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|  MEG ENERGY | CHRISTINA LAKE REGIONAL PROJECT Phase 3A EPC for Central Plant Facilities |  SNC-LAVALIN |
| | SLI Project No. 511036 | |

| | |
|---|--|
|  SNC-LAVALIN | <input type="checkbox"/> A1 Not suitable to initiate fabrication, modify as noted, resubmit for review |
| | <input type="checkbox"/> B1 Suitable to initiate fabrication as noted, modify as noted, resubmit for review |
| Vendor's drawing review for conformity with specifications and design drawing. | <input type="checkbox"/> C1 Suitable to fabricate to completion as noted, submit final documents including as-builts as required |
| This review does not relieve the vendor of his responsibility for errors in design and detailing as detailed in his contract. | <input type="checkbox"/> D1 Suitable to fabricate to completion, submit final documents including as-built documents as required |
| | <input type="checkbox"/> E1 Not suitable as final documents as noted, modify as noted and resubmit. |
| | <input checked="" type="checkbox"/> F1 Suitable as final documents, no further resubmittal required (unless revised by vendor) |
| Vendor: Sewon Cellontech Co. Ltd. - P00007 No.: E0351-3AE102-P-02 Rev: 0 Date Rec'd: 2013/09/04 | |
| Doc. Title: L53.51, L53.53 - THERMAL DESIGN CALCULATION - Tag:3A-E-102A/B | |
| Client Code: | Project: MEG Phase 3A EPC |
| Reviewed by: <i>SJ</i> | Document No: P-5310-01-0032 |
| Date: <i>11-Sept-2013</i> | Submittal: 02 |

| | | | |
|---|---------------------------------------|--------------|-------------------|
|  SEWON CELLONTECH | DOCUMENT FOR EQUIPMENT | SWC JOB NO | E-0351 |
| | | ITEM NO. | 3A-E-102A/B |
| | | SWC DOC. NO. | E0351-3AE102-P-02 |

ASME-U

FOR APPROVAL

| | | | |
|---|---|---|--|
|  MEG Energy Corp. | |  SNC-LAVALIN | |
| P.O NO. | | P-5310-01 | |
| PROJECT NAME | CLRP Phase 3A Central Plant Facility: EPC | | |
| PROJECT NO. | 511036 | | |
| DOCUMENT TITLE | THERMAL DESIGN CALCULATION | | |
| ITEM NO. | ITEM DESCRIPTION | | |
| 3A-E-102A/B | PRODUCED GAS / GLYCOL EXCHANGER | | |

- Total Sheet : 15 Sheet (Including This Cover)



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|-----|-------------------------------|----------------------------|-----------------------------|--------------|
| | | | | |
| | | | | |
| | | | | |
| 1 | <i>M.K. Park</i> 8/16/2013 | <i>T.W. Kim</i> 8/16/13 | <i>Y.S. Ji</i> 8/12/2013 | SECOND ISSUE |
| 0 | M.K.PARK | T.W.KIM | Y.S.JI | FIRST ISSUED |
| REV | PREPARED BY | REVIEWED BY | APPROVED BY | DESCRIPTION |

SEWON CELLONTECH CO.,LTD.

**SEWON CELLONTECH****TUBULAR HEAT EXCHANGER**

SHEET 2 OF 15

| | | | | | | | | |
|---|---|-----------------------|---------------------------|---------------------|---------------|---|---|------------------------------|
| CUSTOMER | MEG Energy Corp. | | | REV | MADE BY | CHECKED BY | APPROVED BY | DATE |
| LOCATION | CANADA | | | 0 | - | - | - | 07-01-2013 |
| JOB NO. | 511036 | | | 1 | - | - | - | 08-14-2013 |
| SERVICE | Produced Gas / Glycol Exchanger | | | | | | | |
| ITEM NO. | 3A-E-102A/B (Max Duty and UA Case) | | | | | | | |
| Total | 2 | Shells, Connected in | 2 | Parallel | 1 | Series Shells | Install <input checked="" type="checkbox"/> Hor. <input type="checkbox"/> Vert. | Size 1,170.0 ID - 12,192.0 L |
| Code | ASME Sec.VIII Div.1 (STAMP), TEMA, API660 TEMA Type AEL | | | TEMA Class R | | Effective Area 1,464.62 m ² /Shell | | |
| PERFORMANCE OF ONE BATTERY | | | | | | | | |
| | | SHELL SIDE | | TUBE SIDE | | | | |
| | | INLET | | OUTLET | | INLET | | |
| | | | | | | OUTLET | | |
| Fluid Circulated | | TEG/Water (60/40 wt%) | | Produced Gas | | | | |
| Total Fluid kg/hr | | 610243 | | 139760 | | | | |
| Vapor kg/hr | | | | | | 87324.8 | | |
| MW | | | | | | 33863.7 | | |
| Liquid kg/hr | | 610243 | | 610243 | | 52434.7 | | |
| Steam kg/hr | | | | | | 105896 | | |
| Water kg/hr | | | | | | | | |
| Noncondensable kg/hr | | | | | | | | |
| MW | | | | | | | | |
| Operating Temperature °C | | 40.00 | | 120.00 | | 155.20 | | 50.00 |
| Operating Pressure kPag | | 994.015 | | | | 959.014 | | |
| Density kg/m3 | | L / V | 1078.00 | 1013.00 | 899.1 | 4.8687 | 984.60 | 5.8912 |
| Viscosity cP | | L / V | 4.6610 | 1.1150 | 0.1747 | 0.0130 | 0.5787 | 0.0122 |
| Thermal Conductivity W/m·°C | | L / V | 0.3281 | 0.3411 | 0.6858 | 0.0399 | 0.6206 | 0.0376 |
| Specific Heat kJ/kg·°C | | L / V | 3.2231 | 3.5081 | 4.5927 | 2.2237 | 4.2671 | 2.2970 |
| Latent Heat kJ/kg | | | | | | | | |
| Bubble / Dew Point °C | | / | | / | | / | | / |
| Critical Press. / Temp. kPag / °C | | / | | / | | / | | / |
| Velocity m/sec | | 0.45 | | 3.07 | | | | |
| Pressure Drop kPa | | Allow. | 70.001 | Calc. | 61.250 | Allow. | 6.000 | Calc. |
| Fouling Resistance m ² ·°C/kW | | 0.18 | | 0.35 | | | | |
| Film Coefficient W/m ² ·K | | 2,540.24 | | 1,529.56 | | | | |
| Overall Coefficient W/m ² ·K | | Clean | 783.40 | Calc. | 524.63 | Design | 408.15 | |
| Heat Duty KW | | 45,904.00 | | LMTD °C | | MTD °C | | 38.2 °C |
| CONSTRUCTION | | | | | | | | |
| Design Pressure | | Design Temperature | | 1500.0 / FV kPag | -29 / 210 °C | 1500.0 / FV kPag | -29 / 210 °C | |
| No. of Passes | | | | 1 | | 1 | | |
| Tubes No. | | 2035 | / Shell, Size | 19.05 mm | Thickness | 2.11 (Min.) mm | (BWG : 14) | Length |
| Shell | | 1170 mm ID | | Tube Pitch | 23.812 mm | Layout angle | 30 ° | Effective |
| Baffles | | Cross Baffle | 20 ea / Shell, Type | Single Seg. (Hori.) | Cut | 24.0 % Dia. | Spacing c/c | 550.0 mm |
| End | | | | | | | | - mm |
| pv ² | | Inlet Nozzle | 1,420.61 | Entrance | 3,847.87 | Outlet Nozzle | 1,511.76 | kg/m·sec ² |
| Material | | Tube | SA 179 Seamless | | Shell & Cover | SA 516 GR. 70N | | Impingement plate |
| | | Tube Sheet | SA 266 GR.2 (Note 7 & 15) | | Baffle | Carbon Steel | | Channel & Cover |
| | | | | | | | | SA 516 GR. 70N (Note 7) |
| | | | | | | | | Expansion Joint |
| | | | | | | | | Required (Note 3) |
| Estimated Weight | | Empty Weight | kg | Bundle Weight | - kg | Full Water Weight | kg | |
| Corrosion Allowance | | Shell side | 3.2 mm | Tube side | 3.2 mm | Tube Joints : | Rolled (two grooves) and Expanded | |
| Insulation | | Shell side | 64 mm | Tube side | 64 mm | | | |
| MEAN METAL TEMPERATURE | | Temperature, °C | | Pressure, kPag | | 4 Exchangers shall be designed for future field hydrotest in the fully corroded condition. | | |
| Normal Operating | | Shell | - | Tube | - | 5 Seller is to design and install electrical heat tracing for hold temperature of 10 °C. | | |
| Startup | | Shell | - | Tube | - | 6 CSA approval is required for electric components and installation. The heat exchanger is located in hazardous area class 1, zone 2. | | |
| | | Shell | - | Tube | - | 7 Seller shall supply and install 64mm mineral fiber insulation. | | |
| | | Shell | - | Tube | - | 8 Tube side is in sour service. Materials and fabrication shall be in accordance with NACE MR0175-2002. PWHT is required for tube side welds. | | |
| | | Shell | - | Tube | - | 9 All tube side category D welds shall be 100% UT examined after PWHT. | | |
| | | Shell | - | Tube | - | 10 All Tube Side butt-welds (including all flange to nozzle welds) shall be 100% RT examined after PWHT. | | |
| | | Shell | - | Tube | - | 11 Exchanger shall body shall be 1% sloped to the tube side outlet to facilitate tube side condensing. All flange faces shall be horizontal. | | |
| | | Shell | - | Tube | - | 12 Each process nozzle shall be provided with 1-1" 300# RFLWN (complete with blind flange, gasket, bolts & nuts). | | |
| | | Shell | - | Tube | - | 13 Tube side shall be provided with a NPS 2 (300#, RFLWN) vent and drain. Vent and drain shall come complete with blind flange, gasket, bolts & nuts. | | |
| | | Shell | - | Tube | - | 14 Tube side girth flanges shall be fabricated from SA 266, Grade 2. | | |
| | | Shell | - | Tube | - | 15 For tubeside shell plates, Seller shall specify supplementary requirement S3 of ASTM A20 in the plate purchase order. Simulated PWHT holding time shall be three times that of production PWHT holding time. Plate mill shall guarantee the mechanical properties of the plate after three times production PWHT holding time. | | |
| | | Shell | - | Tube | - | 16 Seller shall meet requirement noted in UW-13(f)(1). | | |
| Thermowell | | | | | | | | |
| Util. Con. | | | | | | | | |
| RATING | | RFWN 300# | | RFWN 300# | | | | |
| Remarks | | | | | | | | |
| 1) Seller shall verify and guarantee thermal rating of the unit. | | | | | | | | |
| 2) Refer to heat curve. | | | | | | | | |
| 3) Expansion joint design shall be based on design conditions noted on page 3 & 4. | | | | | | | | |
| Expansion joint shall be flanged and flued type per TEMA RCB 8. Expansion joint shall include vent and drain connections. | | | | | | | | |

