

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

Caption of static calculation: Regularstatics MKG 26 - Egg 250/375, GW 2,50 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: No
 Wallthickness liner: t_L 3.10 mm
 Four-hinge global imperfection: WGR_v/r_L 3.00 %
 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: 2Φ 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: γ_L 17.50 kN/m³
 Poissons ratio: μ 0.35 [-]
 Material is othogonal anisotropic: No
 E-modulus long-term, characteristic: E_L 13,000.00 N/mm²
 E-modulus short-term, characteristic: E_K 15,600.00 N/mm²
 Bending tensile strength long-term, characteristic: $\sigma_{bZ,L}$ 170.00 N/mm²
 Bending tensile strength short-term, characteristic: $\sigma_{bZ,K}$ 245.00 N/mm²
 Compressive strength long-term, characteristic: $\sigma_{D,L}$ 170.00 N/mm²
 Compressive strength short-term, characteristic: $\sigma_{D,K}$ 245.00 N/mm²
 Coefficient of thermal expansion: α_T 0.00003 1/K
 Safety coeff: γ_M 1.35 [-]

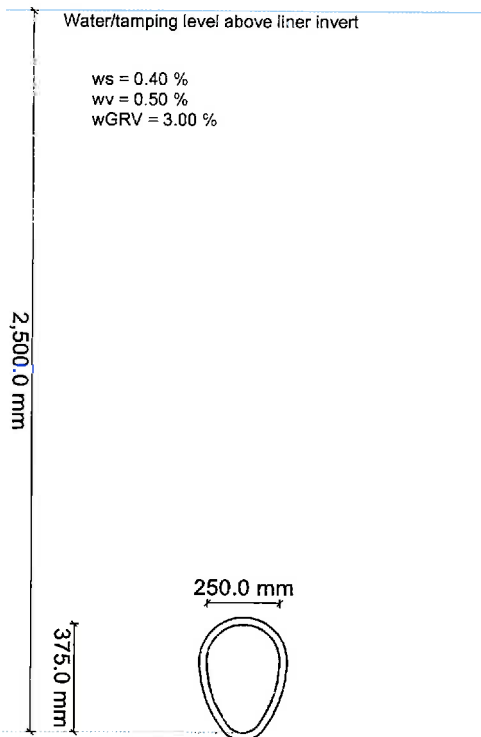
1.1.3 Loads

| | | | |
|---------------------------------|------------|-------|-------------------|
| Water level above liner invert: | h_w | 2.50 | m |
| Weight water: | γ_w | 10.00 | kN/m ³ |
| Temperature change: | ΔT | 0.00 | K |

| | | | |
|--|---------------|------|-----|
| Manuell definition reduction ratio for dynamic load: | N_o | | |
| Partial safety coefficient dead load: | γ_{GE} | 1.35 | [-] |
| Partial safety coefficient water pressure: | γ_w | 1.50 | [-] |
| Partial safety coefficient internal pressure: | γ_{pl} | 1.50 | [-] |
| Partial safety coefficient temperature: | γ_T | 1.10 | [-] |

1.2 Results

1.2.1 Load host pipe state II - hW 2.50 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: | ω_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: | ω_v | 0.80 | % |

| | | | |
|------------------------------|-------|------|----|
| Local imperfection absolute: | w_v | 2.99 | 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: | ω_s | 0.40 | % |
| Annular gap absolute (const. value): | w_s | 0.62 | mm |

1.2.1.1 Material values

liner

| | | | |
|---|-------------------|-----------|-------------------|
| Partial safety factor material: | γ_M | 1.35 | [-] |
| Poissons ratio: | μ | 0.35 | [-] |
| E-Modulus, longterm: | E_L | 13,000.00 | N/mm ² |
| E-Modulus, longterm, design: | $E_{L,d}$ | 9,629.63 | N/mm ² |
| Used E-Modulus: | E | 10,973.94 | N/mm ² |
| Admissible compressive strength, long term: | $\sigma_{D,L}$ | 170.00 | N/mm ² |
| Admissible compressive strength, long term, design: | $\sigma_{D,L,d}$ | -125.93 | N/mm ² |
| Admissible tensile bending strength, long term: | $\sigma_{bZ,L}$ | 170.00 | N/mm ² |
| Admissible tensile bending strength, long term, design: | $\sigma_{bZ,L,d}$ | 125.93 | N/mm ² |
| Admissible tensile strength, long term: | $\sigma_{Z,L}$ | 0.00 | N/mm ² |
| Admissible tensile strength, long term, design: | $\sigma_{Z,L,d}$ | 0.00 | N/mm ² |

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 | 2.99 | mm |
| Global imperfection absolute, one side: | $W_{GR,v}$ | 0.00 | mm |
| Elastic deformation absolute: | w_{el} | 8.7 | mm |
| Relative elastic deformation: | $\delta_{v,el}$ | 2.80 | % |
| Allowed elastic deformation: | $zul \delta_{v,el}$ | 3.00 | % |

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

| | | | |
|------------------------------------|----------------|-------|----|
| Total diameter deviation: | w | 11.73 | mm |
| Relative total deformation: | δ_v | 3.75 | % |
| 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 2.50 m

| | | | |
|--------------------------|---|------|---------------------|
| Surface (wallthickness): | A | 3.10 | mm ² /mm |
|--------------------------|---|------|---------------------|

outside

| | | compression | tensile | |
|---|----------------|-------------|---------|-------------------|
| Stress in element | Max σ_d | -86.55 | 56.14 | N/mm ² |
| Max. allowed stress, Long term, Design: | $\sigma_{L,d}$ | -125.93 | 125.93 | N/mm ² |
| Utilisation stress | U_σ | 68.7 | 44.6 | % |

The outside stress proof is ok.

inside

| | | compression | tensile | |
|---|----------------|-------------|---------|-------------------|
| Stress in element | Max σ_d | -67.80 | 75.64 | N/mm ² |
| Max. allowed stress, Long term, Design: | $\sigma_{L,d}$ | -125.93 | 125.93 | N/mm ² |
| Utilisation stress | U_σ | 53.8 | 60.1 | % |

The inside stress proof is ok.

The stress proof is ok.

All necessary proofs are ok.