

## 1 Statics according to DWA-A 143-2: 2015-07: Regularstatics MKG 26 - Egg 250/375, GW 4,50 m

Caption of static calculation: Regularstatics MKG 26 - Egg 250/375, GW 4,50 m

Host pipe state: HPC II  
 Verification buoyancy: No  
 Default options according standard: Yes

### 1.1 Input

#### 1.1.1 Geometry

|   |   |
|---|---|
| Geometry:                                 | Egg shaped profile according to DIN 250/375 |
| Nominal diameter DN:                      | No  |
| Mirroring horizontal:                     | $t_L$ 3.80 mm                               |
| Wallthickness liner:                      | $WGR_v/r_L$ 3.00 %                          |
| Four-hinge global imperfection:           |   |
| Type of host pipe:                        | Egg-shaped profile B:H = 2:3                |
| Local imperfection intensity long side:   | $w_v/r_L$ 0.50 %                            |
| Opening angle of local imperfection:      | $2\Phi$ 30.00 °                             |
| Type of annular gap:                      | Constant degree of shrinkage                |
| Annular gap (const. degree of shrinkage): | $w_s/U$ 0.400 %                             |

#### 1.1.2 Material

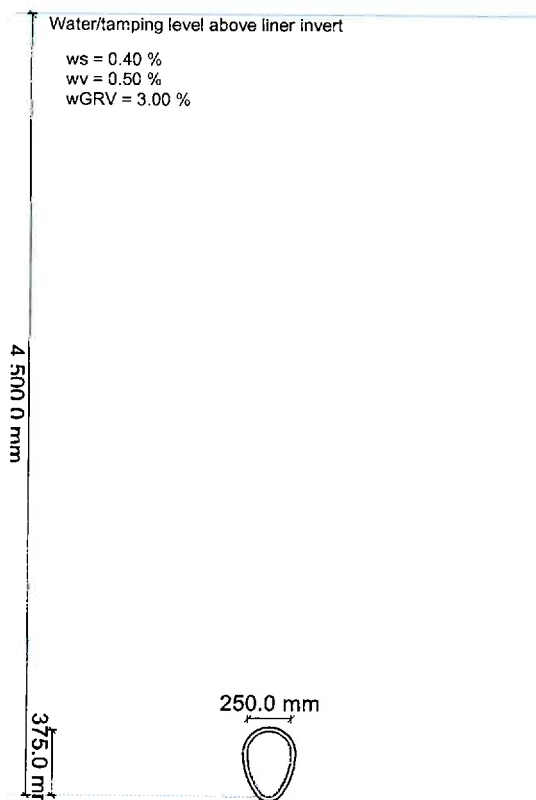
|  |  |
|--|--|
| Manual definition material:                          | Manual definition                        |
| Use long-term values:                                | Yes                                      |
| Shear stress proof conducting:                       | No                                       |
| Material name:                                       | UP-GF                                    |
| Weight liner:  | $\gamma_L$ 17.50 kN/m <sup>3</sup>       |
| Poissons ratio:                                      | $\mu$ 0.35 [-]                           |
| Material is orthogonally anisotropic:                | No                                       |
| E-modulus long-term, characteristic:                 | $E_L$ 13,000.00 N/mm <sup>2</sup>        |
| E-modulus short-term, characteristic:                | $E_K$ 15,600.00 N/mm <sup>2</sup>        |
| Bending tensile strength long-term, characteristic:  | $\sigma_{bZ,L}$ 170.00 N/mm <sup>2</sup> |
| Bending tensile strength short-term, characteristic: | $\sigma_{bZ,K}$ 245.00 N/mm <sup>2</sup> |
| Compressive strength long-term, characteristic:      | $\sigma_{D,L}$ 170.00 N/mm <sup>2</sup>  |
| Compressive strength short-term, characteristic:     | $\sigma_{D,K}$ 245.00 N/mm <sup>2</sup>  |
| Coefficient of thermal expansion:                    | $\alpha_T$ 0.00003 1/K                   |
| Safety coeff.:                                       | $\gamma_M$ 1.35 [-]                      |

**1.1.3 Loads**

|  |               |       |                   |
|--|---------------|-------|-------------------|
| Water level above liner invert:                      | $h_w$         | 4.50  | m                 |
| Weight water:  | $\gamma_w$    | 10.00 | kN/m <sup>3</sup> |
| Temperature change:                                  | $\Delta T$    | 0.00  | K                 |
| Manuell definition reduction ratio for dynamic load: | $N_d$         |       |                   |
| Partial safety coefficient dead load:                | $\gamma_{GE}$ | 1.35  | [-]               |
| Partial safety coefficient water pressure:           | $\gamma_w$    | 1.50  | [-]               |
| Partial safety coefficient internal pressure:        | $\gamma_{pi}$ | 1.50  | [-]               |
| Partial safety coefficient temperature:              | $\gamma_T$    | 1.10  | [-]               |

**1.2 Results**

**1.2.1 Load host pipe state II - hW 4.50 m, Long-term**



**Global imperfection according A 143-2 is understood as an increase ( $w_{grv}/10$ ) of the entered local deformation. Given values:**

|  |                 |      |                     |
|--|-----------------|------|---------------------|
| Local imperfection:  | $\omega_v$      | 0.50 | %                   |
| Global imperfection:   | $\omega_{GR,v}$ | 3.00 | %                   |
| $\omega_v = \omega_v + \omega_v/10 = 0.50\% + (3.00\% / 10)$ |                 |      | (A 143-2 Tabelle 8) |
| Local imperfection:  | $\omega_v$      | 0.80 | %                   |

|                              |       |      |    |
|------------------------------|-------|------|----|
| Local imperfection absolute: | $w_v$ | 2.98 | mm |
|------------------------------|-------|------|----|