**SEWON CELLONTECH****TUBULAR HEAT EXCHANGER**

SHEET 3 OF 15

| | | | | | | |
|----------|---------------------------------|-----|---------|------------|-------------|------------|
| CUSTOMER | MEG Energy Corp. | REV | MADE BY | CHECKED BY | APPROVED BY | DATE |
| LOCATION | CANADA | 0 | - | - | - | 07-01-2013 |
| JOB NO. | 511036 | 1 | - | - | - | 08-14-2013 |
| SERVICE | Produced Gas / Glycol Exchanger | | | | | |
| ITEM NO. | 3A-E-102A/B (Min Case) | | | | | |

| | | | | | | | | | | |
|-------|---|----------------------|-----|------------|---|----------------|----------|---|------|-------------------------|
| Total | 2 | Shells, Connected in | 2 | Parallel | 1 | Series Shells | Install | <input checked="" type="checkbox"/> Hor. <input type="checkbox"/> Vert. | Size | 1,170.0 ID - 12,192.0 L |
| Code | ASME Sec.VIII Div.1 (STAMP), TEMA, API660 | TEMA Type | AEL | TEMA Class | R | Effective Area | 1,464.62 | m ² /Shell | | |

PERFORMANCE OF ONE BATTERY

| | | | SHELL SIDE | | | | TUBE SIDE | | | |
|--------------------------|-----------|-------|-----------------------|--------|---------|-------|--------------|--------|---------|---------|
| | | | INLET | | OUTLET | | INLET | | OUTLET | |
| Fluid Circulated | | | TEG/Water (60/40 wt%) | | | | Produced Gas | | | |
| Total Fluid | kg/hr | | 44481.1 | | | | 32254.1 | | | |
| Vapor | kg/hr | MW | | | | | 4314.82 | | 3554.41 | |
| Liquid | kg/hr | MW | 44481.1 | | 44481.1 | | 27939.3 | | 28699.7 | |
| Steam | kg/hr | | | | | | | | | |
| Water | kg/hr | | | | | | | | | |
| Noncondensable | kg/hr | MW | | | | | | | | |
| Operating Temperature °C | | | 40.00 | | 98.30 | | 108.30 | | 50.00 | |
| Operating Pressure kPag | | | 994.015 | | | | 959.014 | | | |
| Density | kg/m3 | L / v | 1078.00 | | 1032.00 | | 932.00 | 6.6266 | 977.6 | 7.5981 |
| Viscosity | cP | L / v | 4.6610 | | 1.4700 | | 0.2915 | 0.0144 | 0.6307 | 0.0129 |
| Thermal Conductivity | W/m·°C | L / v | 0.3281 | | 0.3391 | | 0.6301 | 0.0390 | 0.5866 | 0.0336 |
| Specific Heat | kJ/kg·°C | L / v | 3.2301 | | 3.4321 | | 4.3111 | 1.9314 | 4.1871 | 1.8310 |
| Latent Heat | kJ/kg | | | | | | | | | |
| Bubble / Dew Point | °C | | / | | / | | / | | / | |
| Critical Press. / Temp. | kPag / °C | | / | | / | | / | | / | |
| Velocity | m/sec | | 3.258e-2 | | | | 0.22 | | | |
| Pressure Drop | kPa. | | Allow. | 70.001 | Calc. | 0.688 | Allow. | 6.000 | Calc. | 0.083 |
| Fouling Resistance | m2·°C/kW | | 0.18 | | | | 0.35 | | | |
| Film Coefficient | W/m2·K | | 534.04 | | | | 172.05 | | | |
| Overall Coefficient | W/m2·K | | Clean | 106.61 | Calc. | | 99.90 | Design | 79.12 | |
| Heat Duty | KW | | 2,400.00 | | | | LMTD | °C | MTD | 10.3 °C |

