
29 SHG-V-SZ (LB/FT-SZ)		357.	527.	
30				
31 ISRA E. SHELL WITH VERT. N.T.I.W. RAFFLES AND EXTS BUNDLE				
32 NUMBER OF INTERMEDIATE SUPPORT PLATES PER SPAN 0				
33 FINNED CIRCULAR TUBES 1.6000 DIAMETER (IN) 90 DEGREE LAYOUT				
34 PITCH RATIO 1.432				
* FREQUENCY RATIOS ARE BASED ON THE LOWEST NATURAL FREQUENCY				

APPENDIX K

HX#3 RUN SUMMARY, 450°F RESOURCE

(Page K-1 to K-5)

CARD 1 CONTROL INFORMATION			*CARD 5* BASIC SHELL DESCRIPTION			*CARD 12* TUBE FIELD DESCRIPTION		
01 CIN	INPUT UNITS CODE	0.	01 TEMA	TEMA SHELL STYLE	AEL	01 ZMTD	NO OF TUBES/SHELL	0.
02 COUT	OUTPUT UNITS CODE	0.	02 CS1	SHELL CONSTRUCTION	1.*	02 DIO	TUBE OD	1.0000
03 CCI	CALCULATION TYPE	1.	03 CB1	REAR HEAD TYPE	1.*	03 TTB	TUBE THICKNESS	.0630
04 CHC	FLUID ALLOCATION	2.	04 DSD	SHELL ID	66.000	04 TLDV	TUBE LENGTH	42.000
05 CHN	HEAT DUTY CODE	6.	05			05 PT	TUBE PITCH	1.3120
06 COUTY	HEAT DUTY(1.0E6)	0.00000	06			06 TLA	TUBE FIELD PATTERN	90.
07			07 CTP	TUBE PASS CODE	0.	07 CMAT	TUBE MATERIAL CODE	41.
08			08 ZTPD	NO OF TUBE PASSES	1.	08 CTK	THERMAL CONDUCT	0.000
09 COM	CALCULATION METHOD	0.	09 ZNSD	PAIRS SEAL DEVICES	0.	09 CFIN	TUBE TYPE	1.
10 FLASH	WICKED FLASH CODE	0.	10 ZNSRD	NO OF SEAL RODS	0.	10		
11 PUNE	PURE CONDENSABLE	0.	11 DRD	SEAL ROD DIAMETER	0.0000	11 TLMAX	MAX TUBE LENGTH	54.000
12 POOL	POOL BOILING	0.	12 SFEND	SHELL FRIC MULT	1.0000*	12 TLINC	INCREMENT LENGTH	2.000
13			13			13 TFFMD	TUBE FRIC MULT	1.0000*
14 CVIB	VIBRATION CODE	1.	14			14 TFFTD	TUBE FRIC CODE	0.
15 RBA	SHELL ORIENTATION	0.				15		
16								
17								
18								
19								
20 CMON	MONITOR CODE	9.						
21 COUT	PRINTOUT CODE	0.						
22 CPROF	PROFIL CODE	0.						
23								
CARD 6 BASIC RAFFLE GEOMETRY			*CARD 7* CONSTRUCTION INFORMATION			*CARD 13* EXTERNAL TUBE GEOMETRY		
01 CP2	RAFFLE TYPE	4.	01 SFHSD1	INLET H.T. PENALTY	1.000*	01 XNF	NO OF FINS/LENGTH	19.00
02 EOC	RAFFLE ORIENTATION	0.	02 SFHSD2	OUTLET H.T. PENALTY	1.000*	02 XFH	FIN HEIGHT	.0570
03 RCF	RAFFLE CUT (PCT)	0.00	03 SFHSD	U-BEND H.T. PENALTY	0.000	03 DFR	FIN FOOT DIAMETER	.0770
04 FAWP	FRACT WINDOW AREA	0.00	04 HNTD1	INLET NOZ HEIGHT	0.000	04 XLF	FIN THICKNESS	.0180
05 RVWV	NTW KHU-V-SQUARED	5000.0*	05 HNTD2	OUTLET NOZ HEIGHT	0.000	05 FARP	SURE AREA/LENGTH	.495
06 HWD	TUBE ROWS OVERLAP	0.00	06 DDDK	CLEARANCE CODE	0.	06 TRTH	THICKNESS UNDER FIN	.0440
07 ZCPD1	NO OF CROSS PASSES	0.	07 CED	BAFFLE-SHELL CLEAR	0.0000			
08 XLBCD1	CENTRAL BAF SPACE	0.000	08 CAD	TUBE-BAFFLE CLEAR	0.0000			
09 XLBD1	INLET BAF SPACE	0.000	09 COTLD	BUNDLE-SHELL CLEAR	0.0000			
10 XLBD2	OUTLET BAF SPACE	0.000	10 TSID	TUB-SHELL THICK	0.0000			
11 XLBD	BAFFLE THICKNESS	0.0000	11 STRES	ALLOWABLE STRESS	0.00			
12 XLBD10	TUB-HOLE BAF THICK	0.0000	12 CS3	DOUBLE TUBESHEET	0.			
13 CDS	SEAL END SPACING	0.	13 CS2	EXP JOINT CODE	0.			
14 CDSMX	MAX BAF SPACING	0.00	14 PPVN	NO VERT PASS LANE	0.			
15 CDS	BAFFLE WINDOW	0.	15 PPHN	NO HORZ PASS LANE	0.			
16			16 WPPV	WIDTH VERT LANES	0.000			
17			17 WPPH	WIDTH HORZ LANES	0.000			
18								
19								
CARD 8 VARIABLE BAFFLE SPACING			*CARD 10* NOZZLE INFORMATION			*CARD 18* VIBRATION INFORMATION		
01 ZCPD2	CROSS PASSES REG-2	0.	01 DNZD1	SHELL-INLET NOZ ID	35.300	01 LMOD	TUB ELAST MODULUS	0.00
02 XLCPD2	BAF SPACING REG-2	0.000	02 DNZD2	SHELL-OUTLET NOZ ID	35.300	02 DTMAT	TUBE DENSITY	0.00
03 ZCPD3	CROSS PASSES REG-3	0.	03 DNZD3	SHELL-LIQUID NOZ ID	0.000	03 AXLD	AXIAL STRESS LOAD	0.
04 XLCPD3	BAF SPACING REG-3	0.000	04 DNZD1	TUBE-INLET NOZ ID	12.100	04 AMFD	ADDED MASS FACTOR	2.5604*
05 ZCPD4	CROSS PASSES REG-4	0.	05 DNZD2	TUBE-OUTLET NOZ ID	8.100	05 SUPPD	SUP PLATE/BAF SPACE	1.
06 XLCPD4	BAF SPACING REG-4	0.000	06 DNZD3	TUBE-LIQUID NOZ ID	0.000	06 CLDCD	VIB LOC DECREMENT	.0300*
07 ZCPD5	CROSS PASSES REG-5	0.	07 AUDD	ANNULAR DISTRIBUTOR	0.	07 CBFD	STABILITY CONSTANT	2.6791*
08 XLCPD5	BAF SPACING REG-5	0.000	08 ALCD	ANN-DIST CLEARANCE	0.000			
			09 AOLD	ANN-DIST LENGTH	0.000			
			10 ADSA1	IN--DIST SLOT AREA	0.000			
			11 ADSA2	OUT-DIST SLOT AREA	0.000			
			12 ZNOZ1	NO NOZ SHELL INLET	1.*			
			13 ZNOZ2	NO NOZ SHELL OUTLET	1.*			
			14 CNOZ	NOZZLE ORIENTATION	0.			
			15 CFTC	IMPINGEMENT CODE	0.			
			16 RVD	RHO-V-SQUARED	1500.0*			
			17 CAXAL	TUBESIDE AXIAL NOZ	0.			

