



**FABSCO**  
SHELL & TUBE, LLC



Member HTRI

HEAT EXCHANGER SPECIFICATION SHEET

Page 1  
US Units

|                       |                                               |                        |                        |
|-----------------------|-----------------------------------------------|------------------------|------------------------|
| Customer              | AIR PRODUCTS (WORLD ENERGY PARAMOUNT)         | Job No.                | S-16030-6-18-X-370REV4 |
| Address               | ALLENTOWN, PA                                 | P.O. No.               | 4505600058             |
| Plant Location        | PARAMOUNT, CA                                 | Fabsco Job             | S21-13258-6 & 7        |
| Service of Unit       | PROPANE RECOVERY COMPRESSOR INTERSTAGE COOLER | Date                   | 10/31/2022             |
| Size                  | 21 x 168 inch                                 | Rev. D                 |                        |
| Surf/Unit (Gross/Eff) | 571.77 / 558.16 ft2                           | Item No.               | 18-X-370               |
| Type                  | AEU                                           | Connected In           | 1 Parallel 1 Series    |
| Horizontal            |                                               | Surf/Shell (Gross/Eff) | 571.77 / 558.16 ft2    |

PERFORMANCE OF ONE UNIT

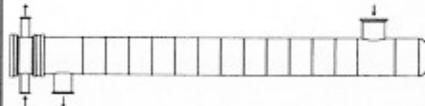
| Fluid Allocation                      | Shell Side | Tube Side         |
|---------------------------------------|------------|-------------------|
| Fluid Name                            | OFFGASES   | COOLING WATER     |
| Fluid Quantity, Total lb/hr           | 40039      | 154186            |
| Vapor (In/Out)                        | 40039      | 39046             |
| Liquid                                |            | 992.91            |
| Steam                                 |            | 154186            |
| Water                                 |            | 154186            |
| Noncondensables                       |            |                   |
| Temperature (In/Out) F                | 219.80     | 111.70            |
| Specific Gravity                      |            | 0.6341            |
| Viscosity cP                          | 0.0130     | 0.0100 V/L 0.2500 |
| Molecular Weight                      |            | 18.02             |
| Molecular Weight, Noncondensables     |            |                   |
| Specific Heat Btu/lb-F                | 0.5290     | 0.4709 V/L 0.5830 |
| Thermal Conductivity Btu/hr-ft-F      | 0.0250     | 0.0201 V/L 0.0590 |
| Latent Heat Btu/lb                    | 146.85     | 253.70            |
| Inlet Pressure psia                   |            | 64.696            |
| Velocity ft/sec                       | 27.53      | 6.20              |
| Pressure Drop, Allow/Calc psi         | 5.000      | 2.529             |
| Fouling Resistance (min) ft2-hr-F/Btu | 0.00200    | 0.00200           |

|                        |                    |                 |                     |
|------------------------|--------------------|-----------------|---------------------|
| Heat Exchanged         | 2310000 Btu/hr     | MTD (Corrected) | 57.7 F              |
| Transfer Rate, Service | 71.76 Btu/ft2-hr-F | Clean           | 105.26 Btu/ft2-hr-F |
|                        |                    | Actual          | 71.84 Btu/ft2-hr-F  |

CONSTRUCTION OF ONE SHELL

Sketch (Bundle/Nozzle Orientation)

| Design/Test Pressure     | Shell Side       | Tube Side       |
|--------------------------|------------------|-----------------|
| psig                     | 95/FV / CODE     | 120 / CODE      |
| Design Temperature F     | 300 / 300 / 32   | 150 / 32        |
| No Passes per Shell      | 1                | 4               |
| Corrosion Allowance inch | 0.1875 ON C'STL. | 0.125 ON C'STL. |
| Connections              | In inch          | 1 @ 10"-300# RF |
| Size & Rating            | Out inch         | 1 @ 4"-300# RF  |
|                          | Intermediate     | 1 @ 8"-300# RF  |



|                                                                                                           |                                     |             |             |          |              |                      |                                      |                        |             |            |
|-----------------------------------------------------------------------------------------------------------|-------------------------------------|-------------|-------------|----------|--------------|----------------------|--------------------------------------|------------------------|-------------|------------|
| Tube No.                                                                                                  | 104 U's                             | OD          | 0.7500 inch | Thk(Avg) | 0.0650 inch  | Length               | 14.000 ft                            | Pitch                  | 1.0000 inch |            |
| Tube Type                                                                                                 | Plain                               | Material    |             |          |              |                      | SA789-S31803 / S32205 (SEAMLESS)     | Tube pattern           |             | 45         |
| Shell                                                                                                     | SA-516-70N                          | ID          | 21.000      | OD       | 22.000 inch  | Shell Cover          | SA-516-70N (INTEGRAL)                |                        |             |            |
| Channel or Bonnet                                                                                         | SA-516-70N                          |             |             |          |              |                      | Channel Cover                        | SA-516-70N (REMOVABLE) |             |            |
| Tubesheet-Stationary                                                                                      | SA-240-S31803 (W/ 0.0625" TOTAL CA) |             |             |          |              | Tubesheet-Floating   |                                      |                        |             |            |
| Floating Head Cover                                                                                       |                                     |             |             |          |              | Impingement Plate    | RODS (2 ROWS X 0.75" OD)             |                        |             |            |
| Baffles-Cross                                                                                             | SA-240-316/316L (VERT. CUT Type     | DOUBLE SEG. | %Cut (Diam) | 26       | Spacing(c/c) | 10.750               | Inlet                                | 15.000 inch            |             |            |
| Baffles-Long                                                                                              |                                     |             |             |          |              | Seal Type            |                                      |                        |             |            |
| Supports-Tube                                                                                             | 14 Cross Passes                     |             |             |          |              |                      | U-Bend                               | Type FULL SUPPORT      |             |            |
| Bypass Seal Arrangement                                                                                   | 2 Pair Seal Strips & 2 Dummy Tubes  |             |             |          |              | Tube-Tubesheet Joint | SEAL WELD, ROLL & EXPAND (2 GROOVES) |                        |             |            |
| Expansion Joint                                                                                           |                                     |             |             |          |              | Type                 |                                      |                        |             |            |
| Rho-V2-Inlet Nozzle                                                                                       | 1108.8                              | lb/ft-sec2  |             |          |              | Bundle Entrance      | 638.99                               | Bundle Exit            | 452.24      | lb/ft-sec2 |
| Gaskets - 0.175" THK. TP304 S/S SPIRAL WOUND GRAPHITE FILLED W/ TP304 S/S INNER & OUTER COMPRESSION RINGS |                                     |             |             |          |              |                      |                                      |                        |             |            |

Gaskets - 0.175" THK, TP304 S/S SPIRAL WOUND GRAPHITE FILLED W/ TP304 S/S INNER & OUTER COMPRESSION RINGS

| Code Requirements | ASME SECTION VIII, DIV. 1 |                      | NATIONAL BOARD |    | TEMA Class R | API 660   |
|-------------------|---------------------------|----------------------|----------------|----|--------------|-----------|
| Weight/Shell      | 5,800.                    | lb Filled with Water | 8,300.         | lb | Bundle       | 2,150. lb |

1. CORN OIL JET MODE - EOR. UNIT IS THERMALLY & MECHANICALLY GUARANTEED.
2. FLOWS & DUTY INCREASED BY 10%.
3. (2)TWO IDENTICAL EXCHANGERS ARE REQUIRED, EACH TO PERFORM SHOWN DUTY.
4. PROVIDE PARTIAL TUBE SUPPORT IN SHELL INLET, UNDER THE NOZZLE. SUPPORTING (4)FOUR TUBE ROWS.
5. PROVIDE (1)2"-300# RFLWN W/ BLIND IN EACH PROCESS NOZZLE.
6. PROVIDE (2)2"-300# RFLWN W/ BLIND IN CHANNEL FOR VENT & DRAIN.
7. TUBES ARE TO BE SOLUTION ANNEALED.