CONSTRUCTION

| | | | | | | | | | | | |
|---------------------|--|--------------------|--|------------------|--|---------------------|--|--------------------|--|----------------------|--|
| Design Pressure | | Design Temperature | | / kPag | | / °C | | / kPag | | / °C | |
| No. of Passes | | | | | | | | | | | |
| Tubes No. | | / Shell, Size | | mm | | Thickness (Min.) mm | | (BWG :) | | Length mm | |
| Shell | | | | mm ID | | Tube Pitch mm | | Layout angle ° | | Leffective - mm | |
| Baffles | | Cross Baffle | | ea / Shell, Type | | Cut - % Dia. | | Spacing c/c mm | | End - mm | |
| pv ² | | Inlet Nozzle | | 7.55 | | Entrance 20.44 | | Outlet Nozzle 7.88 | | kg/m·sec2 | |
| | | | | | | | | | | Impingement plate | |
| Material | | Tube | | Shell & Cover | | | | Channel & Cover | | | |
| | | Tube Sheet | | Baffle | | | | Expansion Joint | | | |
| Estimated Weight | | Empty Weight | | kg | | Bundle Weight | | kg | | Full Water Weight kg | |
| Corrosion Allowance | | Shell side | | mm | | Tube side | | mm | | Tube Joints : | |
| Insulation | | Shell side | | mm | | Tube side | | mm | | | |

| MEAN METAL TEMPERATURE | Temperature, °C | | | | Pressure, kPag | | | |
|------------------------|-----------------|----|------|---------|----------------|----|------|---------|
| | Shell | | Tube | | Shell | | Tube | |
| Normal Operating | - | | - | | - | | - | |
| Startup | - | | - | | - | | - | |
| | | | | | | | | |
| NOZZLE | SHELL SIDE | | | | TUBE SIDE | | | |
| | Tag | No | NPS | Remarks | Tag | No | NPS | Remarks |
| Inlet | | | | | | | | |
| Outlet | | | | | | | | |
| Vent | | | | | | | | |
| Drain | | | | | | | | |
| Liquid Outlet | | | | | | | | |
| Thermowell | | | | | | | | |
| Util. Con. | | | | | | | | |
| RATING | | | | | | | | |

MMT Condition

| Item | condition | shell | | tube | |
|------|---------------------------|-------------------|-------|-------------------|--------|
| | | pressure (kPa(g)) | temp | pressure (kPa(g)) | temp |
| E102 | Maximum Op Temperature | 1500 | 66.8 | 1500 | 77.3 |
| | Maximum Op Pressure | 1500 | 66.8 | 1500 | 77.3 |
| | Steam Out(Tube side) | 103.506 | 10 | 103.506 | 83.5 |
| | Shutdown&Depressured | 103.506 | -39 | 103.506 | -39 |
| | Hydortest-shell side | 2498 | 20 | 103.506 | 15 |
| | Hydortest-tube side | 103.506 | 10 | 2010 | 20 |
| | Prod. Gas CV Falls Closed | 1500 | 40 | 1500 | 40.92 |
| | Glycol CV Falls Closed | 1500 | 87.62 | 1500 | 149.52 |
| | Start-up tube side | 103.506 | 10 | 1500 | 82.6 |
| | Start-up shell side | 1500 | 40 | 103.506 | 40 |

⑩ EHT design shall use voltage of 277 VAC.

**SEWON CELLONTECH****TUBULAR HEAT EXCHANGER**

SHEET 4 OF 15

| | | | | | | |
|----------|---------------------------------|-----|---------|------------|-------------|------------|
| CUSTOMER | MEG Energy Corp. | REV | MADE BY | CHECKED BY | APPROVED BY | DATE |
| LOCATION | CANADA | 0 | - | - | - | 07-01-2013 |
| JOB NO. | 511036 | 1 | - | - | - | 08-14-2013 |
| SERVICE | Produced Gas / Glycol Exchanger | | | | | |
| ITEM NO. | 3A-E-102A/B | | | | | |

Design Conditions for Expansion Joint

| | Shell Side | | | | | | Tube Side | | | | | |
|---------------------------|--------------------------------|------------------|-------------------|--------------|------------------------|------------------|----------------|------------------|-------------------|--------------|------------------------|------------------|
| | Flow Condition | Fluid Temp Inlet | Fluid Temp Outlet | Pressure (a) | Mean Metal Temperature | Number of Cycles | Flow Condition | Fluid Temp Inlet | Fluid Temp Outlet | Pressure (a) | Mean Metal Temperature | Number of Cycles |
| | kg/hr | °C | °C | kPa(g) | °C | Cycles | kg/hr | °C | °C | kPa(g) | °C | Cycles |
| Maximum Op Temperature | 610241 | 40 | 120 | 1500 | 96.2 | norm op | 139759 | 155.2 | 50 | 1500 | 77.3 | norm op |
| Maximum PG Flow | Same as Maximum Op Temperature | | | | | | | | | | | |
| Steam Out (Tube side) | Stagnant | 10 | 10 | atm | 10 | 3 / year | 2083 | 157 | 157 | atm | 83.5 | 3 / year |
| Shutdown & Depressured | Stagnant | -39 | -39 | atm | -39 | 3 / year | Stagnant | -39 | -39 | atm | -39 | 3 / year |
| Hydrotest - Shell side | Stagnant | 20 | 20 | By Seller | 20 | 1 / year | Empty | 10 | 10 | atm | 15 | 1 / year |
| Hydrotest - Tube side | Empty | 10 | 10 | atm | 10 | 1 / year | Stagnant | 20 | 20 | By Seller | 20 | 1 / year |
| Prod. Gas CV Fails Closed | 610241 | 40 | 40 | 1500 | 40 | 1 / year | Stagnant | 155.2 | 44.5 | 1500 | 40.9 | 1 / year |
| Glycol CV Fails Closed | Stagnant | 40 | 120 | 1500 | 87.8 | 1 / year | 139759 | 155.2 | 115.1 | 1500 | 149.5 | 1 / year |
| Start-up tube side | Empty | 10 | 10 | atm | 10 | 3 / year | 139759 | 155.2 | 155.2 | 1500 | 92.6 | 3 / year |
| Start-up shell side | 610241 | 40 | 40 | 1500 | 40 | 3 / year | Empty | 10 | 40 | atm | 40 | 3 / year |

(a) System design pressure for maximum operating conditions. Maximum actual pressure for other conditions.

Inlet Produced Gas Vapour Composition (Maximum Duty and UA Case)

| Component | Overall Phase Mole Fraction | Vapour Phase Mole Fraction |
|-------------|-----------------------------|----------------------------|
| CO2 (Note*) | 0.0020 | 0.0833 |
| H2S (Note*) | 0.0001 | 0.0901 |
| Nitrogen | 0.9018 | 0.0029 |
| Methane | 0.2553 | 0.4107 |
| Ethane | 0.0001 | 0.0002 |
| Propane | 0.0000 | 0.0001 |
| i-Butane | 0.0000 | 0.0000 |
| n-Butane | 0.0000 | 0.0000 |
| i-Pentane | 0.0000 | 0.0000 |
| n-Pentane | 0.0000 | 0.0000 |
| n-Hexane | 0.0000 | 0.0000 |
| n-Heptane | 0.0000 | 0.0000 |
| n-Octane | 0.0000 | 0.0000 |
| n-Nonane | 0.0000 | 0.0000 |
| n-Decane | 0.0000 | 0.0000 |
| H2O | 0.7387 | 0.5796 |
| Bitumen | 0.0019 | 0.0030 |
| Total | 1.0000 | 1.0000 |

Note*: Maximum expected concentration in heat exchanger outlet

vapour phase is 38.28 mol% CO2 and 1.85 mol% H2S.

Maximum in the liquid phase is 23380 ppmw CO2

and 2707 ppmw H2S.