** A * INDICATES **
** A DEFAULT VALUE **

HTRI SHELL AND TUBE CONDENSER PROGRAM
INPUT DATA PRINT

US UNITS

CST-1 MOD 1.1
PROBLEM DESCRIPTION-MX STUDY

HTRI VERSION

PAGE NO- 2
CASE-AHX3/R3

HOT FLUID NAME--GEOSTEAM				**COLD FLUID NAME--ISCR+NHX**				*CARD 25* OP, VELOCITY, NOZZLE INFO				
CARD 20 PROCESS INFORMATION				*CARD 22* PROCESS INFORMATION								
01	FCON1	FLUID CONDITION	2.	01	FCON2	FLUID CONDITION	0.	01	PMD1	HOT	ALLOWABLE DP	5.00
02	WD1	FLOW RATE(1.GE3)	187.00	02	WD2	FLOW RATE(1.GE3)	2500.00	02	PNMD11	HOT	MAXDP IN--NOZ	0.00
03	TIND1	INLET TEMPERATURE	336.90	03	TIND2	INLET TEMPERATURE	0.00	03	PNMD21	HOT	MAXDP OUT-NOZ	0.00
04	TOUTD1	OUTLET TEMPERATURE	333.60	04	TOUTD2	OUTLET TEMPERATURE	326.90	04	PD1	HOT	DESIGN PRESS	113.10
05	PIIN1	INLET PRESSURE	113.10	05	PIIN2	INLET PRESSURE	675.00	05				
06	YIND1	INLET VAPOR QUALITY	1.000	06	YIND2	INLET VAPOR QUALITY	0.000	06	PMD2	COLD	ALLOWABLE DP	10.00
07	YOUTD1	EXIT VAPOR QUALITY	0.000	07	YOUTD2	EXIT VAPOR QUALITY	0.000	07	PNMD12	COLD	MAXDP IN--NOZ	0.00
08	SF01	H.T. SAFETY FACTOR	1.000*	08	SF02	H.T. SAFETY FACTOR	1.000*	08	PNMD22	COLD	MAXDP OUT-NOZ	0.00
09	TSHD1	BOIL DEG SUP HEAT	0.00	09	TSHD2	BOIL DEG SUP HEAT	0.00	09	PD2	COLD	DESIGN PRESS	675.00
10	TSCD1	BOIL DEG SUB COOL	2.00	10	TSCD2	BOIL DEG SUB COOL	0.00	10	VMAXD2	COLD	MAX VELOCITY	0.00
11	RFD1	FOUL RESISTANCE	0.0000	11	RFD2	FOUL RESISTANCE	0.00050	11	VMIND2	COLD	MIN VELOCITY	0.00
12	FL1	FOUL LAYER THICK	0.0000	12	FL2	FOUL LAYER THICK	0.00000	12	PMAXD	TOTAL	DP	0.00
13	HSDP1	SUBCOOL H.T. COEF	0.00	13	HCD	H.T. COEFFICIENT	0.00					
14	HDPD1	2-PHASE H.T. COEF	0.00									

HOT FLUID (GEOSTEAM) PHYSICAL PROPERTIES

CARD 31 PHYSICAL PROPERTY CONTROL

COMPONENT	1
NAME	GEOSTEAM
04	WUPAD 0.0010
05	ZNCG 1.
06	APC 0.00
07	APL 0.00
08	HCF 0.00
09	APPL 0.00
10	ANW 0.00
11	ZD 0.0000
12	GRCD 0.00
13	OTCD 0.00
14	QZCD 0.0000
15	HLCD 0.00
16	PZFRD 0.