# Output Summary

Page 1

Released to the following HTRI Member Company:

ST

Al Nader

Xist 9 (64 bit) 10/31/2022 9:41 SN: 13528-113450684

US Units

Shell 1

Rating - Horizontal Multipass Flow TEMA AEU Shell With Double-Segmental Baffles

No Data Check Messages.

See Runtime Message Report for Warning Messages.

| Process Conditions    |                 | Hot Shellside      |                    | Cold Tubeside  |          |
|-----------------------|-----------------|--------------------|--------------------|----------------|----------|
| Fluid name            |                 | OFFGASES           |                    | COOLING WATER  |          |
| Total flow rate       | (1000-lb/hr)    |                    | 40.039 *           |                | 154.19 * |
| Inlet/Outlet Y        | (Wt. frac vap.) | 1.0000             | 0.9752             | 0.0000         | 0.0000   |
| Inlet/Outlet T        | (Deg F)         | 219.80             | 111.70             | 80.00          | 95.00    |
| Inlet P/Avg           | (psia)          | 77.696             | 76.431             | 64.696         | 59.825   |
| dP/Allow.             | (psi)           | 2.529              | 5.000              | 9.742          | 10.000   |
| Fouling               | (ft2-hr-F/Btu)  |                    | 0.00200            |                | 0.00200  |
| Exchanger Performance |                 |                    |                    |                |          |
| Shell h               | (Btu/ft2-hr-F)  | 124.87             | Actual U           | (Btu/ft2-hr-F) | 71.84    |
| Tube h                | (Btu/ft2-hr-F)  | 1466.8             | Required U         | (Btu/ft2-hr-F) | 71.76    |
| Hot regime            | (--)            | Sens Gas           | Total duty         | (MM Btu/hr)    | 2.3100   |
| Cold regime           | (--)            | Sens. Liquid       | Eff. area          | (ft2)          | 558.16   |
| EMTD                  | (Deg F)         | 57.7               | Overdesign         | (%)            | 0.11     |
| Shell Geometry        |                 |                    | Baffle Geometry    |                |          |
| TEMA type             | (--)            | AEU                | Baffle type        | Double-Seg.    |          |
| Shell ID              | (inch)          | 21.000             | Baffle cut         | (Pct Dia.)     | 26       |
| Series                | (--)            | 1                  | Baffle orientation | (--)           | Parallel |
| Parallel              | (--)            | 1                  | Central spacing    | (inch)         | 10.750   |
| Orientation           | (deg)           | 0.00               | Crosspasses        | (--)           | 14       |
| Tube Geometry         |                 |                    | Nozzles            |                |          |
| Tube type             | (--)            | Plain              | Shell inlet        | (inch)         | 9.7500   |
| Tube OD               | (inch)          | 0.7500             | Shell outlet       | (inch)         | 7.6250   |
| Length                | (ft)            | 14.000             | Inlet height       | (inch)         | 2.4995   |
| Pitch ratio           | (--)            | 1.3333             | Outlet height      | (inch)         | 3.1360   |
| Layout                | (deg)           | 45                 | Tube inlet         | (inch)         | 4.0260   |
| Tubecount             | (--)            | 208                | Tube outlet        | (inch)         | 4.0260   |
| Tube Pass             | (--)            | 4                  |                    |                |          |
| Thermal Resistance, % |                 | Velocities, ft/sec |                    | Flow Fractions |          |
| Shell                 | 57.53           | Min                | Max                | A              | 0.031    |
| Tube                  | 5.92            | Tubeside           | 6.19 6.45          | B              | 0.705    |
| Fouling               | 31.75           | Crossflow          | 16.32 28.21        | C              | 0.052    |
| Metal                 | 4.80            | Longitudinal       | 15.41 37.61        | E              | 0.119    |
|                       |                 |                    |                    | F              | 0.093    |

## Runtime Messages

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US Units

Shell 1

Rating - Horizontal Multipass Flow TEMA AEU Shell With Double-Segmental Baffles

### Unit ID 100 - WARNING MESSAGES (CALCULATIONS CONTINUE)

#### Geometry, Mechanical Design, and Vibration

The design has parallel-cut baffles and the reported height under the nozzle lowers the bundle below the baffle cut. Unrestricted longitudinal flow can bypass the bundle. This bypass region can be reduced by decreasing the height under the nozzle, changing the baffle cut, or adding sealing arrangements. (MN 3505)

The areas in the window for multi-segmental baffles are not equal. Check the specified baffle cut and overlap. The program uses the average window area for calculating shellside pressure drop and heat transfer. (MN 3031)

The inlet baffle spacing is less than the calculated minimum inlet spacing 17.625 in. ( 447 mm) using estimated nozzle clearance requirements. This could result in the first baffle being placed beneath or before the inlet nozzle. This geometry is not recommended. (MN 3036)

The longest unsupported span of the bundle is in the U-bend region and thus prone to excessive vibration, even with a full support plate. The longest unsupported span should be in the straight portion of the U-tube. (MN 0042)

ASME Section VIII Div. 1 Code was used to ESTIMATE all pressure vessel dimensions and weights. The dimensions in this report cannot be used to fabricate the vessel. (MN 10170)

#### Fluid Properties

The physical properties of the hot fluid have been extrapolated beyond the valid temperature range. Check the calculated values. The thermal analysis requires properties at bulk and skin/wall temperatures. (MN 5033)

**Final Results**

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US Units

Shell 1

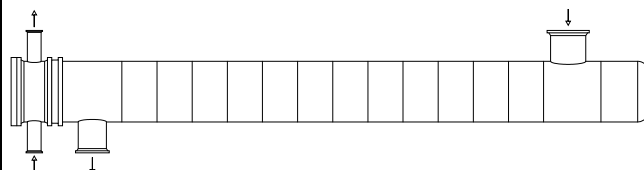
Rating - Horizontal Multipass Flow TEMA AEU Shell With Double-Segmental Baffles

| Process Data                  |                | Hot Shellside |          | Cold Tubeside |          |
|-------------------------------|----------------|---------------|----------|---------------|----------|
| Fluid name                    |                | OFFGASES      |          | COOLING WATER |          |
| Fluid condition               |                | Cond. Vapor   |          | Sens. Liquid  |          |
| Total flow rate               | (1000-lb/hr)   |               | 40.039 * |               | 154.19 * |
| Weight fraction vapor, In/Out | (--)           | 1.0000        | 0.9752   | 0.0000        | 0.0000   |
| Temperature, In/Out           | (Deg F)        | 219.80        | 111.70   | 80.00         | 95.00    |
| Skin temperature, Min/Max     | (Deg F)        | 93.90         | 147.97   | 82.14         | 99.54    |
| Wall temperature, Min/Max     | (Deg F)        | 89.28         | 128.93   | 87.74         | 122.58   |
| Pressure, In/Average          | (psia)         | 77.696        | 76.431   | 64.696        | 59.825   |
| Pressure drop, Total/Allowed  | (psi)          | 2.529         | 5.000    | 9.742         | 10.000   |
| Velocity, Mid/Max allow       | (ft/sec)       | 27.53         |          | 6.20          |          |
| Mole fraction inert           | (--)           |               | 0.0000   |               |          |
| Average film coef.            | (Btu/ft2-hr-F) |               | 124.87   |               | 1466.8   |
| Heat transfer safety factor   | (--)           |               | 1.0000   |               | 1.0000   |
| Fouling resistance            | (ft2-hr-F/Btu) |               | 0.00200  |               | 0.00200  |

**Overall Performance Data**

|                                          |                |          |          |        |
|------------------------------------------|----------------|----------|----------|--------|
| Overall coef., Req'd/Clean/Actual        | (Btu/ft2-hr-F) | 71.76 /  | 105.26 / | 71.84  |
| Heat duty, Calculated/Specified          | (MM Btu/hr)    | 2.3100 / | 2.1000   |        |
| Effective overall temperature difference | (Deg F)        | 57.7     |          |        |
| EMTD = (MTD) * (DELTA) * (F/G/H)         | (Deg F)        | 58.3 *   | 0.9893 * | 1.0000 |

See Runtime Messages Report for warnings.