Inlet Produced Gas Vapour Composition (Minimum Case)

| Component | Overall Phase Mole Fraction | Vapour Phase Mole Fraction |
|-------------|-----------------------------|----------------------------|
| CO2 (Note*) | 0.0164 | 0.1373 |
| H2S (Note*) | 0.0011 | 0.0086 |
| Nitrogen | 0.0007 | 0.0063 |
| Methane | 0.0009 | 0.0060 |
| Ethane | 0.0002 | 0.0021 |
| Propane | 0.0001 | 0.0011 |
| i-Butane | 0.0000 | 0.0003 |
| n-Butane | 0.0001 | 0.0007 |
| i-Pentane | 0.0000 | 0.0002 |
| n-Pentane | 0.0000 | 0.0003 |
| n-Hexane | 0.0001 | 0.0004 |
| n-Heptane | 0.0002 | 0.0012 |
| n-Octane | 0.0000 | 0.0000 |
| n-Nonane | 0.0000 | 0.0000 |
| n-Decane | 0.0000 | 0.0000 |
| H2O | 0.8944 | 0.1463 |
| Bitumen | 0.0059 | 0.0087 |
| Total | 1.0000 | 1.0000 |

Note*: Maximum expected concentration in heat exchanger outlet

vapour phase is 35.25 mol% CO2 and 1.85 mol% H2S.

Maximum in the liquid phase is 23380 ppmw CO2

and 2707 ppmw H2S.

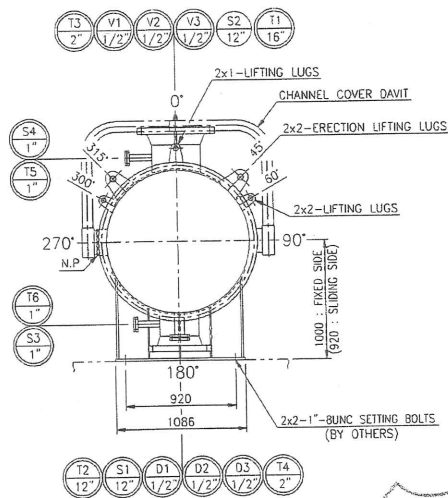
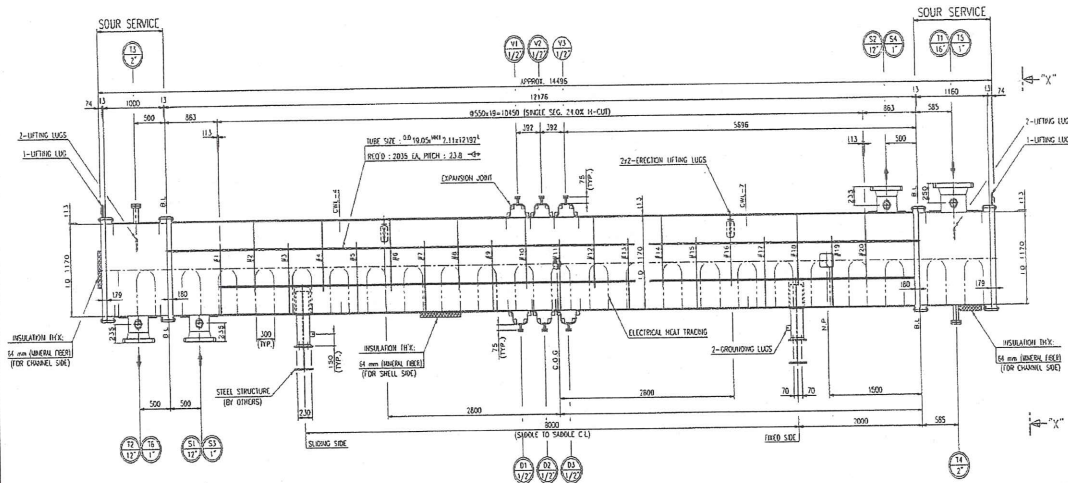


SEWON CELLONTECH

TUBULAR HEAT EXCHANGER

SHEET 5 OF 15

| | | | | | | | | | | | |
|----------|---------------------------------|-----|---|---------|---|------------|---|-------------|---|------------|------------|
| CUSTOMER | MEG Energy Corp. | REV | 0 | MADE BY | - | CHECKED BY | - | APPROVED BY | - | DATE | 07-01-2013 |
| LOCATION | CANADA | 1 | - | - | - | - | - | - | - | 08-14-2013 | |
| JOB NO. | 511036 | | | | | | | | | | |
| SERVICE | Produced Gas / Glycol Exchanger | | | | | | | | | | |
| ITEM NO. | 3A-E-102A/B | | | | | | | | | | |



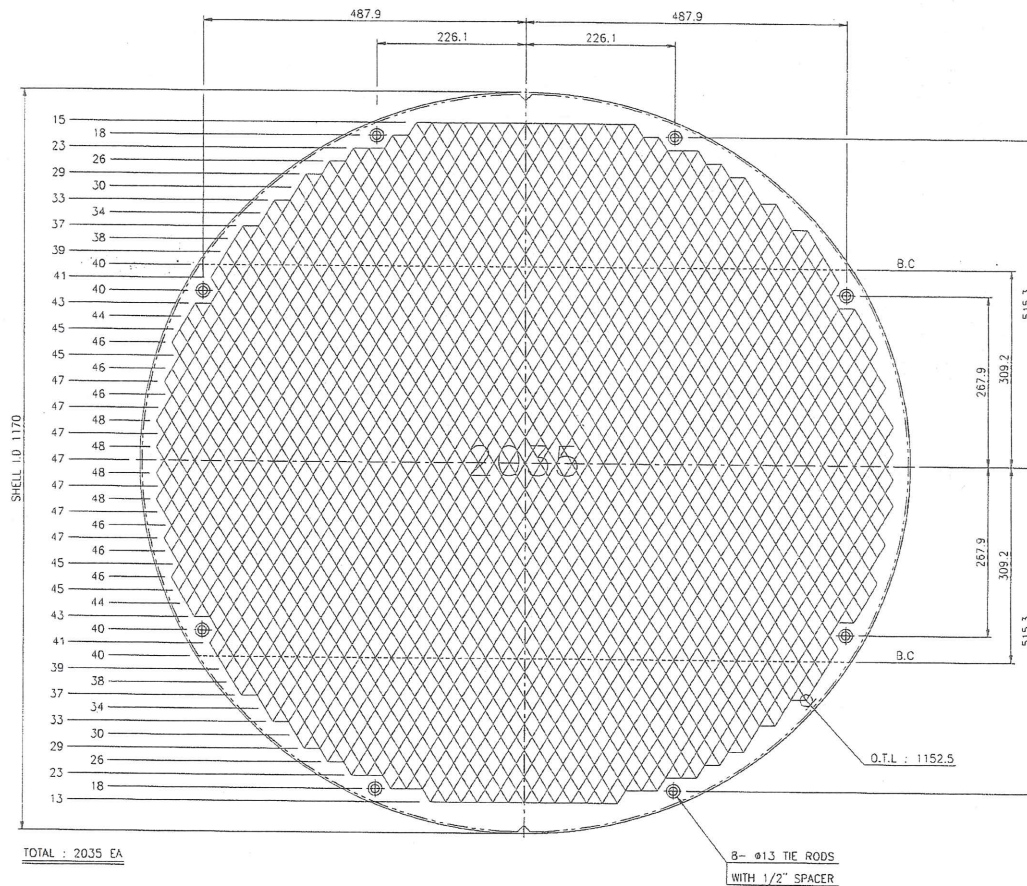


SEWON CELLONTECH

TUBULAR HEAT EXCHANGER

SHEET 6 OF 15

| | | | | | | |
|----------|---------------------------------|-----|---------|------------|-------------|------------|
| CUSTOMER | MEG Energy Corp. | REV | MADE BY | CHECKED BY | APPROVED BY | DATE |
| LOCATION | CANADA | 0 | - | - | - | 07-01-2013 |
| JOB NO. | 511036 | 1 | - | - | - | 08-14-2013 |
| SERVICE | Produced Gas / Glycol Exchanger | | | | | |
| ITEM NO. | 3A-E-102A/B | | | | | |



TOTAL 2035 HOLES FOR 19.05 OD TUBES ON 23.812 TRIANGULAR PITCH.
1 PASSES. BAFFLE CUT SINGLE SEGM. 24% DIA.

| | | |
|-----------------|------------|-------|
| I.D.-SHELL | 1,170.0 ID | (AEL) |
| ALLOWABLE O.T.L | 1152.5 | mm |
| ACTUAL O.T.L | 1152.5 | mm |
| SEAL STRIP | N/A | Pairs |
| SEAL Rod | N/A | ea |

Remarks

Thermal/Hydraulic/ Vibration **Verification Report**

(Rev.1)

3A-E-102A/B

Client : MEG Energy Corp.