COLD FLUID (ISOB+NHX) PHYSICAL PROPERTIES PROFILE

40 PXP	ISOBARS	(K=1)	670.000					FPC	0.00	0.00	0.00	0.00
	(K)	I=1	I=2	I=3	I=4	I=5	I=6	I=7	I=8	I=9	I=10	
41 TXP	1	330.00	320.00	310.00	300.00	280.00	250.00	220.00	180.00	140.00	80.00	
42 OXFP												
43 YXP												
44 ROVP												
45 XROVP												
46 YROVP												
47 HXFP												
48 CPVP												
49 RGLP	1	21.2900	13.4070	16.1400	19.0790	23.2490	26.5230	28.6410	30.7780	32.5290	34.7920	
51 XNLLP	1	.0201	.0251	.0338	.0403	.0502	.0627	.0745	.0914	.1110	.1439	
52 YNLLP	1	.0205	.0289	.0325	.0347	.0376	.0408	.0434	.0467	.0503	.0565	
53 HLLP	1	211.5700	197.3300	181.8900	166.6100	142.3200	115.7500	93.3330	66.4160	41.5700	6.9900	
54 CPLP	1	1.3114	1.5088	1.5687	1.4505	1.0211	.7957	.7082	.6436	.6008	.5544	
55 SLOP												
56 PCLP												

***** ** ** ** ** WARNING MESSAGES --- CALCULATIONS CONTINUE ** ** ** ** *****

20- 0(1. 0) *WARNING* WEIGHT ESTIMATION ROUTINE IS LIMITED TO 600 PSI (4137 KPA) AND 650 DEG F (343 DEG C)
20-10(3. 0) TSCD WILL BE CALCULATED BY THE PROGRAM EXCEPT IN STRAIGHT LINE PROFILE CASES SET TSCD = 0
22- 3(3. 0) INLET TEMPERATURE (TIND) HAS BEEN RESET TO THE PROFILE VALUE TO PREVENT EXTRAPOLATION

** INTEGRAL CONDENSING FLUID FLASH. CONDENSING FLUID -- GEOSTEAM **

---	TEMPERATURE---	WEIGHT FRACTION VAPOR	---	MOLE FRACTIONS IN VAPOR PHASE---	---	MOLE FRACTIONS IN LIQUID PHASE---
1	336.90	1.0000	1.0000	1.0000	0.0000	1.0000
2	335.82	1.0000	1.0000	1.0000	0.0000	1.0000
3	334.72	1.0000	1.0000	1.0000	0.0000	1.0000
4	333.62	1.0000	1.0000	1.0000	0.0000	1.0000
5	332.52	1.0000	1.0000	1.0000	0.0000	1.0000
6	331.42	1.0000	1.0000	1.0000	0.0000	1.0000
7	330.32	1.0000	1.0000	1.0000	0.0000	1.0000
8	329.22	1.0000	1.0000	1.0000	0.0000	1.0000
9	328.12	1.0000	1.0000	1.0000	0.0000	1.0000
10	327.02	1.0000	1.0000	1.0000	0.0000	1.0000

PRESSURE = 110.50 110.77 111.05

DEW POINT TEMPERATURE = 335.02
BOBBLE POINT TEMPERATURE = 335.02

NOTE--THE BOBBLE AND DEW POINTS, AND LIQUID AND VAPOR MOLE FRACTIONS ARE AT THE LOWEST PRESSURE (110.50).

COMPONENT GEOSTEAM
FEED FRAC 1.0000 0.0000 0.0000 0.0000 0.0000

K-10

HTRI SHELL AND TUBE CONDENSER PROGRAM CST-1 MOD 1.1

FINAL RESULTS PROBLEM DESCRIPTION-MX STUDY
COOLANT DESIGN- TUBESIDE HOT COUNTERCURRENT

HTRI VERSION

PAGE NO- 44

CASE-AHX3/R3

ALT. SOLN- 3

HORIZONTAL TEMA AEL SHELL WITH N.T.I.W. BUNDLE

*** PROCESS DATA ***			COLD SHELLSIDE	HOT TUBESIDE	*** SHELLSIDE PERFORMANCE ***		
01 FLUID NAME			ISOB+NH ₃	GEOSTEAM	01 NOM. VEL, X-FLOW/WINDOW	5.43/	19.58
02 FLUID CONDITION			SENS. LIQUID	COND. VAPOR	02 FILM COEF, X-FLOW/WINDOW	477.7/	0.0
03 TOTAL FLOW RATE	(1.00+3)(LB/HR)		2500.000	187.000	03 FLOW FRACTIONS FOR HEAT TRANSFER		.794
					04 A= .143 B= .742 C= .041 E= .073 F=0.000		

*** SHELLSIDE HEAT TRANSFER CORRECTIONS ***		
04 WEIGHT FRACTION VAPOR, IN/OUT (--)	0.000+/- 0.000	1.000 / 0.000
05 TEMPERATURE, IN/OUT (DEG F)	276.9+/- 326.9	336.9 / 333.6
06 TEMPERATURE, AVERAGE/SKIN (DEG F)	302.9/ 317.3	335.3/ 331.5
07 PRESSURE, INLET/AVERAGE (PSIA)	675.00/ 675.06	113.10/ 111.79
08 PRESSURE DROP, TOTAL/ALLOW (PSI)	9.87/ 10.00	2.61/ 5.00
09 VELOCITY, MID/MAX ALLOW (FT/SEC)	4.78/ 0.00	29.37/ 0.00

*** PRESSURE DROPS *** (PERCENT OF TOTAL)		
10 AVERAGE FILM COEF (BTU/HR-FT ² -F)	438.74	3751.85
11 HEAT TRANSFER SAFETY FACTOR (--)	1.000	1.000
12 FOULING RESISTANCE (HR-FT ² -F/BTU)	.000500	.001000

*** CONDENSATION PARAMETERS ***		
13 OVERALL COEF, REQD/CLEAN/ACTUAL (BTU/HR-FT ² -F)	137.00/ 300.42/ 139.02	
14 HEAT DUTY, REQUIRED/SPECIFIED (1.E+6)(BTU/HR)	164.48900/ 0.00000	
15 EFFECTIVE OVERALL TEMPERATURE DIFFERENCE (DEG F)	24.36	

*** CONDENSER PERFORMANCE CRITERIA ***		
16 PRESSURE DROP RATIOS BASED ON SPECIFIED/REQUIRED AREAS, SHELLSIDE/TUBESIDE	1.003 / 1.002	
17 RATIO OF AREA SPECIFIED TO AREA REQUIRED	1.0081	