**Exchanger Fluid Volumes**

|                             |        |
|-----------------------------|--------|
| Approximate shellside (ft3) | 29.772 |
| Approximate tubeside (ft3)  | 9.133  |

**Shell Construction Information**

|                                  |            |          |                                       |                    |
|----------------------------------|------------|----------|---------------------------------------|--------------------|
| TEMA shell type                  | AEU        | Shell ID | (inch)                                | 21.000             |
| Shells Series                    | 1 Parallel | 1        | Total area                            | (ft2) 571.77       |
| Passes Shell                     | 1 Tube     | 4        | Eff. area                             | (ft2/shell) 558.16 |
| Shell orientation angle (deg)    | 0.00       |          |                                       |                    |
| Impingement present              | Rods       |          | Impingement rod rows                  | 2                  |
| Pairs seal strips                | 2          |          | Passlane seal rods (inch)             | 0.5000 No. 2       |
| Shell expansion joint            | No         |          | UBend tangent to Support Dist. (inch) | 2.0000             |
| Weight estimation Wet/Dry/Bundle |            | 7171 /   | 4740.7 /                              | 2016.1 (lb/shell)  |

**Baffle Information**

|                          |          |             |                    |               |
|--------------------------|----------|-------------|--------------------|---------------|
| Type                     | Parallel | Double-Seg. | Baffle cut (% dia) | 26            |
| Crosspasses/shellpass    |          | 14          | No. (Pct Area)     | (inch) to C.L |
| Central spacing          | (inch)   | 10.750      | 1                  | 40.49 5.0400  |
| Inlet spacing            | (inch)   | 15.000      | 2                  | 35.76 2.9190  |
| Outlet spacing           | (inch)   | 19.500      | Baffle overlap     | (inch) 2.1210 |
| Baffle thickness         | (inch)   | 0.1875      |                    |               |
| Use deresonating baffles |          | No          |                    |               |

**Tube Information**

|                   |                     |                          |                     |
|-------------------|---------------------|--------------------------|---------------------|
| Tube type         | Plain               | Tubecount per shell      | 208                 |
| Length to tangent | (ft) 14.000         | Pct tubes removed (both) | 21.21               |
| Effective length  | (ft) 13.667         | Outside diameter         | (inch) 0.7500       |
| Total tubesheet   | (inch) 2.0000       | Wall thickness           | (inch) 0.0650       |
| Area ratio        | (out/in) 1.2097     | Pitch (inch)             | 1.0000 Ratio 1.3333 |
| Tube metal        | Alloy 2205 (S31803) | Tube pattern (deg)       | 45                  |

# Final Results

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US Units

Shell 1

Rating - Horizontal Multipass Flow TEMA AEU Shell With Double-Segmental Baffles

## Shellside Performance

Nom vel, X-flow/window 24.10 / 38.39

Flow fractions for vapor phase

A=0.0312 B=0.7052 C=0.0519 E=0.1190 F=0.0927

## Shellside Heat Transfer Corrections

| Total | Beta  | Gamma | End   | Fin   |
|-------|-------|-------|-------|-------|
| 0.981 | 0.920 | 1.066 | 0.922 | 1.000 |

## Pressure Drops (Percent of Total)

| Cross    | Window | Ends  | Nozzle | Shell | Tube |
|----------|--------|-------|--------|-------|------|
| 23.48    | 45.96  | 8.73  | Inlet  | 6.92  | 4.60 |
| MOMENTUM |        | -0.01 | Outlet | 14.92 | 2.93 |

## Two-Phase Parameters

| Method | Inlet    | Center   | Outlet | Mix F  |
|--------|----------|----------|--------|--------|
| RPM    | Sens Gas | Sens Gas | Shear  | 0.3350 |

## H. T. Parameters

## Shell

## Tube

|                            |        |       |
|----------------------------|--------|-------|
| Overall wall correction    |        | 1.001 |
| Midpoint Prandtl no.       |        | 5.29  |
| Midpoint Reynolds no.      | 107189 | 37986 |
| Bundle inlet Reynolds no.  | 68409  | 34613 |
| Bundle outlet Reynolds no. | 25970  | 42726 |
| Fouling layer (inch)       |        |       |

## Thermal Resistance, %

| Shell                    | Tube           | Fouling | Metal | Over Des |
|--------------------------|----------------|---------|-------|----------|
| 57.53                    | 5.92           | 31.75   | 4.80  | 0.11     |
| Total fouling resistance | (ft2-hr-F/Btu) |         |       | 0.0044   |
| Differential resistance  | (ft2-hr-F/Btu) |         |       | 1.6e-5   |

## Shell Nozzles

|                           |              | No            |        |        |        |
|---------------------------|--------------|---------------|--------|--------|--------|
|                           |              | Before U-bend |        |        |        |
|                           |              | Inlet         | Outlet | Liquid | Outlet |
| Inlet at channel end      |              | 1             | 1      | 0      |        |
| Nozzle location at U-bend |              |               |        |        |        |
| Number at each position   |              | 1             | 1      | 0      |        |
| Diameter                  | (inch)       | 9.7500        | 7.6250 |        |        |
| Velocity                  | (ft/sec)     | 51.69         | 78.89  |        |        |
| Pressure drop             | (psi)        | 0.175         | 0.377  |        |        |
| Height under nozzle       | (inch)       | 2.4995        | 3.1360 |        |        |
| Nozzle R-V-SQ             | (lb/ft-sec2) | 1108.8        | 2766.9 |        |        |
| Shell ent.                | (lb/ft-sec2) | 639.05        | 843.86 |        |        |

## Tube Nozzle

|               |              | Inlet  | Outlet | Liquid |
|---------------|--------------|--------|--------|--------|
|               |              | RADIAL | RADIAL | Outlet |
| Diameter      | (inch)       | 4.0260 | 4.0260 |        |
| Velocity      | (ft/sec)     | 7.79   | 7.81   |        |
| Pressure drop | (psi)        | 0.448  | 0.286  |        |
| Nozzle R-V-SQ | (lb/ft-sec2) | 3771.9 | 3781.7 |        |

## Annular Distributor

## Inlet

## Outlet

|           |        |
|-----------|--------|
| Length    | (inch) |
| Height    | (inch) |
| Slot area | (in2)  |

## Diametral Clearances (inch)

| Baffle-to-shell | Bundle-to-shell | Tube-to-baffle |
|-----------------|-----------------|----------------|
| 0.1875          | 0.5363          | 0.0313         |

