

1 Statics according to DWA-A 143-2: 2015-07: MKG 26 - DN 350, GW 4,50 m

Caption of static calculation: MKG 26 - DN 350, 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:	Circle profile		
Wallthickness liner:	t_L	2.60	mm
Inner diameter pipe:	$d_{AR,i}$	350.00	mm
Four-hinge global imperfection:	$WGRV/r_L$	3.00	%
Local imperfection intensity invert:	w/r_L	2.00	%
Opening angle of local imperfection:	2Φ	40.00	°
Axe opening angle of local imperfection:	Φ_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:	γ_L	17.50	kN/m ³
Poissons ratio:	μ	0.35	[-]
Material is orthogonally anisotropic:	No		
E-modulus long-term, characteristic:	E_L	13,000.00	N/mm ²
E-modulus short-term, characteristic:	E_K	15,600.00	N/mm ²
Bending tensile strength long-term, characteristic:	$\sigma_{bZ,L}$	170.00	N/mm ²
Bending tensile strength short-term, characteristic:	$\sigma_{bZ,K}$	245.00	N/mm ²
Compressive strength long-term, characteristic:	$\sigma_{D,L}$	170.00	N/mm ²
Compressive strength short-term, characteristic:	$\sigma_{D,K}$	245.00	N/mm ²
Coefficient of thermal expansion:	α_T	0.00003	1/K
Safety coeff.:	γ_M	1.35	[-]

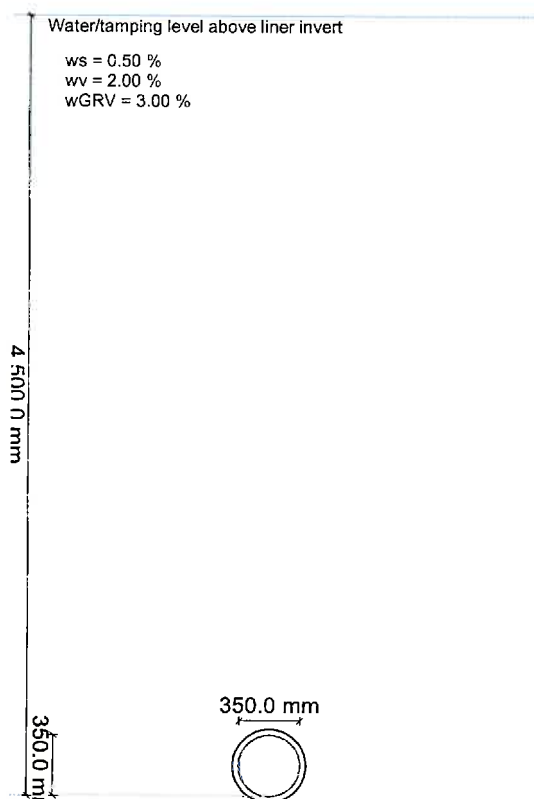
1.1.3 Loads

Water level above liner invert:	h_w	4.50	m
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Weight water:	γ_w	10.00	kN/m ³
Inner pressure:	p_i	0.00	bar
Pressure surge, short term:	$p_{i,ds}$	0.00	bar
Temperature change:	ΔT	0.00	K
Manuell definition reduction ratio for dynamic load:	No		
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 4.50 m, Long-term



Local imperfection:	w_v	2.00	%
Local imperfection absolute:	w_v	3.47	mm
Global imperfection:	$w_{GR,v}$	3.00	%
Global imperfection absolute, one side:	$w_{GR,v}$	5.21	mm
Annular gap:	w_s	0.50	%
Annular gap absolute (const. value):	w_s	0.87	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	350.00	mm
Annular gap absolute (const. value):	w_s	0.87	mm
Local imperfection absolute:	w_v	3.47	mm
Global imperfection absolute, one side:	WGR_v	5.21	mm
Elastic deformation absolute:	w_{el}	6.5	mm
Relative elastic deformation:	$\delta_{v,el}$	1.86	%
Allowed elastic deformation:	$zul \delta_{v,el}$	3.00	%

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

Total diameter deviation:	w	20.40	mm
Relative total deformation:	δ_v	5.83	%
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:	$p_{a,d}$	67.50	kN/m ²
Critical external water pressure (snap-through load):	$k_{krit} p_a$	73.26	kN/m ²
Utilisation simplified buckling proof:	U_{pa}	92.1	%

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 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	2.60	mm ² /mm
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outside

Stress in element	Max σ_d	compression -123.14	tensile 56.73	N/mm ²
Max. allowed stress, Long term, Design:	$\sigma_{L,d}$	-125.93	125.93	N/mm ²
Utilisation stress	U_σ	97.8	45.0	%

The outside stress proof is ok.

inside

Stress in element	Max σ_d	compression -69.87	tensile 111.30	N/mm ²
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Max. allowed stress, Long term, Design:	$\sigma_{L,d}$	-125.93	125.93	N/mm ²
Utilisation stress	U_{σ}	55.5	88.4	%

The inside stress proof is ok.

The stress proof is ok.

All necessary proofs are ok.

checked by comparative calculation