18 ----- SEE NEXT PAGE FOR WARNING MESSAGES -----

*** SHELL CONSTRUCTION INFORMATION ***		
21 SHELL TYPE	PEAR HEAD F115	SHELL ID (IN) 66.000
22 SHELLS SPECIFIED	1 PARALLEL	TOTAL AREA (FT ²) 49537
23 PASSES SHELL	1 TUBE	EFF. AREA (FT ² /SHELL) 48971.1
24 SHELL ORIENTATION ANGLE	0	(DEGREES FROM HORIZONTAL)
25 PAIRS OF SEALING DEVICES	0	IMPINGEMENT PLATE INCLUDED NO
26 WEIGHT ESTIMATION (LB/SHELL)	WGT 188227	DRY 88475

*** BAFFLE INFORMATION ***		
27 TYPE	VERT N.T.I.W.	BAFFLE CUT (PCT DIA) 15.621
28 CROSSLAPSES/SHELLPASS	9	NO. (PCT AREA) (IN TO C.L.) 22.690
29 CENTRAL SPACING (IN)	62.095	1 15.140
30 INLET SPACING (IN)	62.095	
31 OUTLET SPACING (IN)	62.095	
32 BAFFLE THICKNESS (IN)	.500	

*** TUBE INFORMATION ***		
33 TUBE TYPE	(FINS/IN) 19	TUBECOUNT PER SHELL 1513
34 OVERALL LENGTH (FT)	48.000	PCT TUBES REMOVED (BOTH) 19.66
35 EFFECTIVE LENGTH (FT)	46.571	OUTSIDE DIAMETER (IN) 1.0000
36 TOTAL TUBESHEET THICK (IN)	17.1	INSIDE DIAMETER (IN) .7690
37 AREA RATIO (OUT/IN)	3.365	PITCH (IN) 1.3120 RATIO 1.432
38		LAYOUT ANGLE (DEGREES) 90

*** DIAMETRAL CLEARANCES (IN) ***		
29 BAFFLE-TO-SHELL BUNDLE-TO-SHELL TUBE-TO-BAFFLEHOLE	.2897	.7500 .0246

HTRI CST-1 MOD 1.1 HTRI VERSION PAGE NO- 47
 PROBLEM DESCRIPTION-MX STUDY CASE-AHX3/R3

FLOW INDUCED VIBRATION ANALYSIS SENS. LIQUID SHELLSIDE

01 LOG DECREMENT .0300 AXIAL STRESS LOADING 0.0 (KPSI)
 02 BETA 2.579 ADDED MASS FACTOR 2.5604 POSITION IN BUNDLE

	INLET	CENTER	OUTLET
03 LENGTH FOR NATURAL FREQUENCY (FT)	2.587	2.587	2.587
04 LENGTH/TOTAL MAXIMUM SPAN (---)	.591	.591	.591
05 NUMBER OF SPANS (---)	18	18	18
06 NATURAL FREQUENCY (FTUBE) (HZ)	46.69	49.27	50.31

	INLET	CENTER	OUTLET
07 FLOW VELOCITIES			
08 WINDUP (PARALLEL FLOW) (FT/SEC)	10.75	16.79	21.02
09 C-STREAM VELOCITY (FT/SEC)	3.87	6.05	7.58
10 C-STREAM VELOCITY (FT/SEC)	14.13	22.07	27.63
11 CROSSFLOW VELOCITY (FT/SEC)	2.94	4.60	5.76
12 CRITICAL VELOCITY (FT/SEC)	4.21	5.27	5.89

	INLET	CENTER	OUTLET
13 CROSSFLOW REYNOLDS NUMBER (---)	154398	260155	361236
14 CROSSFLOW RHO-V-SQ (LB/FT-SQ)	202	316	396
15 FREQUENCY RATIOS			
16 (FVXSD)/(FTUBE) (---)	.258	.402	.504

	INLET	CENTER	OUTLET
17 DAMAGE NUMBERS			
18 RAFFLE (---)	.0253	.0395	.0495
19 COLLISION (---)	.0067	.0105	.0132
20 RHO-V-SQ (MU) (SEE STV-1, FIG 9-6)	66.7757	55.4846	52.2177

	INLET	CENTER	OUTLET
21 VIBRATION AMPLITUDES			
22 CROSSFLOW-INDUCED (IN)	.00330	.00563	.00771

	ENTRANCE	EXIT
23 SHELL PARAMETERS AT NOZZLES		
24 IMPINGEMENT PLATE NO		
25 FLOW AREA (FT ²)	8.0180	8.0180
26 VELOCITY (FT/SEC)	3.71	7.25
27 RHO-V-SQ (LB/FT-SQ)	321	627

30 TEMA 2 SHELL WITH VERT N.T.I.W. BAFFLES AND FXTS BUNDLE
 31 NUMBER OF INTERMEDIATE SUPPORT PLATES PER SPAN 1
 32 FINNED TUBES 1.0000 DIAMETER (IN) 90 DEGREE LAYOUT
 33 PITCH RATIO 1.432

* FREQUENCY RATIOS ARE BASED ON THE LOWEST NATURAL FREQUENCY

K-5

APPENDIX L

HX#4 RUN SUMMARY, 450⁰F RESOURCE

(Page L-1 to L-5)

HTRI SHELL AND TUBE CONDENSER PROGRAM
INPUT DATA REPRINT

CST-1 MOD 1.1
PROBLEM DESCRIPTION-MX CONDENSER

HTRI VERSION

PAGE NO-1
CASE-ACX1/R3

CARD 1 CONTROL INFORMATION

01	CIN	INPUT UNITS CODE	0.
02	COU	OUTPUT UNITS CODE	0.
03	CCI	CALCULATION TYPE	1.
04	CHS	FLUID ALLOCATION	2.
05	CHB	HEAT DUTY CODE	4.
06	QOUTY	HEAT DUTY(1.0E6)	0.00000
07			
08			
09	CCM	CALCULATION METHOD	0.
10	FLASH	RIGOROUS FLASH CODE	0.
11	PURL	PURE CONDENSABLE	0.
12	POOL	POOL BULLING	0.
13			
14	CVIB	VIBRATION CODE	1.
15	EDA	SHELL ORIENTATION	0.

