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|-------------------|--|---|-----------------|------------|
| <b>PROJECT :</b>  |  |  | <b>DATE :</b>   | 02/05/2013 |
| <b>PROJ. NO.:</b> |  |   | <b>BY :</b>     | S.R.M      |
| <b>CLIENT :</b>   |  |   | <b>REV :</b>    | 0          |
| <b>UNIT :</b>     |  |   | <b>DOC NO.:</b> |            |

### Liquid Thermal Expansion Final Pressure Calculation

| Input Data                        |            |        |          |
|-----------------------------------|------------|--------|----------|
| Initial pressure                  | P1         | kpa    | 102      |
| Initial temprature                | T1         | C      | 20       |
| Final temprature                  | T2         | C      | 27       |
| Liquid cubical expansion coe.     | $\alpha_v$ | 1/C    | 2.23E-04 |
| Metal linear expansion coe.       | $\alpha_l$ | 1/C    | 1.21E-05 |
| Liquid isothermal compressibility | $\chi$     | 1/kpa  | 4.46E-07 |
| Pipe diameter                     | d          | m      | 5.08E-02 |
| Metal elasticity                  | E          | kpa    | 2.07E+08 |
| Pipe metal thickness              | $\sigma$   | m      | 6.25E-03 |
| Poisson ratio                     | $\mu$      | -      | 0.3      |
| Leakage rate                      | qll        | m3/sec | 0        |

| Calulation Results |    |      |         |
|--------------------|----|------|---------|
| Final pressure     | P2 | kpa  | 2801.25 |
| Final pressure     | P2 | barg | 27.01   |

| Notes |
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### Liquid Thermal Expansion Pressure Rise Calculation

| Input data            |                |      |
|-----------------------|----------------|------|
| Fluid Name            | Water + 40% EG |      |
| Operating Temperature | C              | -5.0 |
| Operating Pressure    | barg           | 0.0  |

| Isothermal Compressibility Calculation  |                    |                 |           |           |           |
|---|--------------------|-----------------|-----------|-----------|-----------|
| Temperature                             | C                  | -5.0            | -5.0      | -5.0      | -5.0      |
| Pressure                                | barg               | 0.0             | 1.0       | 2.0       | 3.0       |
| Density                                 | kg/m <sup>3</sup>  | 1,132.46        | 1,132.55  | 1,132.64  | 1,132.73  |
| Specific Volume                         | m <sup>3</sup> /kg | 8.830E-04       | 8.830E-04 | 8.829E-04 | 8.828E-04 |
| $\gamma$ or K                           | 1/bar              | 7.94E-05        | 7.93E-05  | 7.93E-05  |           |
| <b>Average <math>\gamma</math> or K</b> | <b>1/bar</b>       | <b>7.93E-05</b> |           |           |           |

| Cubical Expansion Coef. Calculation                        |                    |                 |           |           |           |
|--|--------------------|-----------------|-----------|-----------|-----------|
| Temperature  | C                  | -5.0            | -3.0      | -1.0      | 1.0       |
| Pressure   | barg               | 0.0             | 0.0       | 0.0       | 0.0       |
| Density  | kg/m <sup>3</sup>  | 1,134.60        | 1,132.46  | 1,131.04  | 1,129.61  |
| Specific Volume  | m <sup>3</sup> /kg | 8.814E-04       | 8.830E-04 | 8.841E-04 | 8.853E-04 |
| $\alpha_v$ or $\beta$                                      | 1/C                | 9.42E-04        | 6.30E-04  | 6.32E-04  |           |
| <b>Average <math>\alpha_v</math> or <math>\beta</math></b> | <b>1/C</b>         | <b>7.35E-04</b> |           |           |           |

| Pressure Rise Calculation |       |      |
|---------------------------|-------|------|
| $\Delta p/\Delta t$       | bar/C | 9.26 |

| Notes |
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