Project : MEG Energy Christina Lake Regional Project
Phase 3A-Central Plant Facilities

Date : 08-14-2013

3A-E-102A/B (Max Duty and UA Case)

The Thermal/Hydraulic/Vibration calculations are performed by using HTRI Xist Ver. 6.00 SP3.

The process condition and the physical properties are based on Buyer data sheet.

For the design result (the geometry data), please refer to the Equipment data sheet and Fabrication drawing.

1. Thermal and Hydraulic performance

| | | | | |
|-------------------------|---------------|----------------------|------------|------------|
| - Thermal performance : | <u>28.54</u> | % Over - Design Case | ----- | O.K. |
| - Pressure drop : | | | | |
| Shell-side | <u>61.250</u> | < | 70.000 kPa | ----- O.K. |
| tube-side | <u>5.466</u> | < | 6.000 kPa | ----- O.K. |

2. Vibration Analysis

| | | | | | |
|------------------------------|-----------------------|----|----------|-------|------|
| - Fluidelastic instability : | characteristic values | << | criteria | ----- | O.K. |
| - Acoustic vibration : | characteristic values | << | criteria | ----- | O.K. |
| - Tube vibration check: | characteristic values | << | criteria | ----- | O.K. |
| - Bundle Entrance/Exit : | characteristic values | << | criteria | ----- | O.K. |
| - Shell Entrance /Exit: | characteristic values | << | criteria | ----- | O.K. |

9/15

3A-E-102A/B (Max Duty and UA Case)

Used Program : HTRI Xist Ver.6.00 SP.3 Vibration Analysis

| VALUE TO BE CHECKED | Inlet | Center | Outlet | RECOMMEND LIMIT | CONCLUSION |
|---------------------------------|--------|----------|---------|-------------------------------------|------------|
| Unsupported span (mm) | 1338. | 1100. | 1338. | 1524 (By TEMA) | O.K |
| Length / TEMA maximum span | 0.878 | 0.722 | 0.878 | < 1.0 TEMA | O.K |
| Fluidelastic Instability Check | | | | | |
| Baffle tip cross velocity ratio | 0.2314 | 0.2316 | 0.2415 | < 0.8 | O.K |
| Ave. crossflow velocity ratio | 0.2102 | 0.2104 | 0.2194 | < 0.8 | O.K |
| Acoustic Vibration Check | | | | | |
| Vortex shedding ratio | - | - | - | - | - |
| Tubulent buffeting ratio | - | - | - | - | - |
| Tube Vibration Check | | | | | |
| Vortex shedding ratio | 0.093 | 0.138 | 0.099 | < 0.5 | O.K |
| Tubulent buffeting ratio | - | - | - | - | - |
| Bundle Entrance / Exit | | Entrance | Exit | | |
| Fluidelastic Instability ratio | | 0.262 | 0.273 | < 0.8 | O.K |
| Vortex shedding ratio | | 0.333 | 0.355 | < 0.5 | O.K |
| Shell Entrance / Exit | | | | | |
| Velocity (m/sec) | | 1.89 | 2.01 | < If velocity is exceed 1.44 / 1.47 | O.K. |
| pv2 (kg/m-s2) | | 3847.87 | 4094.77 | < 5953 by TEMA | O.K. |