CARD 6 BASIC BAFFLE GEOMETRY

01	CB2	BAFFLE TYPE	4.
02	BCC	BAFFLE ORIENTATION	0.
03	BCC	BAFFLE CUT (PCT)	0.00
04	FWB	FRACT WINDOW AREA	0.00
05	KVOW	NTIW KHD-V-SQUARED	5000.0*
06	HUVO	TUBE ROWS OVERLAP	0.00
07	ZCPD1	NO OF CROSSPASSES	0.
08	XLBCD1	CENTRAL BAF SPACE	0.000
09	XLBJD	INLET BAF SPACE	0.000
10	XLBJD	OUTLET BAF SPACE	0.000
11	XLBD	BAFFLE THICKNESS	0.0000
12	XLBD	TUBEHOLE BAF THICK	0.0000
13	CB3S	EQUAL END SPACING	0.
14	CB3MX	MAX BAF SPACING	0.00
15	CB3	BAFFLE WINDOW	0.

CARD 3 VARIABLE BAFFLE SPACING

01	ZCPD2	CROSSPASSES REG-2	0.
02	XLBCD2	BAF SPACING REG-2	0.000
03	ZCPD3	CROSSPASSES REG-3	0.
04	XLBCD3	BAF SPACING REG-3	0.000
05	ZCPD4	CROSSPASSES REG-4	0.
06	XLBCD4	BAF SPACING REG-4	0.000
07	ZCPD5	CROSSPASSES REG-5	0.
08	XLBCD5	BAF SPACING REG-5	0.000

CARD 5 BASIC SHELL DESCRIPTION

01	TEMA	TEMA SHELL STYLE	AEL
02	CS1	SHELL CONSTRUCTION	1.*
03	CB1	REAR HEAD TYPE	1.*
04	OSD	SHELL ID	96.000
05			
06	CTP	TUBEPASS CODE	0.
07	ZTPD	NO OF TUBEPASSES	1.
08	ZNSD	PAIRS SEAL DEVICES	0.
09	ZNSRD	NO OF SEAL RODS	0.
10	DRD	SEAL ROD DIAMETER	0.0000
11	SFFMD	SHELL FRIC MULT	1.0000*
12			
13			
14			

CARD 7 CONSTRUCTION INFORMATION

01	SFHS01	INLET H.T. PENALTY	1.000*
02	SFHS02	OUTLET H.T. PENALTY	1.000*
03	SFHSU	U-BEND H.T. PENALTY	0.000
04	HNTD1	INLET NOZ HEIGHT	0.000
05	HNTD2	OUTLET NOZ HEIGHT	0.000
06	DBDK	CLEARANCE CODE	0.
07	CEB	BAFFLE-SHELL CLEAR	0.0000
08	CAD	TUBE-BAFFLE CLEAR	0.0000
09	COTL3	BUNDLE-SHELL CLEAR	0.0000
10	TS10	TUBESHEET THICK	0.0000
11	STRES	ALLOWABLE STRESS	0.00
12	CS3	DOUBLE TUBESHEET	0.
13	CS2	EXP JOINT CODE	0.
14	PPVN	NO VERT PASS LANE	0.
15	PPHN	NO HDRZ PASS LANE	0.
16	WPPV	WIDTH VERT LANES	0.000
17	WPPH	WIDTH HDRZ LANES	0.000

CARD 10 NOZZLE INFORMATION

01	DNZDS1	SHEL-INLET NOZ ID	36.000
02	DNZDS2	SHEL-OUTLET NOZ ID	36.000
03	DNZDS3	SHEL-LIQUID NOZ ID	0.000
04	DNZD1	TUBE-INLET NOZ ID	36.000
05	DNZD2	TUBE-OUTLET NOZ ID	12.000
06	DNZD3	TUBE-LIQUID NOZ ID	0.000
07	ADCD	ANNULAR DISTRIBUTOR	0.
08	ALCD	ANN-DIST CLEARANCE	0.000
09	ADLD	ANN-DIST LENGTH	0.000
10	ADSA1	IN--DIST SLOT AREA	0.000
11	ADSA2	OUT--DIST SLOT AREA	0.000
12	ZNOZ1	NO NOZ SHELL INLET	1.*
13	ZNOZ2	NO NOZ SHELL OUTLET	1.*
14	CNOZ	NOZZLE ORIENTATION	0.
15	CFTC	IMPINGEMENT CODE	0.
16	RVD	RHD-V-SQUARED	1500.0*
17	CAXAL	TUBESIDE AXIAL NOZ	0.

CARD 12 TUBEFIELD DESCRIPTION

01	ZNTD	NO OF TUBES/SHELL	0.
02	DTD	TUBE OD	.7500
03	TIB	TUBE THICKNESS	.0650
04	TLOV	TUBE LENGTH	47.000
05	PT	TUBE PITCH	1.0620
06	TLA	TUBEFIELD PATTERN	90.
07	CHAT	TUBE MATERIAL CODE	41.
08	CTK	THERMAL CONDUCT	0.000
09	CFIN	TUBE TYPE	0.
10			
11	TLMAX	MAX TUBE LENGTH	53.000
12	TLINC	INCREMENT LENGTH	1.000
13	TFMD	TUBE FRIC MULT	1.0000*
14	TFD	TUBE FRIC CODE	0.
15			

CARD 13 EXTERNAL TUBE GEOMETRY

01	XNF	NO OF FINS/LENGTH	0.00
02	XFH	FIN HEIGHT	0.0000
03	DFK	FIN ROOT DIAMETER	0.0000
04	XLK	FIN THICKNESS	0.0000
05	FARP	SURE AREA/LENGTH	0.000
06	TRTH	THICKNESS UNDER FIN	0.0000

CARD 18 VIBRATION INFORMATION

01	EMOD	TUB ELAST MODULUS	0.00
02	DIMAT	TUBE DENSITY	0.00
03	AXLD	AXIAL STRESS LOAD	0.
04	AMFD	ADDED MASS FACTOR	2.1353*
05	SUPPD	SUP PLATE/BAF SPACE	0.
06	CLDCD	VIB LOG DECREMENT	.0300*
07	CBFD	STABILITY CONSTANT	2.8622*
08			