## Supplementary Results

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US Units

Shell 1

Rating - Horizontal Multipass Flow TEMA AEU Shell With Double-Segmental Baffles

**Externally Enhanced Tube Geometry**

|               |                       |
|---------------|-----------------------|
| Type          | Plain                 |
| Fin density   | (fin/inch)            |
| Fin height    | (inch)                |
| Fin thickness | (inch)                |
| Root diameter | (inch)                |
| Area/length   | (ft <sup>2</sup> /ft) |

**Internally Enhanced Tube Geometry**

|           |        |
|-----------|--------|
| Type      | None   |
| Thickness | (inch) |
| Pitch     | (L/D)  |

**Mean Metal Temperatures**

Mean shell temperature 145.78 (F)

Tubesheet temperature 300.00 (F)

**Mean tube metal temperature in each tubepass, (F)**

| <u>Tube Pass</u> | <u>Inside</u> | <u>Outside</u> | <u>Radial</u> |
|------------------|---------------|----------------|---------------|
| 1                | 96.54         | 99.59          | 98.16         |
| 2                | 100.45        | 103.27         | 101.95        |
| 3                | 102.61        | 105.36         | 104.07        |
| 4                | 106.11        | 108.66         | 107.47        |

# Vibration Analysis

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US Units

Shell 1

Rating - Horizontal Multipass Flow TEMA AEU Shell With Double-Segmental Baffles

|                                       |              |                             |                     |               |
|---------------------------------------|--------------|-----------------------------|---------------------|---------------|
| Shellside condition                   |              | Cond. Vapor                 |                     |               |
| Axial stress loading                  | (1000-psi)   | 0.000                       | Added mass factor   | 1.394         |
| Beta                                  |              | 4.217                       |                     |               |
| <b>Position In The Bundle</b>         |              | <b>Inlet</b>                | <b>Center</b>       | <b>Outlet</b> |
| Length for natural frequency          | (ft)         | 2.146                       | 1.792               | 2.521         |
| Length/TEMA maximum span              | (--)         | 0.429                       | 0.358               | 0.504         |
| Number of spans                       | (--)         | 7                           | 8                   | 7             |
| Tube natural frequency                | (Hz)         | 149.7                       | 146.8               | 124.9 +       |
| Shell acoustic frequency              | (Hz)         | 262.3 +                     |                     |               |
| <b>Flow Velocities</b>                |              | <b>Inlet</b>                | <b>Center</b>       | <b>Outlet</b> |
| Window parallel velocity              | (ft/sec)     | 38.54                       | 37.16               | 35.97         |
| Bundle crossflow velocity             | (ft/sec)     | 15.13                       | 20.71               | 10.86         |
| Bundle/shell velocity                 | (ft/sec)     | 17.69                       | 17.05               | 8.94          |
| <b>Fluidelastic Instability Check</b> |              | <b>Inlet</b>                | <b>Center</b>       | <b>Outlet</b> |
| Log decrement                         | HTRI         | 0.025                       | 0.026               | 0.025         |
| Critical velocity                     | (ft/sec)     | 139.18                      | 199.24              | 97.44         |
| Baffle tip cross velocity ratio       | (--)         | 0.1306                      | 0.1249              | 0.1339        |
| Average crossflow velocity ratio      | (--)         | 0.1443                      | 0.1380              | 0.1480        |
| <b>Acoustic Vibration Check</b>       |              | <b>Inlet</b>                | <b>Center</b>       | <b>Outlet</b> |
| Vortex shedding ratio                 | (--)         | 0.671                       |                     |               |
| Chen number                           | (--)         | 12729                       |                     |               |
| Turbulent buffeting ratio             | (--)         | 0.657                       |                     |               |
| <b>Tube Vibration Check</b>           |              | <b>Inlet</b>                | <b>Center</b>       | <b>Outlet</b> |
| Vortex shedding ratio                 | (--)         | 1.157                       | 1.584               | 0.831         |
| Parallel flow amplitude               | (inch)       | 0.0001                      | 0.0001              | 0.0001        |
| Crossflow amplitude                   | (inch)       | 0.0020                      | 0.0010              | 0.0007        |
| Tube gap                              | (inch)       | 0.2500                      | 0.2500              | 0.2500        |
| Crossflow amplitude/tube gap          | (--)         | 0.0078                      | 0.0038              | 0.0026        |
| Crossflow RHO-V-SQ                    | (lb/ft-sec2) | 167.46                      | 325.62              | 92.49         |
| <b>Bundle Entrance/Exit</b>           |              |                             |                     |               |
| <b>(analysis at first tube row)</b>   |              |                             | <b>Entrance</b>     | <b>Exit</b>   |
| Fluidelastic instability ratio        | (--)         |                             | 0.138               | 0.083         |
| Vortex shedding ratio                 | (--)         |                             | 3.002               | 2.440         |
| Crossflow amplitude                   | (inch)       |                             | 0.00047             | 0.00026       |
| Crossflow velocity                    | (ft/sec)     |                             | 39.24               | 31.89         |
| Tubesheet to inlet/outlet support     | (inch)       |                             | 7.7500              | 15.250        |
| <b>Shell Entrance/Exit Parameters</b> |              |                             | <b>Entrance</b>     | <b>Exit</b>   |
| Impingement device                    |              |                             | Rods                | --            |
| Flow area                             | (ft2)        |                             | 0.683               | 0.574         |
| Velocity                              | (ft/sec)     |                             | 39.24               | 43.57         |
| Critical velocity                     | (ft/sec)     |                             | 284.83              | 383.42        |
| RHO-V-SQ                              | (lb/ft-sec2) |                             | 639.05              | 843.86        |
| Shell type                            | AEU          | Baffle type                 | Double-Seg.         |               |
| Tube type                             | Plain        | Baffle layout               | Parallel            |               |
| Pitch ratio                           | 1.3333       | Tube diameter, (inch)       | 0.7500              |               |
| Layout angle                          | 45           | Tube material               | Alloy 2205 (S31803) |               |
| Number U-Bend supports                |              | Elastic modulus, (1000-psi) | 27448               |               |
| Use deresonating baffles              | No           | Supports/baffle space       |                     |               |

## Program Messages

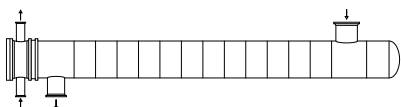
+ Natural or acoustic frequency used in vibration analysis.

See help for additional information.

\* Items with asterisk exceed a conservative lower limit for vibration-free design.

Review your case using the procedure described in Online Help;

You may find that a vibration problem is unlikely.