10/15

| Vibration Analysis | | | | |
|---|---|-----------------------|-------------------|---------|
| Released to the following HTRI Member Company: | | | | |
| sewon | | | | |
| M.K.Park | | | | |
| Xist Ver. 6.00 SP3 2013/07/10 8:39 SN: 1500213869 | | | MEG Energy Units | |
| Max. Duty and UA Case | | | | |
| Rating - Incline Countercurrent Flow TEMA AEL Shell With Single-Segmental Baffles | | | | |
| 1 | Shellside condition | Sens. Liquid | (Level 2.3) | |
| 2 | Axial stress loading (MPa) | 0.000 | Added mass factor | 1.761 |
| 3 | Beta | 4.000 | | |
| 4 | Position In The Bundle | Inlet | Center | Outlet |
| 5 | Length for natural frequency (mm) | 1338. | 1100. | 1338. |
| 6 | Length/TEMA maximum span (---) | 0.878 * | 0.722 | 0.878 * |
| 7 | Number of spans (---) | 11 | 11 | 11 |
| 8 | Tube natural frequency (Hz) | 31.4 + | 31.5 | 31.8 |
| 9 | Shell acoustic frequency (Hz) | | | |
| 10 | Flow Velocities | Inlet | Center | Outlet |
| 11 | Window parallel velocity (m/s) | 0.73 | 0.74 | 0.78 |
| 12 | Bundle crossflow velocity (m/s) | 0.30 | 0.45 | 0.32 |
| 13 | Bundle/shell velocity (m/s) | 0.21 | 0.32 | 0.23 |
| 14 | Fluidelastic Instability Check | Inlet | Center | Outlet |
| 15 | Log decrement HTRI | 0.100 | 0.100 | 0.100 |
| 16 | Critical velocity (m/s) | 1.44 | 2.14 | 1.47 |
| 17 | Baffle tip cross velocity ratio (---) | 0.2314 | 0.2316 | 0.2415 |
| 18 | Average crossflow velocity ratio (---) | 0.2102 | 0.2104 | 0.2194 |
| 19 | Acoustic Vibration Check | Inlet | Center | Outlet |
| 20 | Vortex shedding ratio (---) | | | |
| 21 | Chen number (---) | | | |
| 22 | Turbulent buffeting ratio (---) | | | |
| 23 | Tube Vibration Check | Inlet | Center | Outlet |
| 24 | Vortex shedding ratio (---) | 0.093 | 0.138 | 0.099 |
| 25 | Parallel flow amplitude (mm) | 0.002 | 0.003 | 0.002 |
| 26 | Crossflow amplitude (mm) | 0.050 | 0.050 | 0.053 |
| 27 | Tube gap (mm) | 4.762 | 4.762 | 4.762 |
| 28 | Crossflow RHO-V-SQ (kg/m-s2) | 98.81 | 215.57 | 105.15 |
| 29 | Bundle Entrance/Exit | | | |
| 30 | (analysis at first tube row) | | Entrance | Exit |
| 31 | Fluidelastic instability ratio (---) | | 0.262 | 0.273 |
| 32 | Vortex shedding ratio (---) | | 0.333 | 0.355 |
| 33 | Crossflow amplitude (mm) | | 0.08549 | 0.09251 |
| 34 | Crossflow velocity (m/s) | | 1.09 | 1.16 |
| 35 | Tubesheet to inlet/outlet support (mm) | | None | None |
| 36 | Shell Entrance/Exit Parameters | | Entrance | Exit |
| 37 | Impingement plate | | No | |
| 38 | Flow area (m2) | | 0.042 | 0.042 |
| 39 | Velocity (m/s) | | 1.89 | 2.01 |
| 40 | RHO-V-SQ (kg/m-s2) | | 3847.87 | 4094.77 |
| 41 | Shell type AEL | Baffle type | Single-Seg. | |
| 42 | Tube type Plain | Baffle layout | Perpend. | |
| 43 | Pitch ratio 1.2500 | Tube diameter, (mm) | 19.050 | |
| 44 | Layout angle 30 | Tube material | Carbon steel | |
| 45 | | Supports/baffle space | | |
| 46 | Program Messages | | | |
| 47 | + Frequency ratios are based upon lowest natural or acoustic frequency | | | |
| 48 | * Items with asterisk exceed a conservative lower limit for vibration-free design. Review your case | | | |
| 49 | using the procedure described in Online Help; You may find that a vibration problem is unlikely. | | | |
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| Final Results | | | | | | | | | | |
|---|--|--|--|--------------------------|------------------|---|--|--|--|-------------------------------------|
| Released to the following HTRI Member Company: | | | | | | | | | | |
| sewon | | | | | | | | | | |
| M.K.Park | | | | | | | | | | |
| Xist Ver. 6.00 SP3 2013/07/10 8:39 SN: 1500213869 | | | | | MEG Energy Units | | | | | |
| Max. Duty and UA Case | | | | | | | | | | |
| Rating - Incline Countercurrent Flow TEMA AEL Shell With Single-Segmental Baffles | | | | | | | | | | |
| 1 | Process Data | | | Cold Shellside | | Hot Tubeside | | Shellside Performance | | |
| 2 | Fluid name | | | TEG/Water (60/40 wt%) | | Produced Gas | | Nom vel, X-flow/window 0.61 / 0.81 | | |
| 3 | Fluid condition | | | Sens. Liquid | | Cond. Vapor | | Flow fractions for heat transfer 0.676 | | |
| 4 | Total flow rate (kg/hr) | | | 610243 | | 139760 | | A=0.0833 B=0.6537 C=0.0376 E=0.2253 F=0.0000 | | |
| 5 | Weight fraction vapor, In/Out (-) | | | 0.000 0.000 | | 0.625 0.242 | | | | |
| 6 | Temperature, In/Out (Deg C) | | | 40.00 120.00 | | 155.20 50.00 | | | | |
| 7 | Temperature, Average/Skin (Deg C) | | | 80.00 76.06 | | 102.60 89.55 | | | | |
| 8 | Wall temperature, Min/Max (Deg C) | | | 42.65 133.16 | | 42.83 134.38 | | | | |
| 9 | Pressure, In/Average (kPa) | | | 994.015 963.390 | | 959.014 956.281 | | | | |
| 10 | Pressure drop, Total/Allowed (kPa) | | | 61.250 70.000 | | 5.466 6.000 | | | | |
| 11 | Velocity, Mid/Max allow (m/s) | | | 0.45 | | 3.07 | | | | |
| 12 | Mole fraction inert (-) | | | | | 0.0000 | | | | |
| 13 | Average film coef. (W/m2-K) | | | 2540.24 | | 1529.56 | | | | |
| 14 | Heat transfer safety factor (-) | | | 1.000 | | 1.000 | | | | |
| 15 | Fouling resistance (m2-K/W) | | | 0.000180 | | 0.000350 | | | | |
| 16 | Overall Performance Data | | | | | | | | | Shellside Heat Transfer Corrections |
| 17 | Overall coef., Req'd/Clean/Actual (W/m2-K) | | | 408.15 / 783.40 / 524.63 | | Total Beta Gamma End Fin | | | | |
| 18 | Heat duty, Calculated/Specified (kW) | | | 45904. / 45648. | | 0.983 0.917 1.072 0.976 1.000 | | | | |
| 19 | Effective overall temperature difference (Deg C) | | | 38.2 | | Pressure Drops (Percent of Total) | | | | |
| 20 | EMTD = (MTD) * (DELTA) * (F/G/H) (Deg C) | | | 38.64 * 0.9881 * 1.0000 | | Cross Window Ends Nozzle Shell Tube | | | | |
| 21 | | | | | | 60.75 24.04 6.64 Inlet 4.43 37.80 | | | | |
| 22 | | | | | | MOMENTUM 0.00 Outlet 4.14 21.55 | | | | |
| 23 | | | | | | Two-Phase Parameters | | | | |
| 24 | | | | | | Method Inlet Center Outlet Mix F | | | | |
| 25 | | | | | | RPM Transition Gravity Gravity 0.1484 | | | | |
| 26 | | | | | | H. T. Parameters Shell Tube | | | | |
| 27 | | | | | | Overall wall correction 0.990 | | | | |
| 28 | | | | | | Midpoint Prandtl no. 30.27 | | | | |
| 29 | | | | | | Midpoint Reynolds no. 3102 3715 | | | | |
| 30 | | | | | | Bundle inlet Reynolds no. 1401 8810 | | | | |
| 31 | | | | | | Bundle outlet Reynolds no. 5855 1724 | | | | |
| 32 | | | | | | Fouling layer (mm) | | | | |
| 33 | | | | | | Thermal Resistance | | | | |
| 34 | | | | | | Shell Tube Fouling Metal Over Des | | | | |
| 35 | | | | | | 20.65 44.06 33.03 2.26 28.54 | | | | |
| 36 | | | | | | Total fouling resistance 6.292e-4 | | | | |
| 37 | | | | | | Differential resistance 5.44e-4 | | | | |
| 38 | | | | | | Shell Nozzles | | | | |
| 39 | | | | | | Inlet at channel end-No Inlet Outlet Liquid | | | | |
| 40 | | | | | | Number at each position 1 1 0 | | | | |
| 41 | | | | | | Diameter (mm) 295.301 295.301 | | | | |
| 42 | | | | | | Velocity (m/s) 1.15 1.22 | | | | |
| 43 | | | | | | Pressure drop (kPa) 2.712 2.538 | | | | |
| 44 | | | | | | Height under nozzle (mm) 39.578 39.578 | | | | |
| 45 | | | | | | Nozzle R-V-SQ (kg/m-s2) 1420.61 1511.76 | | | | |
| 46 | | | | | | Shell ent. (kg/m-s2) 3847.87 4094.77 | | | | |
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3A-E-102A/B (Min Case)

The Thermal/Hydraulic/Vibration calculations are performed by using HTRI Xist Ver. 6.00 SP3.

The process condition and the physical properties are based on Buyer DATA SHEET (2).

For the design result (the geometry data), please refer to the Equipment DATA SHEET (2) and Fabrication drawing.