** A * INDICATES **
** A DEFAULT VALUE **

HTRI SHELL AND TUBE CONDENSER PROGRAM
INPUT DATA REPRINT US UNITS

CST-1 MJD 1.1
PROBLEM DESCRIPTION-MX CONDENSER

HTRI VERSION

PAGE NO- 2
CASE-ACX1/R3

HOT FLUID NAME--ISOB*NHFX			**COLD FLUID NAME--WATER**			*CARD 25* DP, VELOCITY, NOZZLE INFO		
CARD 20 PROCESS INFORMATION			*CARD 22* PROCESS INFORMATION					
01 FCON1	FLUID CONDITION	2.*	01 FCON2	FLUID CONDITION	0.	01 PMD1	HOT ALLOWABLE DP	0.00
02 WDI	FLOW RATE(1.OE3)	625.00	02 WDI	FLOW RATE(1.OE3)	4924.00	02 PNMD11	HOT MAXDP IN--NOZ	0.00
03 TIND1	INLET TEMPERATURE	145.10	03 TIND2	INLET TEMPERATURE	70.00	03 PNMD21	HOT MAXDP OUT--NOZ	0.00
04 TOUTD1	OUTLET TEMPERATURE	80.50	04 TOUTD2	OUTLET TEMPERATURE	0.00	04 PD1	HOT DESIGN PRESS	150.00*
05 PIND1	INLET PRESSURE	51.40	05 PIND2	INLET PRESSURE	50.00	06		
06 YIND1	INLET VAPOR QUALITY	1.000	06 YIND2	INLET VAPOR QUALITY	0.000	07 PMD2	COLD ALLOWABLE DP	10.00
07 YOUTD1	EXIT VAPOR QUALITY	0.000*	07 YOUTD2	EXIT VAPOR QUALITY	0.000	08 PNMD12	COLD MAXDP IN--NOZ	0.00
08 SFD1	H.T. SAFETY FACTOR	1.700	08 SFD2	H.T. SAFETY FACTOR	1.000*	09 PNMD22	COLD MAXDP OUT--NOZ	0.00
09 TSHD1	COND DEG SUP HEAT	0.00	09 TSHD2	COND DEG SUP HEAT	0.00	10 PD2	COLD DESIGN PRESS	150.00*
10 TSCD1	COND DEG SUB COOL	0.00	10 TSCD2	COND DEG SUB COOL	0.00	11 VMAXD2	COLD MAX VELOCITY	0.00
11 RFD1	FOUL RESISTANCE	0.00090	11 RFD2	FOUL RESISTANCE	0.00100	12 VMIND2	COLD MIN VELOCITY	0.00
12 FL1	FOUL LAYER THICK	0.0000	12 FL2	FOUL LAYER THICK	0.0000	13 PMAXD	TOTAL DP	0.00
13 HSUBD	SUBCOOL H.T. COEF	0.00	13 HCD	H.T. COEFFICIENT	0.00			
14 HTPZD	2-PHASE H.T. COEF	0.00						

COLD FLUID (WATER) PHYSICAL PROPERTIES
CARD 31 PHYSICAL PROPERTY CONTROL
COMPONENT 1
NAME WATER
04 HMMND 1.0000
05 ZNCG 0.
06 APC 1.
07 API 0.00
08 HCF 0.00
09 AMWL 0.00
10 AMW 0.00
11 ZD 0.0000
12 OPCD 0.00
13 DTCD 0.00
14 OZCD 0.0000
15 HLGD 0.00
16 PZERO 0.