| HEAT EXCHANGER RATING DATA SHEET                                                                  |                     |  |                      |            |                              |                        |                      |        |                                                                                    | Page 7                             |
|---------------------------------------------------------------------------------------------------|---------------------|--|----------------------|------------|------------------------------|------------------------|----------------------|--------|------------------------------------------------------------------------------------|------------------------------------|
| Released to the following HTRI Member Company:                                                    |                     |  |                      |            |                              |                        |                      |        |                                                                                    | US Units                           |
| ST                                                                                                |                     |  |                      |            |                              |                        |                      |        |                                                                                    |                                    |
| Al Nader                                                                                          |                     |  |                      |            |                              |                        |                      |        |                                                                                    |                                    |
| Service of Unit PROPANE RECOVERY COMPRESSOR INTERSTAC Item No. 18-X-370 (Corn Oil Jet Mode - EOR) |                     |  |                      |            |                              |                        |                      |        |                                                                                    |                                    |
| Type                                                                                              | AEU                 |  | Orientation          | Horizontal |                              | Connected In           | 1 Parallel           |        | 1 Series                                                                           |                                    |
| Surf/Unit (Gross/Eff)                                                                             | 571.77 / 558.16 ft2 |  | Shell/Unit           | 1          |                              | Surf/Shell (Gross/Eff) | 571.77 / 558.16 ft2  |        |                                                                                    |                                    |
| PERFORMANCE OF ONE UNIT                                                                           |                     |  |                      |            |                              |                        |                      |        |                                                                                    |                                    |
| Fluid Allocation                                                                                  |                     |  | Shell Side           |            |                              |                        | Tube Side            |        |                                                                                    |                                    |
| Fluid Name                                                                                        |                     |  | OFFGASES             |            |                              |                        | COOLING WATER        |        |                                                                                    |                                    |
| Fluid Quantity, Total                                                                             |                     |  | 40.039               |            |                              |                        | 154.19               |        |                                                                                    |                                    |
| Vapor (In/Out)                                                                                    |                     |  | wt%                  |            | 100.00                       | 97.52                  |                      | 0.00   |                                                                                    | 0.00                               |
| Liquid                                                                                            |                     |  | wt%                  |            | 0.00                         | 2.48                   |                      | 100.00 |                                                                                    | 100.00                             |
| Temperature (In/Out)                                                                              |                     |  | F                    |            | 219.80                       | 111.70                 |                      | 80.00  |                                                                                    | 95.00                              |
| Density                                                                                           |                     |  | lb/ft3               |            | 0.4150                       | 0.4337 V/L 39.570      |                      | 62.226 |                                                                                    | 62.065                             |
| Viscosity                                                                                         |                     |  | cP                   |            | 0.0130                       | 0.0100 V/L 0.2500      |                      | 0.8572 |                                                                                    | 0.7193                             |
| Specific Heat                                                                                     |                     |  | Btu/lb-F             |            | 0.5290                       | 0.4709 V/L 0.5830      |                      | 0.9991 |                                                                                    | 0.9986                             |
| Thermal Conductivity                                                                              |                     |  | Btu/hr-ft-F          |            | 0.0250                       | 0.0201 V/L 0.0590      |                      | 0.3526 |                                                                                    | 0.3595                             |
| Critical Pressure                                                                                 |                     |  | psia                 |            |                              |                        |                      |        |                                                                                    |                                    |
| Inlet Pressure                                                                                    |                     |  | psia                 |            | 77.696                       |                        |                      |        | 64.696                                                                             |                                    |
| Velocity                                                                                          |                     |  | ft/sec               |            |                              |                        |                      |        | 27.53                                                                              |                                    |
| Pressure Drop, Allow/Calc                                                                         |                     |  | psi                  |            | 5.000                        |                        |                      |        | 2.529                                                                              |                                    |
| Average Film Coefficient                                                                          |                     |  | Btu/ft2-hr-F         |            | 124.87                       |                        |                      |        | 1466.8                                                                             |                                    |
| Fouling Resistance (min)                                                                          |                     |  | ft2-hr-F/Btu         |            | 0.00200                      |                        |                      |        | 0.00200                                                                            |                                    |
| Heat Exchanged                                                                                    |                     |  | 2.3100 MM Btu/hr     |            | MTD (Corrected)              |                        | 57.7 F               |        | Overdesign 0.11 %                                                                  |                                    |
| Transfer Rate, Service                                                                            |                     |  | 71.76 Btu/ft2-hr-F   |            | Calculated                   |                        | 71.84 Btu/ft2-hr-F   |        | Clean 105.26 Btu/ft2-hr-F                                                          |                                    |
| CONSTRUCTION OF ONE SHELL                                                                         |                     |  |                      |            |                              |                        |                      |        |                                                                                    | Sketch (Bundle/Nozzle Orientation) |
| Design Pressure                                                                                   |                     |  | psig                 |            | 95.000                       |                        | 120.00               |        |  |                                    |
| Design Temperature                                                                                |                     |  | F                    |            | 300.00                       |                        | 150.00               |        |                                                                                    |                                    |
| No Passes per Shell                                                                               |                     |  |                      |            | 1                            |                        | 4                    |        |                                                                                    |                                    |
| Flow Direction                                                                                    |                     |  |                      |            | Downward                     |                        | Upward               |        |                                                                                    |                                    |
| Connections                                                                                       |                     |  | In inch              |            | 1 @ 9.7500                   |                        | 1 @ 4.0260           |        |                                                                                    |                                    |
| Size & Rating                                                                                     |                     |  | Out inch             |            | 1 @ 7.6250                   |                        | 1 @ 4.0260           |        |                                                                                    |                                    |
| Tube No.                                                                                          |                     |  | 208.00               |            | OD 0.7500 inch               |                        | Thk(Avg) 0.0650 inch |        | Length 14.000 ft                                                                   |                                    |
| Tube Type                                                                                         |                     |  | Plain                |            | Material Alloy 2205 (S31803) |                        | Pitch 1.0000 inch    |        | Tube pattern 45                                                                    |                                    |
| Shell ID                                                                                          |                     |  | 21.000 inch          |            | Kettle ID                    |                        | inch                 |        | Pairs seal strips 2                                                                |                                    |
| Cross Baffle Type                                                                                 |                     |  | Parallel Double-Seg. |            | %Cut (Diam)                  |                        | 26                   |        | Passlane Seal Rod No. 2                                                            |                                    |
| Spacing(c/c)                                                                                      |                     |  | 10.750 inch          |            | Inlet                        |                        | 15.000 inch          |        | Impingement Plate Rods                                                             |                                    |
| Rho-V2-Inlet Nozzle                                                                               |                     |  | 1108.8 lb/ft-sec2    |            | Shell Entrance               |                        | 639.05 lb/ft-sec2    |        | No. of Crosspasses 14                                                              |                                    |
|                                                                                                   |                     |  |                      |            | Bundle Entrance              |                        | 638.99 lb/ft-sec2    |        | Shell Exit 843.86 lb/ft-sec2                                                       |                                    |
|                                                                                                   |                     |  |                      |            |                              |                        |                      |        | Bundle Exit 452.24 lb/ft-sec2                                                      |                                    |
| Weight/Shell                                                                                      |                     |  | 4483.0 lb            |            | Filled with Water            |                        | 6910.7 lb            |        | Bundle 1955.3 lb                                                                   |                                    |
| Notes:                                                                                            |                     |  |                      |            | Thermal Resistance, %        |                        | Velocities, ft/sec   |        | Flow Fractions                                                                     |                                    |
|                                                                                                   |                     |  |                      |            | Shell 57.53                  |                        | Shellside 27.53      |        | A 0.031                                                                            |                                    |
|                                                                                                   |                     |  |                      |            | Tube 5.92                    |                        | Tubeside 6.20        |        | B 0.705                                                                            |                                    |
|                                                                                                   |                     |  |                      |            | Fouling 31.75                |                        | Crossflow 24.10      |        | C 0.052                                                                            |                                    |
|                                                                                                   |                     |  |                      |            | Metal 4.80                   |                        | Window 38.39         |        | E 0.119                                                                            |                                    |
| Reported duty and flow rates include a user-specified multiplier of 1.10.                         |                     |  |                      |            |                              |                        |                      |        | F 0.093                                                                            |                                    |

# HEAT EXCHANGER SPECIFICATION SHEET

Page 8

Released to the following HTRI Member Company:

US Units

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Al Nader

Job No. S-16030-6-18-X-370REV4

|                       |                                               |      |            |               |                                  |                        |                     |
|-----------------------|-----------------------------------------------|------|------------|---------------|----------------------------------|------------------------|---------------------|
| Customer              | AIR PRODUCTS ( WORLD ENERGY PARAMOUNT )       |      |            | Reference No. | P.O.# 4505600058                 |                        |                     |
| Address               | ALLENTOWN, PA                                 |      |            | Proposal No.  | S21-13258-6 & 7                  |                        |                     |
| Plant Location        | PARAMOUNT, CA                                 |      |            | Date          | 10/31/2022                       |                        |                     |
| Service of Unit       | PROPANE RECOVERY COMPRESSOR INTERSTAGE COOLEF |      |            | Item No.      | 18-X-370 (Corn Oil Jet Mode-EOR) |                        |                     |
| Size                  | 21 x 168                                      | inch | Type       | AEU           | Horizontal                       | Connected In           | 1 Parallel 1 Series |
| Surf/Unit (Gross/Eff) | 571.77 / 558.16                               | ft2  | Shell/Unit | 1             |                                  | Surf/Shell (Gross/Eff) | 571.77 / 558.16 ft2 |

## PERFORMANCE OF ONE UNIT

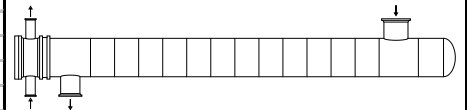
| Fluid Allocation                      |  | Shell Side |                   | Tube Side     |         |
|---------------------------------------|--|------------|-------------------|---------------|---------|
| Fluid Name                            |  | OFFGASES   |                   | COOLING WATER |         |
| Fluid Quantity, Total lb/hr           |  | 40039      |                   | 154186        |         |
| Vapor (In/Out)                        |  | 40039      | 39046             |               |         |
| Liquid                                |  |            | 992.91            | 154186        | 154186  |
| Steam                                 |  |            |                   |               |         |
| Water                                 |  |            |                   | 154186        | 154186  |
| Noncondensables                       |  |            |                   |               |         |
| Temperature (In/Out) F                |  | 219.80     | 111.70            | 80.00         | 95.00   |
| Specific Gravity                      |  |            | 0.6341            | 0.9972        | 0.9946  |
| Viscosity cP                          |  | 0.0130     | 0.0100 V/L 0.2500 | 0.8572        | 0.7193  |
| Molecular Weight                      |  |            |                   | 18.02         | 18.02   |
| Molecular Weight, Noncondensables     |  |            |                   |               |         |
| Specific Heat Btu/lb-F                |  | 0.5290     | 0.4709 V/L 0.5830 | 0.9991        | 0.9986  |
| Thermal Conductivity Btu/hr-ft-F      |  | 0.0250     | 0.0201 V/L 0.0590 | 0.3526        | 0.3595  |
| Latent Heat Btu/lb                    |  | 146.85     | 253.70            |               |         |
| Inlet Pressure psia                   |  |            | 77.696            |               | 64.696  |
| Velocity ft/sec                       |  |            | 27.53             |               | 6.20    |
| Pressure Drop, Allow/Calc psi         |  | 5.000      | 2.529             | 10.000        | 9.742   |
| Fouling Resistance (min) ft2-hr-F/Btu |  |            | 0.00200           |               | 0.00200 |

|                        |                    |                 |                     |
|------------------------|--------------------|-----------------|---------------------|
| Heat Exchanged         | 2310000 Btu/hr     | MTD (Corrected) | 57.7 F              |
| Transfer Rate, Service | 71.76 Btu/ft2-hr-F | Clean           | 105.26 Btu/ft2-hr-F |
|                        |                    | Actual          | 71.84 Btu/ft2-hr-F  |

## CONSTRUCTION OF ONE SHELL

## Sketch (Bundle/Nozzle Orientation)

|                           |          | Shell Side |   | Tube Side  |   |
|---------------------------|----------|------------|---|------------|---|
| Design/Test Pressure psig |          | 95.000     | / | 120.00     | / |
| Design Temperature F      |          | 300.00     |   | 150.00     |   |
| No Passes per Shell       |          | 1          |   | 4          |   |
| Corrosion Allowance inch  |          | 0.1875     |   | 0.125      |   |
| Connections               | In inch  | 1 @ 9.7500 |   | 1 @ 4.0260 |   |
|                           | Out inch | 1 @ 7.6250 |   | 1 @ 4.0260 |   |
|                           | Rating   | @          |   | @          |   |



|                         |                                              |                      |                                      |              |             |                    |                      |       |                 |
|-------------------------|----------------------------------------------|----------------------|--------------------------------------|--------------|-------------|--------------------|----------------------|-------|-----------------|
| Tube No.                | 104U                                         | OD                   | 0.7500 inch                          | Thk(Avg)     | 0.0650 inch | Length             | 14.000 ft            | Pitch | 1.0000 inch     |
| Tube Type               | Plain                                        |                      |                                      |              |             | Material           | Alloy 2205 (S31803)  |       | Tube pattern 45 |
| Shell                   | SA-516 70 Pl. K02700                         | ID                   | 21.000                               | OD           | 22.000 inch | Shell Cover        | SA-516 70 Pl. K02700 |       | (Integ.)        |
| Channel or Bonnet       | SA-516 70 Pl. K02700                         |                      |                                      |              |             | Channel Cover      | SA-516 70 Pl. K02700 |       |                 |
| Tubesheet-Stationary    | Alloy 2205 (S31803)                          |                      |                                      |              |             | Tubesheet-Floating |                      |       |                 |
| Floating Head Cover     |                                              |                      |                                      |              |             | Impingement Plate  | Rods                 |       |                 |
| Baffles-Cross           | 316 Stainless steel (17 Cr, Type Double-Seg. | %Cut (Diam)          | 26                                   | Spacing(c/c) | 10.750      | Inlet              | 15.000 inch          |       |                 |
| Baffles-Long            |                                              | Seal Type            | None                                 |              |             |                    |                      |       |                 |
| Supports-Tube           |                                              | U-Bend               |                                      |              |             | Type               | Full support         |       |                 |
| Bypass Seal Arrangement | 2 pairs seal strips                          | Tube-Tubesheet Joint | Expanded and Seal Welded (2 grooves) |              |             |                    |                      |       |                 |
| Expansion Joint         |                                              | Type                 | None                                 |              |             |                    |                      |       |                 |
| Rho-V2-Inlet Nozzle     | 1108.8 lb/ft-sec2                            | Bundle Entrance      | 638.99                               | Bundle Exit  | 452.24      | lb/ft-sec2         |                      |       |                 |
| Gaskets-Shell Side      | Spiral Wound Metal (SS)                      | Tube Side            | Spiral Wound Metal (SS)              |              |             |                    |                      |       |                 |
| - Floating Head         |                                              |                      |                                      |              |             |                    |                      |       |                 |
| Code Requirements       |                                              |                      |                                      |              |             | TEMA Class         | R                    |       |                 |
| Weight/Shell            | 4740.7 lb                                    | Filled with Water    | 7171 lb                              |              |             | Bundle             | 2016.1 lb            |       |                 |

Remarks:

Note: Reported duty and flow rates include a user-specified multiplier of 1.10.