1. Thermal and Hydraulic performance

| | | | | |
|-------------------------|--------------|----------------------|------------|------------|
| - Thermal performance : | <u>26.26</u> | % Over - Design Case | ----- | O.K. |
| - Pressure drop : | | | | |
| Shell-side | <u>0.688</u> | < | 70.000 kPa | ----- O.K. |
| tube-side | <u>0.083</u> | < | 6.000 kPa | ----- O.K. |

2. Vibration Analysis

| | | | | | |
|------------------------------|-----------------------|----|----------|-------|------|
| - Fluidelastic instability : | characteristic values | << | criteria | ----- | O.K. |
| - Acoustic vibration : | characteristic values | << | criteria | ----- | O.K. |
| - Tube vibration check: | characteristic values | << | criteria | ----- | O.K. |
| - Bundle Entrance/Exit : | characteristic values | << | criteria | ----- | O.K. |
| - Shell Entrance /Exit: | characteristic values | << | criteria | ----- | O.K. |

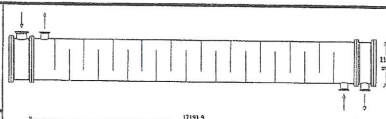
3A-E-102A/B (Min Case)

Used Program : HTRI Xist Ver.6.00 SP.3 Vibration Analysis

| VALUE TO BE CHECKED | Inlet | Center | Outlet | RECOMMEND LIMIT | CONCLUSION |
|---------------------------------|--------|----------|--------|-------------------------------------|------------|
| Unsupported span (mm) | 1338. | 1100. | 1338. | 1524 (By TEMA) | O.K |
| Length / TEMA maximum span | 0.878 | 0.722 | 0.878 | < 1.0 TEMA | O.K |
| Fluidelastic Instability Check | | | | | |
| Baffle tip cross velocity ratio | 0.0165 | 0.0166 | 0.0170 | < 0.8 | O.K |
| Ave. crossflow velocity ratio | 0.0150 | 0.0151 | 0.0155 | < 0.8 | O.K |
| Acoustic Vibration Check | | | | | |
| Vortex shedding ratio | - | - | - | - | - |
| Tubulent buffeting ratio | - | - | - | - | - |
| Tube Vibration Check | | | | | |
| Vortex shedding ratio | 0.007 | 0.010 | 0.007 | < 0.5 | O.K |
| Tubulent buffeting ratio | - | - | - | - | - |
| Bundle Entrance / Exit | | Entrance | Exit | | |
| Fluidelastic Instability ratio | | 0.019 | 0.020 | < 0.8 | O.K |
| Vortex shedding ratio | | 0.024 | 0.025 | < 0.5 | O.K |
| Shell Entrance / Exit | | | | | |
| Velocity (m/sec) | | 0.14 | 0.14 | < If velocity is exceed 1.45 / 1.47 | O.K. |
| pv2 (kg/m-s ²) | | 20.44 | 21.36 | < 5953 by TEMA | O.K. |