HTRI SHELL AND TUBE CONDENSER PROGRAM
INPUT DATA REPRINT

CST-1 MOD 1.1
PROBLEM DESCRIPTION-MX CONDENSER

HTRI VERSION

PAGE NO- 3
CASE-ACX1/R3

HOT FLUID (ISOB-NHEX) PHYSICAL PROPERTIES PROFILE

40 PXP	ISOBARS	(K=1)	48.000	(K=2)	50.000	(K=3)	52.000	FPC	0.00	0.00	0.00	0.00
	(K)	I=1	I=2	I=3	I=4	I=5	I=6	I=7	I=8	I=9	I=10	
41 TXP	1	150.00	136.00	120.00	111.86	92.00	86.00	82.00	80.81	80.00	70.00	
	2	150.00	136.00	120.00	114.16	94.00	83.00	86.00	83.38	80.00	70.00	
	3	150.00	140.00	130.00	116.39	96.00	90.00	88.00	85.88	80.00	70.00	
42 QXFP	1	0.0000	6.4400	13.7000	17.3500	60.4320	91.1580	141.6200	172.9800	173.4600	179.0400	
	2	0.0000	6.4600	13.7300	16.3600	61.2760	94.6890	116.3200	171.3400	173.2500	178.8400	
	3	0.0000	4.6200	9.2100	15.3900	61.9990	98.0420	122.3000	169.6900	173.0400	176.6200	
43 YXP	1	1.0000	1.0000	1.0000	1.0000	.7588	.5610	.2176	0.0000	0.0000	0.0000	
	2	1.0000	1.0000	1.0000	1.0000	.7459	.5284	.3815	0.0000	0.0000	0.0000	
	3	1.0000	1.0000	1.0000	1.0000	.7339	.4967	.3336	0.0000	0.0000	0.0000	
44 RDVP	1	.4728	.4870	.5045	.6023	.5750	.5627	.5533	.5503	.5503	.5503	
	2	.4941	.5091	.5276	.6254	.5964	.5836	.5788	.5722	.5722	.5722	
	3	.5158	.5267	.5358	.5483	.6179	.6046	.5996	.5941	.5941	.5941	
45 XMUVP	1	.0085	.0083	.0031	.0080	.0078	.0077	.0077	.0076	.0076	.0076	
	2	.0085	.0083	.0081	.0080	.0078	.0077	.0077	.0077	.0077	.0077	
	3	.0085	.0084	.0033	.0081	.0079	.0078	.0078	.0077	.0077	.0077	
46 XKVP	1	.0125	.0119	.0114	.0111	.0135	.0103	.0102	.0102	.0102	.0102	
	2	.0125	.0119	.0114	.0112	.0106	.0104	.0104	.0103	.0103	.0103	
	3	.0125	.0121	.0117	.0113	.0107	.0105	.0104	.0104	.0104	.0104	
47 HVXP	1	.4639	.4573	.4479	.4463	.4359	.4342	.4324	.4319	.4319	.4319	
48 CPVP	2	.4849	.4583	.4511	.4486	.4391	.4364	.4358	.4346	.4346	.4346	
	3	.4658	.4612	.4557	.4508	.4413	.4387	.4378	.4359	.4369	.4369	
50 RULP	1	36.2560	36.2560	36.2550	36.2560	35.2750	34.8260	34.4540	34.3350	34.3640	34.7460	
	2	36.1350	36.1350	36.1350	36.1350	35.1470	34.6740	34.4920	34.2360	34.3670	34.7480	
	3	36.0180	36.0180	36.0180	36.0180	35.0080	34.5300	34.3480	34.1400	34.3680	34.7490	
51 XMULP	1	.1694	.1694	.1694	.1694	.1540	.1467	.1411	.1393	.1399	.1474	
	2	.1657	.1667	.1657	.1667	.1512	.1439	.1412	.1374	.1399	.1474	
	3	.1641	.1641	.1641	.1641	.1485	.1413	.1386	.1356	.1399	.1474	
52 XKLP	1	.0569	.0569	.0569	.0569	.0560	.0553	.0548	.0546	.0547	.0559	
	2	.0566	.0566	.0566	.0566	.0556	.0550	.0547	.0543	.0547	.0559	
	3	.0563	.0563	.0563	.0563	.0553	.0546	.0543	.0540	.0547	.0559	
53 HLXP	1	.5733	.5733	.5733	.5733	.5660	.5642	.5631	.5627	.5621	.5547	
54 CPLP	2	.5750	.5750	.5750	.5750	.5677	.5659	.5634	.5647	.5621	.5546	
	3	.5766	.5766	.5766	.5766	.5694	.5677	.5672	.5667	.5621	.5546	
55 SIGP												
56 PCLP												

HTRI SHELL AND TUBE CONDENSER PROGRAM CST-1 MOD 1.1
 FINAL RESULTS PROBLEM DESCRIPTION-MX CONDENSER
 COOLANT DESIGN- TUBESIDE HOT COUNTERCURRENT

HTRI VERSION

PAGE NO- 40
 CASE-ACK1/R3
 ALT. SOLN- 3

HORIZONTAL TEMA AEL SHELL WITH N.T.I.W. BUNDLE

**** PROCESS DATA ****

	COLD SHELLSIDE	HOT TUBESIDE
01 FLUID NAME	WATER	ISOB+NHEX
02 FLUID CONDITION	SENS. LIQUID	COND. VAPOR
03 TOTAL FLOW RATE (1.0E+3)(LB/HR)	4924.000	625.000
04 WEIGHT FRACTION VAPOR, IN/OUT (--)	0.000 / 0.000	1.000 / 0.000
05 TEMPERATURE, IN/OUT (DEG F)	70.0 / 91.7	145.1 / 80.5
06 TEMPERATURE, AVERAGE/SKIN (DEG F)	80.8 / 81.6	112.8 / 87.5
07 PRESSURE, INLET/AVERAGE (PSIA)	50.00 / 45.124	51.40 / 50.88
08 PRESSURE DROP, TOTAL/ALLOW (PSI)	9.51 / 10.00	1.03 / 0.00
09 VELOCITY, MID/MAX ALLOW (FT/SEC)	1.66 / 0.00	14.36 / 0.00
10 AVERAGE FILM COEF (BTU/HR-FT ² -F)	1141.00	450.74
11 HEAT TRANSFER SAFETY FACTOR (--)	1.000	1.700
12 FOULING RESISTANCE (HR-FT ² -F/BTU)	.001000	.000900
13 OVERALL COEF, REQD/CLEAN/ACTUAL (BTU/HR-FT ² -F)	173.34 / 275.49	174.87
14 HEAT DUTY, REQUIRED/SPECIFIED (1.0E+6)(BTU/HR)	106.66044 / 0.00000	
15 EFFECTIVE OVERALL TEMPERATURE DIFFERENCE (DEG F)	12.64	

**** SHELLSIDE PERFORMANCE ****

01 NOM. VEL, X-FLOW/WINDOW	3.38 / 4.66
02 FILM COEF, X-FLOW/WINDOW	1253.9 / 0.0
03 FLOW FRACTIONS FOR HEAT TRANSFER	.571
04 A = .413 B = .432 C = .011 E = .144 F = 0.000	

**** SHELLSIDE HEAT TRANSFER CORRECTIONS ****

	TOTAL	BETA	GAMMA	END	FIN
05	.920	.920	1.000	.974	1.000

**** PRESSURE DROPS **** (PERCENT OF TOTAL)

	CROSS WINDOW	ENDS	NOZZLE	SHELL	TUBE
06	70.55	17.55	10.00	.90	13.46
07 RECOVERY	0.00	0.00	0.00	.90	10.43

**** CONDENSATION PARAMETERS ****

	METHOD	INLET	CENTER	OUTLET
08	PRORATION	MODE ANN-MIST	TRANS	GRAVITY
09	AVG MULTICOMPONENT H.T. CORR FACTOR	.6147		

**** CONDENSER PERFORMANCE CRITERIA ****

16	PRESSURE DROP RATIOS BASED ON SPECIFIED/REQUIRED AREAS, SHELLSIDE/TUBESIDE	1.007 / 1.007
17	RATIO OF AREA SPECIFIED TO AREA REQUIRED	1.0088