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**US Units**

Shell 1

Rating - Horizontal Multipass Flow TEMA AEU Shell With Double-Segmental Baffles

**Exchanger Data**

|                              |                        |
|------------------------------|------------------------|
| Unit identifier              | Shell 1                |
| Service type                 | Generic shell and tube |
| TEMA type                    | AEU                    |
| Run mode                     | Rating                 |
| Hot fluid location           | Shellside              |
| Unit orientation             | Horizontal             |
| Number of shells in series   | 1                      |
| Number of shells in parallel | 1                      |
| Flow in 1st tubepass         | Countercurrent         |
| Train flow direction         | Countercurrent         |

**Construction Data**

|                                  |                                    |
|----------------------------------|------------------------------------|
| Shell material                   | SA-516 70 Pl. K02700               |
| Tube material                    | Alloy 2205 (S31803)                |
| Shell cover material             | SA-516 70 Pl. K02700               |
| Channel or bonnet material       | SA-516 70 Pl. K02700               |
| Channel cover material           | SA-516 70 Pl. K02700               |
| Tubesheet-Stationary material    | Alloy 2205 (S31803)                |
| Baffle-Cross material            | 316 Stainless steel (17 Cr, 12 Ni) |
| Shellside gasket                 | Spiral Wound Metal (SS)            |
| Tubeside gasket                  | Spiral Wound Metal (SS)            |
| Shellside design pressure        | 95.000 psig                        |
| Tubeside design pressure         | 120.00 psig                        |
| Shellside vacuum pressure        | Full                               |
| Tubeside vacuum pressure         | None                               |
| Shellside design temperature     | 300.00 F                           |
| Tubeside design temperature      | 150.00 F                           |
| Shellside corrosion allowance    | 0.1875 inch                        |
| Tubeside corrosion allowance     | 0.125 inch                         |
| Tubesheet design temperature     | 300.00 F                           |
| Shellside radiography            | None                               |
| Tubeside radiography             | None                               |
| TEMA class                       | R                                  |
| Small exchanger                  | No                                 |
| Shell outside diameter           | 22.000 inch                        |
| Shell inside diameter            | 21.000 inch                        |
| Shell wall thickness             | 0.5000 inch                        |
| Front head outside diameter      | 22.000 inch                        |
| Front head inside diameter       | 21.000 inch                        |
| Front head thickness             | 0.5000 inch                        |
| Rear head outside diameter       | 22.000 inch                        |
| Rear head inside diameter        | 21.000 inch                        |
| Rear head thickness              | 0.5000 inch                        |
| Total tubesheet thickness        | 2.0000 inch                        |
| Double tubesheet                 | No                                 |
| Shell expansion joint            | No                                 |
| Suppress mechanical calculations | No                                 |

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**US Units**

Shell 1

Rating - Horizontal Multipass Flow TEMA AEU Shell With Double-Segmental Baffles

**Tube Data**

|                       |                     |
|-----------------------|---------------------|
| Tube type             | Plain               |
| Tube outside diameter | 0.7500 inch         |
| Tube wall thickness   | 0.0650 inch         |
| Tube pitch            | 1.0000 inch         |
| Tube pitch ratio      | 1.3333              |
| Tubepasses per shell  | 4                   |
| Tube pattern          | 45 degrees          |
| Tube count method     | Rigorous            |
| Tube length           | 14.000 ft           |
| Tube material         | Alloy 2205 (S31803) |

**Baffle Data**

|                                             |                   |
|---------------------------------------------|-------------------|
| Baffle type                                 | Double segmental  |
| Baffle orientation                          | Program sets      |
| Baffle cut percent                          | 26.000 % shell ID |
| Adjust baffle cut                           | No adjustment     |
| Double segmental overlap                    | 3.0000 Tuberows   |
| Double segmental set center baffle at inlet | Program set       |
| Central baffle spacing                      | 10.750 inch       |
| Inlet baffle spacing                        | 15.000 inch       |
| Outlet baffle spacing                       | 19.500 inch       |
| Variable baffle spacing                     | No                |
| Baffle thickness                            | 0.1875 inch       |
| Window cut from baffles                     | No                |
| Use deresonating baffles                    | No                |

**Supports Data**

|                                                     |              |
|-----------------------------------------------------|--------------|
| Full support at U-Bend                              | Full support |
| Support distance to U-bend tangent                  | 2.0000 inch  |
| Include inlet vibration support                     | Yes          |
| Distance from tubesheet to inlet vibration support  | 7.7500 inch  |
| Include outlet vibration support                    | Yes          |
| Distance from tubesheet to outlet vibration support | 15.250 inch  |

**Nozzle Data****Shellside**

|                     |                               |
|---------------------|-------------------------------|
| Nozzle standard     | 01-ANSI_B36_10.TABLE          |
| Shell entrance type | Use impingement device        |
| Shell exit type     | Remove tubes if TEMA requires |

|                         | Inlet  | Outlet | Liq. Outlet |
|-------------------------|--------|--------|-------------|
| Nozzle outside diameter | 10.750 | 8.6250 | -- inch     |
| Nozzle inside diameter  | 9.7500 | 7.6250 | -- inch     |
| Number at this position | 1      | 1      | --          |

**Tubeside**

|                 |                      |
|-----------------|----------------------|
| Nozzle standard | 01-ANSI_B36_10.TABLE |
|-----------------|----------------------|

|                         | Inlet  | Outlet | Liq. Outlet |
|-------------------------|--------|--------|-------------|
| Nozzle outside diameter | 4.5    | 4.5    | -- inch     |
| Nozzle inside diameter  | 4.0260 | 4.0260 | -- inch     |
| Number at this position | 1      | 1      | --          |

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**US Units**

Shell 1

Rating - Horizontal Multipass Flow TEMA AEU Shell With Double-Segmental Baffles

**Nozzle Location Data**

|                                                |                 |
|------------------------------------------------|-----------------|
| Radial position on shell inlet nozzle          | Program decides |
| Longitudinal position on shell of inlet nozzle | At rear head    |
| Radial position on shell outlet nozzle         | Program decides |
| Location of nozzle at U-bend                   | Before U-bend   |
| Tubeside entry type                            | Radial          |
| Tubeside inlet position                        | Front head      |
| Tubeside exit type                             | Same as inlet   |

**Impingement Data**

|                                  |             |
|----------------------------------|-------------|
| Impingement type                 | Rods        |
| Use tube positions to place rods | No          |
| Impingement rod rows             | 2           |
| Impingement rod diameter         | 0.7500 inch |
| Impingement rod pitch            | 0.9375 inch |
| Impingement rods on centerline   | Program set |
| Impingement rod layout angle     | 60.00 deg   |
| Rod row width to nozzle diameter | 1.0000      |

**Tube Layout Data**

|                                        |                                           |
|----------------------------------------|-------------------------------------------|
| Pass partition construction            | Program set                               |
| Force symmetric layout                 | No                                        |
| Force continuous cleaning lanes        | No                                        |
| Force uniform layout                   | No                                        |
| Align across primary passlanes         | No                                        |
| Fill knock out area with dummy tubes   | Program set                               |
| Fill bundle periphery with dummy tubes | Program set                               |
| Fill passlanes with dummy tubes        | Program Set                               |
| Shifted staggered layout               | Program set                               |
| Use crossed U-bends                    | No                                        |
| Minimum U-bend diameter                | 3.0000 inch                               |
| Use tube layout drawing as input       | Yes                                       |
|                                        | <b>Inlet      Outlet      Liq. Outlet</b> |
| Height under nozzle                    | 2.0000      3.0000      -- inch           |

**Clearance Data**

|                              |             |
|------------------------------|-------------|
| Number of seal strip pairs   | 2           |
| Block A stream               | No          |
| Block E stream               | No          |
| Block F stream               | No          |
| Number of passlane seal rods | 2           |
| Passlane seal rod diameter   | 0.5000 inch |
| Tubes to remove for tie rods | Calculated  |
| Number of tie rods           | 8           |
| Tie rod outside diameter     | 0.5 inch    |
| Baffle to shell clearance    | 0.1875 inch |
| Bundle to shell clearance    | 0.125 inch  |
| Baffle clearance type        | TEMA        |

