

# 1 Statics according to DWA-A 143-2: 2015-07: MKG 26 - DN 400, GW 3,00 m

Caption of static calculation: MKG 26 - DN 400, GW 3,00 m

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

## 1.1 Input

### 1.1.1 Geometry

|  |                |        |    |
|--|----------------|--------|----|
| Geometry:                                | Circle profile |        |    |
| Wallthickness liner:                     | $t_L$          | 2.60   | mm |
| Inner diameter pipe:                     | $d_{AR,i}$     | 400.00 | mm |
| Four-hinge global imperfection:          | $WGRv/r_L$     | 3.00   | %  |
| Local imperfection intensity invert:     | $w_v/r_L$      | 2.00   | %  |
| Opening angle of local imperfection:     | $2\Phi$        | 40.00  | °  |
| Axe opening angle of local imperfection: | $\Phi_A$       | 180.00 | °  |
| Annular gap (const. width):              | $w_s/r_L$      | 0.500  | %  |
| Enter annular gap as an absolute value:  | No             |        |    |

### 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 othogonal 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      | [-]               |

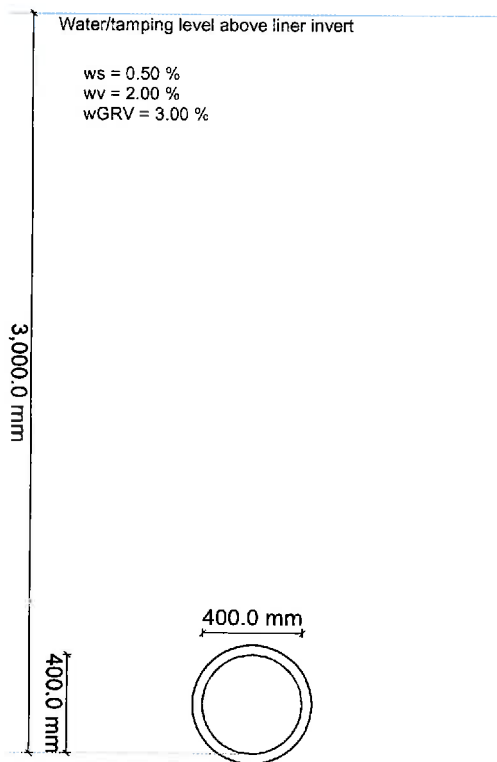
### 1.1.3 Loads

|                                 |       |      |   |
|---------------------------------|-------|------|---|
| Water level above liner invert: | $h_w$ | 3.00 | m |
|---------------------------------|-------|------|---|

|  |                |       |                 |
|--|----------------|-------|-----------------|
| Weight water:  | $\gamma_w$     | 10.00 | $\text{kN/m}^3$ |
| Inner pressure:                                      | $p_i$          | 0.00  | bar             |
| Pressure surge, short term:                          | $p_{i,ds}$     | 0.00  | bar             |
| Temperature change:                                  | $\Delta T$     | 0.00  | K               |
| Manuell definition reduction ratio for dynamic load: | $N_o$          |       |                 |
| Partial safety coefficient dead load:                | $\gamma_{GE}$  | 1.35  | [-]             |
| Partial safety coefficient water pressure:           | $\gamma_w$     | 1.50  | [-]             |
| Partial safety coefficient internal pressure:        | $\gamma_{p_i}$ | 1.50  | [-]             |
| Partial safety coefficient temperature:              | $\gamma_T$     | 1.10  | [-]             |

## 1.2 Results

### 1.2.1 Load host pipe state II - hW 3.00 m, Long-term



|   |                 |      |    |
|---|-----------------|------|----|
| Local imperfection:                     | $\omega_v$      | 2.00 | %  |
| Local imperfection absolute:            | $w_v$           | 3.97 | mm |
| Global imperfection:                    | $\omega_{GR,v}$ | 3.00 | %  |
| Global imperfection absolute, one side: | $w_{GR,v}$      | 5.96 | mm |
| Annular gap:                            | $\omega_s$      | 0.50 | %  |
| Annular gap absolute (const. value):    | $w_s$           | 0.99 | 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: | $d_v$               | 400.00 | mm |
| Annular gap absolute (const. value):          | $w_s$               | 0.99   | mm |
| Local imperfection absolute:                  | $w_v$               | 3.97   | mm |
| Global imperfection absolute, one side:       | $WGR_v$             | 5.96   | mm |
| Elastic deformation absolute:                 | $w_{el}$            | 7.3    | mm |
| Relative elastic deformation:                 | $\delta_{v,el}$     | 1.83   | %  |
| Allowed elastic deformation:                  | $zul \delta_{v,el}$ | 3.00   | %  |

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

|                                    |                |       |    |
|------------------------------------|----------------|-------|----|
| Total diameter deviation:          | $w$            | 23.23 | mm |
| Relative total deformation:        | $\delta_v$     | 5.81  | %  |
| Reference value total deformation: | $\delta_{v,A}$ | 10.00 | %  |

1.2.1.3 Simplified buckling proof (outer water pressure/inner pressure)

|   |            |       |                   |
|---|------------|-------|-------------------|
| Outer water pressure, desin:                          | $p_{a,d}$  | 45.00 | kN/m <sup>2</sup> |
| Critical external water pressure (snap-through load): | $krit p_a$ | 49.19 | kN/m <sup>2</sup> |
| Utilisation simplified buckling proof:                | $U_{pa}$   | 91.5  | %                 |

The safety against buckling is sufficient.

1.2.1.4 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 gama-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 3.00 m

|                          |   |      |                     |
|--------------------------|---|------|---------------------|
| Surface (wallthickness): | A | 2.60 | mm <sup>2</sup> /mm |
|--------------------------|---|------|---------------------|

**outside**

|   |                |             |         |                   |
|---|----------------|-------------|---------|-------------------|
| Stress in element                       |                | compression | tensile |                   |
| Max. allowed stress, Long term, Design: | Max $\sigma_d$ | -103.39     | 48.10   | N/mm <sup>2</sup> |
|   | $\sigma_{L,d}$ | -125.93     | 125.93  | N/mm <sup>2</sup> |
| Utilisation stress                      | $U_\sigma$     | 82.1        | 38.2    | %                 |

The outside stress proof is ok.

**inside**

|                   |                |             |         |                   |
|-------------------|----------------|-------------|---------|-------------------|
| Stress in element | Max $\sigma_d$ | compression | tensile |                   |
|                   |                | -58.05      | 94.45   | N/mm <sup>2</sup> |

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|   |                |         |        |                   |
|---|----------------|---------|--------|-------------------|
| Max. allowed stress, Long term, Design: | $\sigma_{L,d}$ | -125.93 | 125.93 | N/mm <sup>2</sup> |
| Utilisation stress                      | $U_{\sigma}$   | 46.1    | 75.0   | %                 |

The inside stress proof is ok.

The stress proof is ok.

All necessary proofs are ok.

checked by comparative calculation