18 ----- SEE NEXT PAGE FOR WARNING MESSAGES -----
 19
 20

**** H.T. PARAMETERS ****

	SHELL	TUBE
10 MIDPOINT REYNOLDS NO	14599	14286
11 BUNDLE INLET REYNOLDS NO	9057	148639
12 BUNDLE OUTLET REYNOLDS NO	13346	9185
13 FOULING LAYER (IN)	0.00000	0.00000
**** THERMAL RESISTANCES **** (PCT OVERALL)		
14 SHELL TUBE FOULING METAL OVER DLS	15.33	46.93
15 TOTAL FOULING RESISTANCE	36.52	1.549
		.002089

**** SHELL CONSTRUCTION INFORMATION ****

21	SHELL TYPE E REAR HEAD FXTS	SHELL ID (IN)	96.000
22	SHELLS SERIES 1 PARALLEL	TOTAL AREA (FT ²)	49667
23	PASSES SHELL 1 TUBE	EFF. AREA (FT ² /SHELL)	48693.3
24	SHELL ORIENTATION ANGLE	(DEGREES FROM HORIZONTAL)	
25	PAIRS OF SEALING DEVICES	IMPINGEMENT PLATE INCLUDED	NO
26	WEIGHT ESTIMATION (LB/SHELL)	WET	376010
		DRY	185649

**** SHELLSIDE NOZZLES ****

	INLET	OUTLET
16	NUMBER AT EACH POSITION	1
17	DIAMETER (IN)	36.00
18	VELOCITY (FT/SEC)	3.11
19	PRESSURE DROP (PSI)	.09
20	HEIGHT UNDER NOZZLE (IN)	14.40
21	NOZZLE R-V-SQ (LB/FT-SQ)	601
22	SHELL R-V-SQ (LB/FT-SQ)	208

**** BAFFLE INFORMATION ****

	VERT	N.T.I.W.	BAFFLE CUT (PCT DIA)	NO.	(PCT AREA) (IN TO C.L.)
27	TYPE				
28	CROSSPASSES/SHELLPASS	17			33.600
29	CENTRAL SPACING (IN)	33.257		1	13.508
30	INLET SPACING (IN)	47.630			
31	OUTLET SPACING (IN)	41.752			
32	BAFFLE THICKNESS (IN)	.500			

**** TUBESIDE NOZZLES ****

	INLET	OUTLET
23	DIAMETER (IN)	36.00
24	VELOCITY (FT/SEC)	47.73
25	PRESSURE DROP (PSI)	.14

**** TUBE INFORMATION ****

33	TUBE TYPE	PLAIN	TUBE COUNT PER SHELL	5059
34	OVERALL LENGTH (FT)	50.000	PCT TUBES REMOVED (BOTH)	18.44
35	EFFECTIVE LENGTH (FT)	49.020	OUTSIDE DIAMETER (IN)	.7500
36	TOTAL TUBESHEET THICK (IN)	11.8	INSIDE DIAMETER (IN)	.6200
37	AREA RATIO (OUT/IN)	1.210	PITCH (IN)	1.3620
38			RATIO	1.416
			LAYOUT ANGLE (DEGREES)	90

**** DIAMETRICAL CLEARANCES (IN) ****

	BAFFLE-TO-SHELL BUNDLE	TO-SHELL TUBE-TO-BAFFLEHOLE
29	.4237	.8750
		.0313

HTRI CST-1 MOD 1.1 HTRI VERSION PAGE NO- 43
 PROBLEM DESCRIPTION-MX CONDENSER CASE-ACX1/R3

FLOW INDUCED VIBRATION ANALYSIS SENS. LIQUID SHELLSIDE

01 LOG DECREMENT .0300 AXIAL STRESS LOADING 0.0 (KPSI)
 02 BETA 2.852 ADDED MASS FACTOR 2.1353 POSITION IN BUNDLE-----
 03 LENGTH FOR NATURAL FREQUENCY (FT) INLET CENTER OUTLET
 04 LENGTH/TEMA MAXIMUM SPAN (---) 3.969 2.771 3.479
 05 NUMBER OF SPANS (---) .916 .640 .803
 06 NATURAL FREQUENCY(FTUBE) (HZ) 17 17 17
 07 NATURAL FREQUENCY(FTUBE) (HZ) 17.67 36.25 23.01

08 FLOW VELOCITIES
 09 WINDOW (PARALLEL FLOW) (FT/SEC) 2.73 2.73 2.74
 10 C-STREAM VELOCITY (FT/SEC) .84 1.20 .96
 11 E-STREAM VELOCITY (FT/SEC) 6.69 9.60 7.66
 12 CROSSFLOW VELOCITY (FT/SEC) 1.16 1.66 1.33
 13 CRITICAL VELOCITY (FT/SEC) 1.07 2.19 1.39
 15 CROSSFLOW REYNOLDS NUMBER (---) 6849 11040 10093
 16 CROSSFLOW RHO-V-SQ (LB/FT-S2) 83.1 171 109
 17 FREQUENCY RATIOS (FVXSQ)/(FTUBE) (---) .332 .476 .380
 18
 19
 20

21 DAMAGE NUMBERS
 22 BAFFLE (---) .0277 .0278 .0278
 23 COLLISION (---) .0665 .0325 .0513
 24 PHOTO/SCRT(MU)(SEE STV-1, FIG 9-6) 40.4634 42.8530 45.8021
 25 VIBRATION AMPLITUDES

26 CROSSFLOW-INDUCED (IN) .00778 .00357 .00584

27 SHELL PARAMETERS AT NOZZLES ENTRANCE EXIT
 28 IMPINGEMENT PLATE NO
 29 FLOW AREA (FT2) 12.0058 12.0058
 30 VELOCITY (FT/SEC) 1.33 1.84
 31 RHO-V-SQ (LB/FT-S2) 208 209

32 TEMA E SHELL WITH VERT H.T.I.W. BAFFLES AND FXTS BUNDLE
 33 NUMBER OF INTERMEDIATE SUPPORT PLATES PER SPAN 0
 34 PLAIN ADMIRALTY TLBES .7500 DIAMETER (IN) 90 DEGREE LAYOUT
 35 PITCH RATIO 1.416

* FREQUENCY RATIOS ARE BASED ON THE LOWEST NATURAL FREQUENCY