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**US Units**

Shell 1

Rating - Horizontal Multipass Flow TEMA AEU Shell With Double-Segmental Baffles

**Process Conditions Data****Hot Fluid****Cold Fluid**

|                         |           |                   |
|-------------------------|-----------|-------------------|
| Phase condition         | Two phase | Sensible liquid   |
| Flow rate               | 36.399    | 140.17 1000-lb/hr |
| Inlet vapor fraction    | 1.0000    | 0.0000            |
| Outlet vapor fraction   | --        | 0.0000            |
| Inlet temperature       | 219.80    | 80.00 F           |
| Outlet temperature      | 111.70    | -- F              |
| Inlet pressure          | 77.696    | 64.696 psia       |
| Allowable pressure drop | 5.000     | 10.000 psi        |
| Exchanger duty          |           | 2.1000 MM Btu/hr  |
| Duty multiplier         |           | 1.1000            |

**Process Fouling Data****Hot Fluid****Cold Fluid**

|                    |        |                     |
|--------------------|--------|---------------------|
| Fouling resistance | 0.0020 | 0.0020 ft2-hr-F/Btu |
|--------------------|--------|---------------------|

**Hot Fluid Property Data**

|                                  |                       |
|----------------------------------|-----------------------|
| Fluid name                       | OFFGASES              |
| Physical property method         | Combination           |
| Temperature interpolation option | Program               |
| Flash type                       | Integral              |
| Quantity units                   | Moles                 |
| Heat release type                | Total duty from inlet |
| Heat release flow rate           | 36.399 1000-lb/hr     |
| Number of components             | 1                     |
| Property package                 | HTRI (legacy)         |

**Hot Fluid Physical Property Data**

Pressure Set, 77.700 psia

| Temp.<br>F | Duty<br>MM Btu/hr | Vapor<br>Mass<br>Fraction |
|------------|-------------------|---------------------------|
| 219.80     | 0.0000            | 1.0000                    |
| 208.80     | -0.210            | 1.0000                    |
| 197.80     | -0.420            | 1.0000                    |
| 186.80     | -0.620            | 1.0000                    |
| 175.90     | -0.830            | 1.0000                    |
| 164.90     | -1.030            | 1.0000                    |
| 153.90     | -1.230            | 1.0000                    |
| 142.90     | -1.420            | 1.0000                    |
| 132.00     | -1.620            | 1.0000                    |
| 121.00     | -1.860            | 0.9910                    |
| 110.00     | -2.290            | 0.9560                    |

Pressure Set, 72.700 psia

| Temp.<br>F | Duty<br>MM Btu/hr | Vapor<br>Mass<br>Fraction |
|------------|-------------------|---------------------------|
| 219.30     | 0.0000            | 1.0000                    |

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**US Units**

Shell 1

Rating - Horizontal Multipass Flow TEMA AEU Shell With Double-Segmental Baffles

**Hot Fluid Physical Property Data**

Pressure Set, 72.700 psia

| Temp.<br>F | Duty<br>MM Btu/hr | Vapor<br>Mass<br>Fraction |
|------------|-------------------|---------------------------|
| 208.40     | -0.210            | 1.0000                    |
| 197.40     | -0.410            | 1.0000                    |
| 186.50     | -0.620            | 1.0000                    |
| 175.60     | -0.820            | 1.0000                    |
| 164.60     | -1.020            | 1.0000                    |
| 153.70     | -1.220            | 1.0000                    |
| 142.80     | -1.410            | 1.0000                    |
| 131.90     | -1.610            | 1.0000                    |
| 120.90     | -1.820            | 0.9980                    |
| 110.00     | -2.180            | 0.9840                    |

**Hot Fluid Component Data**

|                                   |                    |        |
|-----------------------------------|--------------------|--------|
| Component number                  |                    | 1      |
| Component name                    | [New User-Defined] |        |
| Comp. bank name                   | <User-Defined>     |        |
| Component bank                    | HTRI (legacy)      |        |
| Component code                    | -1                 |        |
| Component phase                   | Mixed              |        |
| Vapor Properties                  |                    |        |
| Reference temperature, F          | 219.80             | 110.00 |
| Density, lb/ft3                   | 0.4150             | 0.4340 |
| Viscosity, cP                     | 0.0130             | 0.0100 |
| Thermal conductivity, Btu/hr-ft-F | 0.0250             | 0.0200 |
| Heat capacity, Btu/lb-F           | 0.5290             | 0.4700 |
| Liquid Properties                 |                    |        |
| Reference temperature, F          | --                 | 110.00 |
| Density, lb/ft3                   | --                 | 39.570 |
| Viscosity, cP                     | --                 | 0.2500 |
| Thermal conductivity, Btu/hr-ft-F | --                 | 0.0590 |
| Heat capacity, Btu/lb-F           | --                 | 0.5830 |
| Surface tension, dyne/cm          | --                 | 15.480 |

**Cold Fluid Property Data**

|                                  |                   |
|----------------------------------|-------------------|
| Fluid name                       | COOLING WATER     |
| Physical property method         | Composition based |
| Temperature interpolation option | Program           |
| Flash type                       | Integral          |
| Quantity units                   | Moles             |
| Number of components             | 1                 |
| Property package                 | HTRI (legacy)     |

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US Units

Shell 1

Rating - Horizontal Multipass Flow TEMA AEU Shell With Double-Segmental Baffles

## Cold Fluid Component Data

|                    |                    |
|--------------------|--------------------|
| Component number   | 1                  |
| Component name     | Water (IAPWS 1997) |
| Comp. bank name    | Water (IAPWS 1997) |
| Component bank     | HTRI (legacy)      |
| Component code     | 1                  |
| Component phase    | Liquid             |
| Component quantity | 1.0000             |

## Control Name Data

|                  |                                               |
|------------------|-----------------------------------------------|
| Job Number       | S-16030-6-18-X-370REV4                        |
| Item Number      | 18-X-370 Corn Oil Jet Mode - EOR              |
| Reference Number | P.O.# 4505600058                              |
| Proposal Number  | S21-13258-6 & 7                               |
| Revision         | D                                             |
| Service          | PROPANE RECOVERY COMPRESSOR INTERSTAGE COOLER |
| Customer         | AIR PRODUCTS ( WORLD ENERGY PARAMOUNT )       |
| Address          | ALLENTOWN, PA                                 |
| Plant            | PARAMOUNT, CA                                 |

## Control Methods Data

|                                           |                                             |
|-------------------------------------------|---------------------------------------------|
| Shellside friction factor method          | Commercial                                  |
| Tubeside friction factor method           | Commercial                                  |
| Pure longitudinal flow                    | No                                          |
| Pure component condensation               | No                                          |
| Condensing correlation                    | HTRI Proration                              |
| Mole fraction inerts                      | 0.0000                                      |
| Momentum exclusion                        | 0.0000 %                                    |
| Perform shellside subcooling calculations | No                                          |
| Pure component boiling                    | No                                          |
| Check film boiling                        | Yes                                         |
| Nucleate boiling method                   | Physical property/theoretical boiling range |
| Component boiling method                  | Nucleate and convective                     |
| Reduced pressure calculation method       | Program decides                             |
| Increments per baffle                     | Calculated                                  |

## Control User-Defined Methods Data

|                          |     |
|--------------------------|-----|
| Add non-nucleate boiling | Yes |
|--------------------------|-----|