**Consideration of global deformation at geometry level is on the unsafe side because the height/width ratio due to expansion at springline becomes favourable against external pressure. Host pipe state II calculations would deliver more favourable results than host pipe state I.**

|   |                 |      |    |
|---|-----------------|------|----|
| Global imperfection:                    | $\omega_{GR,v}$ | 0.00 | %  |
| Global imperfection absolute, one side: | $w_{GR,v}$      | 0.00 | mm |
| Annular gap:                            | $\omega_s$      | 0.40 | %  |
| Annular gap absolute (const. value):    | $w_s$           | 0.62 | mm |

#### 1.2.1.1 Material values

liner

|                                 |            |           |                   |
|---------------------------------|------------|-----------|-------------------|
| Partial safety factor material: | $\gamma_M$ | 1.35      | [-]               |
| Poissons ratio:                 | $\mu$      | 0.35      | [-]               |
| E-Modulus, longterm:            | $E_L$      | 13,000.00 | N/mm <sup>2</sup> |
| E-Modulus, longterm, design:    | $E_{L,d}$  | 9,629.63  | N/mm <sup>2</sup> |
| Used E-Modulus:                 | $E$        | 10,973.94 | N/mm <sup>2</sup> |

|   |                   |         |                   |
|---|-------------------|---------|-------------------|
| Admissible compressive strength, long term:             | $\sigma_{D,L}$    | 170.00  | N/mm <sup>2</sup> |
| Admissible compressive strength, long term, design:     | $\sigma_{D,L,d}$  | -125.93 | N/mm <sup>2</sup> |
| Admissible tensile bending strength, long term:         | $\sigma_{bZ,L}$   | 170.00  | N/mm <sup>2</sup> |
| Admissible tensile bending strength, long term, design: | $\sigma_{bZ,L,d}$ | 125.93  | N/mm <sup>2</sup> |
| Admissible tensile strength, long term:                 | $\sigma_{Z,L}$    | 0.00    | N/mm <sup>2</sup> |
| Admissible tensile strength, long term, design:         | $\sigma_{Z,L,d}$  | 0.00    | N/mm <sup>2</sup> |

#### 1.2.1.2 Deformation proof (Characteristic load)

|   |            |        |    |
|---|------------|--------|----|
| Relevant diameter for percentage deformation: | $d_v$      | 312.50 | mm |
| Annular gap absolute (const. value):          | $w_s$      | 0.62   | mm |
| Local imperfection absolute:                  | $w_v$      | 2.98   | mm |
| Global imperfection absolute, one side:       | $w_{GR,v}$ | 0.00   | mm |

|                               |                     |      |    |
|-------------------------------|---------------------|------|----|
| Elastic deformation absolute: | $w_{el}$            | 8.9  | mm |
| Relative elastic deformation: | $\delta_{v,el}$     | 2.84 | %  |
| Allowed elastic deformation:  | $zul \delta_{v,el}$ | 3.00 | %  |

The calculated elastic deformation is less than the allowed elastic deformation.

|                                    |                |       |    |
|------------------------------------|----------------|-------|----|
| Total diameter deviation:          | $w$            | 11.87 | mm |
| Relative total deformation:        | $\delta_v$     | 3.80  | %  |
| Reference value total deformation: | $\delta_{v,A}$ | 10.00 | %  |

#### 1.2.1.3 Stability proof (Design values)

The decisive buckling verification of the liner is conducted, as in paragraph 7.6.4.2 (DWA-A 143-2) described, by a permitted (more accurate) variation of the calculation, according to the second order theory under consideration of the prestrain (imperfection) and the annular gap. Here is numerically tested if the elastic stability failure occurs under gamma-tuple load. In addition, in this calculation is proved if the determined stresses does not exceed the limited stresses for the single stability.

The stability proof is not necessary.

*Stress analysis liner, host pipe state II - hW 4.50 m*

|                          |   |      |                     |
|--------------------------|---|------|---------------------|
| Surface (wallthickness): | A | 3.80 | mm <sup>2</sup> /mm |
|--------------------------|---|------|---------------------|

**outside**

|   |                |             |         |                   |
|---|----------------|-------------|---------|-------------------|
| Stress in element                       | Max $\sigma_d$ | compression | tensile |                   |
| Max. allowed stress, Long term, Design: | $\sigma_{L,d}$ | -116.87     | 73.01   | N/mm <sup>2</sup> |
|   |                | -125.93     | 125.93  | N/mm <sup>2</sup> |
| Utilisation stress                      | $U_\sigma$     | 92.8        | 58.0    | %                 |

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The outside stress proof is ok.

**inside**

| Stress in element                       | Max $\sigma_d$ | compression       | tensile         |  |
|---|----------------|-------------------|-----------------|--|
| Max. allowed stress, Long term, Design: | $\sigma_{L,d}$ | -91.31<br>-125.93 | 99.76<br>125.93 | N/mm <sup>2</sup><br>N/mm <sup>2</sup> |
| Utilisation stress                      | $U_\sigma$     | 72.5              | 79.2            | %                                      |

The inside stress proof is ok.

The stress proof is ok.

All necessary proofs are ok.