| Vibration Analysis | | | | |
|---|---|-----------------------|-------------------|----------|
| Released to the following HTRI Member Company: | | | | |
| sewon | | | | |
| M.K.Park | | | | |
| Xist Ver. 6.00 SP3 2013/07/10 8:40 SN: 1500213869 | | | MEG Energy Units | |
| Min. Case | | | | |
| Rating - Incline Countercurrent Flow TEMA AEL Shell With Single-Segmental Baffles | | | | |
| 1 | Shellside condition | Sens. Liquid | (Level 2.3) | |
| 2 | Axial stress loading (MPa) | 0.000 | Added mass factor | 1.761 |
| 3 | Beta | 4.000 | | |
| 4 | Position In The Bundle | Inlet | Center | Outlet |
| 5 | Length for natural frequency (mm) | 1338. | 1100. | 1338. |
| 6 | Length/TEMA maximum span (---) | 0.878 * | 0.722 | 0.878 * |
| 7 | Number of spans (---) | 11 | 11 | 11 |
| 8 | Tube natural frequency (Hz) | 31.5 + | 31.6 | 31.8 |
| 9 | Shell acoustic frequency (Hz) | | | |
| 10 | Flow Velocities | Inlet | Center | Outlet |
| 11 | Window parallel velocity (m/s) | 5.761e-2 | 5.868e-2 | 6.017e-2 |
| 12 | Bundle crossflow velocity (m/s) | 2.179e-2 | 3.255e-2 | 2.276e-2 |
| 13 | Bundle/shell velocity (m/s) | 1.811e-2 | 2.706e-2 | 1.892e-2 |
| 14 | Fluidelastic Instability Check | Inlet | Center | Outlet |
| 15 | Log decrement HTRI | 0.100 | 0.100 | 0.100 |
| 16 | Critical velocity (m/s) | 1.45 | 2.16 | 1.47 |
| 17 | Baffle tip cross velocity ratio (---) | 0.0165 | 0.0166 | 0.0170 |
| 18 | Average crossflow velocity ratio (---) | 0.0150 | 0.0151 | 0.0155 |
| 19 | Acoustic Vibration Check | Inlet | Center | Outlet |
| 20 | Vortex shedding ratio (---) | | | |
| 21 | Chen number (---) | | | |
| 22 | Turbulent buffeting ratio (---) | | | |
| 23 | Tube Vibration Check | Inlet | Center | Outlet |
| 24 | Vortex shedding ratio (---) | 0.007 | 0.010 | 0.007 |
| 25 | Parallel flow amplitude (mm) | 0.000 | 0.000 | 0.000 |
| 26 | Crossflow amplitude (mm) | 0.000 | 0.000 | 0.000 |
| 27 | Tube gap (mm) | 4.762 | 4.762 | 4.762 |
| 28 | Crossflow RHO-V-SQ (kg/m-s2) | 0.51 | 1.12 | 0.53 |
| 29 | Bundle Entrance/Exit | | | |
| 30 | (analysis at first tube row) | | Entrance | Exit |
| 31 | Fluidelastic instability ratio (---) | | 0.019 | 0.020 |
| 32 | Vortex shedding ratio (---) | | 0.024 | 0.025 |
| 33 | Crossflow amplitude (mm) | | 0.00040 | 0.00042 |
| 34 | Crossflow velocity (m/s) | | 7.916e-2 | 8.269e-2 |
| 35 | Tubesheet to inlet/outlet support (mm) | | None | None |
| 36 | Shell Entrance/Exit Parameters | | Entrance | Exit |
| 37 | Impingement plate | | No | |
| 38 | Flow area (m2) | | 0.042 | 0.042 |
| 39 | Velocity (m/s) | | 0.14 | 0.14 |
| 40 | RHO-V-SQ (kg/m-s2) | | 20.44 | 21.36 |
| 41 | Shell type AEL | Baffle type | Single-Seg. | |
| 42 | Tube type Plain | Baffle layout | Perpend. | |
| 43 | Pitch ratio 1.2500 | Tube diameter, (mm) | 19.050 | |
| 44 | Layout angle 30 | Tube material | Carbon steel | |
| 45 | | Supports/baffle space | | |
| 46 | Program Messages | | | |
| 47 | + Frequency ratios are based upon lowest natural or acoustic frequency | | | |
| 48 | * Items with asterisk exceed a conservative lower limit for vibration-free design. Review your case | | | |
| 49 | using the procedure described in Online Help; You may find that a vibration problem is unlikely. | | | |
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|---|--|--|--|--------------------------|------------------|--|--|--------------|--|---------------|--|-------|--|
| Final Results | | | | | | | | | | | | | |
| Released to the following HTRI Member Company: | | | | | | | | | | | | | |
| sewon | | | | | | | | | | | | | |
| M.K.Park | | | | | | | | | | | | | |
| Xist Ver. 6.00 SP3 2013/07/10 8:40 SN: 1500213869 | | | | | MEG Energy Units | | | | | | | | |
| Min. Case | | | | | | | | | | | | | |
| Rating - Incline Countercurrent Flow TEMA AEL Shell With Single-Segmental Baffles | | | | | | | | | | | | | |
| Process Data | | Cold Shellside | | Hot Tubeside | | Shellside Performance | | | | | | | |
| Fluid name | | TEG/Water (60/40 wt%) | | Produced Gas | | Nom vel, X-flow/window 4.453e-2 / 5.944e-2 | | | | | | | |
| Fluid condition | | Sens. Liquid | | Cond. Vapor | | Flow fractions for heat transfer 0.653 | | | | | | | |
| Total flow rate | | 44481.1 | | 32254.1 | | A=0.0121 B=0.6456 C=0.0436 E=0.2987 F=0.0000 | | | | | | | |
| Weight fraction vapor, In/Out | | 0.000 0.000 | | 0.134 0.110 | | | | | | | | | |
| Temperature, In/Out | | 40.00 98.30 | | 108.30 50.00 | | | | | | | | | |
| Temperature, Average/Skin | | 69.15 69.23 | | 79.15 69.81 | | | | | | | | | |
| Wall temperature, Min/Max | | 42.28 100.05 | | 42.32 100.10 | | | | | | | | | |
| Pressure, In/Average | | 994.015 993.670 | | 959.014 958.972 | | | | | | | | | |
| Pressure drop, Total/Allowed | | 0.688 70.000 | | 0.083 6.000 | | | | | | | | | |
| Velocity, Mid/Max allow | | 3.258e-2 | | 0.22 | | | | | | | | | |
| Mole fraction inert | | (-) | | 0.0000 | | | | | | | | | |
| Average film coef. | | 534.04 | | 172.05 | | | | | | | | | |
| Heat transfer safety factor | | (-) | | 1.000 | | | | | | | | | |
| Fouling resistance | | 0.000180 | | 0.000350 | | | | | | | | | |
| Overall Performance Data | | | | | | | | | | | | | |
| Overall coef., Req'd/Clean/Actual | | 79.12 / 106.61 / 99.90 | | | | | | | | | | | |
| Heat duty, Calculated/Specified | | 2400. / 2398. | | | | | | | | | | | |
| Effective overall temperature difference | | 10.3 | | | | | | | | | | | |
| EMTD = (MTD) * (DELTA) * (F/G/H) | | 11.05 * 0.9361 * 1.0000 | | | | | | | | | | | |
| See Runtime Messages Report for warnings. | |  | | | | | | | | | | | |
| Exchanger Fluid Volumes | | | | | | | | | | | | | |
| Approximate shellside (L) | | 5879.3 | | | | | | | | | | | |
| Approximate tubeside (L) | | 6658.5 | | | | | | | | | | | |
| Shell Construction Information | | | | | | | | | | | | | |
| TEMA shell type | | AEL | | Shell ID (mm) | | 1170.00 | | | | | | | |
| Shells Series | | 1 Parallel 2 | | Total area (m2) | | 2969.67 | | | | | | | |
| Passes Shell | | 1 Tube 1 | | Eff. area (m2/shell) | | 1464.62 | | | | | | | |
| Shell orientation angle (deg) | | 1.00 | | | | | | | | | | | |
| Impingement present | | No | | | | | | | | | | | |
| Pairs seal strips | | 0 | | Passlane seal rods (mm) | | 0.000 No. 0 | | | | | | | |
| Shell expansion joint | | No | | Rear head support plate | | No | | | | | | | |
| Weight estimation Wet/Dry/Bundle | | 48993.3 / 36464.2 / 23424.8 | | (kg/shell) | | | | | | | | | |
| Baffle Information | | | | | | | | | | | | | |
| Type | | Perpend. Single-Seg. | | Baffle cut (% dia) | | 24.00 | | | | | | | |
| Crosspasses/shellpass | | 21 | | No. (Pct Area) | | (mm) to C.L | | | | | | | |
| Central spacing (mm) | | 550.000 | | 1 19.85 | | 304.200 | | | | | | | |
| Inlet spacing (mm) | | 787.938 | | 2 0.00 | | 0.000 | | | | | | | |
| Outlet spacing (mm) | | 787.938 | | | | | | | | | | | |
| Baffle thickness (mm) | | 12.700 | | | | | | | | | | | |
| Tube Information | | | | | | | | | | | | | |
| Tube type | | Plain | | Tubecount per shell | | 2035 | | | | | | | |
| Overall length (mm) | | 12192. | | Pct tubes removed (both) | | 1.47 | | | | | | | |
| Effective length (mm) | | 12026. | | Outside diameter (mm) | | 19.050 | | | | | | | |
| Total tubesheet (mm) | | 166.000 | | Wall thickness (mm) | | 2.110 | | | | | | | |
| Area ratio (out/in) | | 1.2846 | | Pitch (mm) | | 23.8120 | | Ratio 1.2500 | | | | | |
| Tube metal | | Carbon steel | | Tube pattern (deg) | | 30 | | | | | | | |
| Shellside Heat Transfer Corrections | | | | | | | | | | | | | |
| Total | | | | | | Beta | | Gamma | | End | | Fin | |
| 0.919 | | | | | | 0.919 | | 1.000 | | 0.979 | | 1.000 | |
| Pressure Drops (Percent of Total) | | | | | | | | | | | | | |
| Cross Window | | 71.74 | | 15.70 | | 6.47 | | Nozzle Inlet | | 3.37 | | 21.64 | |
| MOMENTUM | | | | | | 0.00 | | Outlet | | 2.73 | | 27.67 | |
| Two-Phase Parameters | | | | | | | | | | | | | |
| Method | | Inlet | | Center | | Outlet | | Mix F | | | | | |
| RPM | | Gravity | | Gravity | | Gravity | | 0.0193 | | | | | |
| H. T. Parameters | | | | | | Shell | | Tube | | | | | |
| Overall wall correction | | | | | | 1.000 | | | | | | | |
| Midpoint | | | | | | Prandtl no. | | 26.55 | | | | | |
| Midpoint | | | | | | Reynolds no. | | 250 | | 491 | | | |
| Bundle inlet | | | | | | Reynolds no. | | 99 | | 713 | | | |
| Bundle outlet | | | | | | Reynolds no. | | 313 | | 325 | | | |
| Fouling layer (mm) | | | | | | | | | | | | | |
| Thermal Resistance | | | | | | | | | | | | | |
| Shell | | Tube | | Fouling | | Metal | | Over Des | | | | | |
| 18.71 | | 74.59 | | 6.29 | | 0.42 | | 26.26 | | | | | |
| Total fouling resistance | | | | | | 6.292e-4 | | | | | | | |
| Differential resistance | | | | | | 0.00263 | | | | | | | |
| Shell Nozzles | | | | | | | | | | | | | |
| Inlet at channel end-No | | | | | | Inlet | | Outlet | | Outlet | | | |
| Number at each position | | | | | | 1 | | 1 | | 0 | | | |
| Diameter | | | | | | (mm) | | 295.301 | | 295.301 | | | |
| Velocity | | | | | | (m/s) | | 8.368e-2 | | 8.741e-2 | | | |
| Pressure drop | | | | | | (kPa) | | 0.023 | | 0.019 | | | |
| Height under nozzle | | | | | | (mm) | | 39.578 | | 39.578 | | | |
| Nozzle R-V-SQ | | | | | | (kg/m-s2) | | 7.55 | | 7.88 | | | |
| Shell ent. | | | | | | (kg/m-s2) | | 20.44 | | 21.36 | | | |
| Tube Nozzle | | | | | | RADIAL | | RADIAL | | Liquid Outlet | | | |
| Diameter | | | | | | (mm) | | 380.400 | | 295.301 | | | |
| Velocity | | | | | | (m/s) | | 0.83 | | 1.01 | | | |
| Pressure drop | | | | | | (kPa) | | 0.018 | | 0.023 | | | |
| Nozzle R-V-SQ | | | | | | (kg/m-s2) | | 32.81 | | 65.94 | | | |
| Annular Distributor | | | | | | Inlet | | Outlet | | | | | |
| Length | | | | | | (mm) | | | | | | | |
| Height | | | | | | (mm) | | | | | | | |
| Slot area | | | | | | (mm2) | | | | | | | |
| Diametral Clearances (mm) | | | | | | | | | | | | | |
| Baffle-to-shell | | Bundle-to-shell | | Tube-to-baffle | | | | | | | | | |
| 6.3500 | | 17.5000 | | 0.3968 | | | | | | | | | |

