1 Statics according to DWA-A 143-2: 2015-07: MKG 26 - DN 500, GW 1,50 m

Caption of static calculation: MKG 26 - DN 500, GW 1,50 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:	$d_{AR,i}$	500.00	mm
Four-hinge global imperfection:	w_{GRv}/r_L	3.00	%
Local imperfection intensity invert:	w_v/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/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	[-]

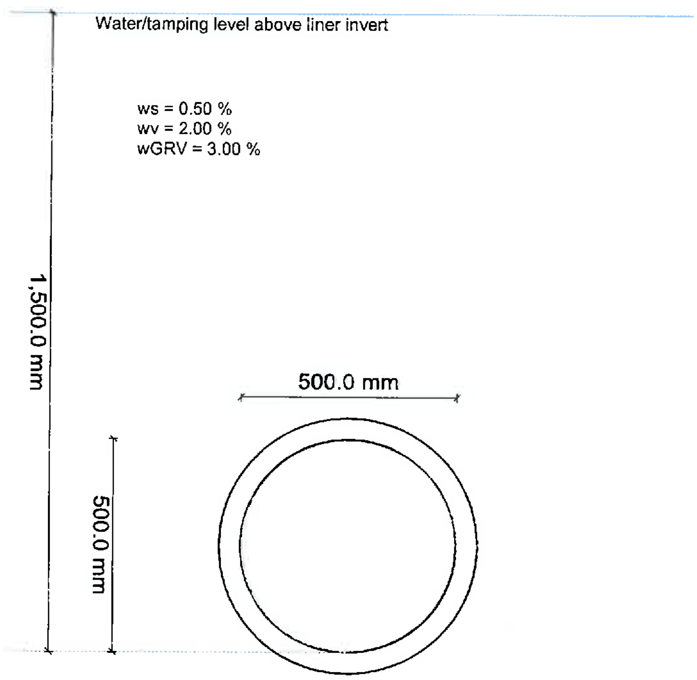
1.1.3 Loads

Water level above liner invert:	h_W	1.50	m

Weight water:	γ_W	10.00	kN/m³
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_{pi}	1.50	[-]
Partial safety coefficient temperature:	γ_T	1.10	[-]

1.2 Results

1.2.1 Load host pipe state II - hW 1.50 m, Long-term



Local imperfection:	ω_v	2.00	%
Local imperfection absolute:	w_v	4.97	mm
Global imperfection:	$\omega_{GR,v}$	3.00	%
Global imperfection absolute, one side:	$w_{GR,v}$	7.46	mm
Annular gap:	ω_s	0.50	%
Annular gap absolute (const. value):	w_s	1.24	mm

1.2.1.1 Material values

checked by comparative calculation

liner			
Partial safety factor material:	γ_M	1.35	[-]
Poissons ratio:	μ	0.35	[-]
E-Modulus, longterm:	E_L	13,000.00	N/mm²
E-Modulus, longterm, design:	$E_{L,d}$	9,629.63	N/mm²
Used E-Modulus:	E	10,973.94	N/mm²
Admissible compressive strength, long term:	$\sigma_{D,L}$	170.00	N/mm²
Admissible compressive strength, long term, design:	$\sigma_{D,L,d}$	-125.93	N/mm²
Admissible tensile bending strength, long term:	$\sigma_{bZ,L}$	170.00	N/mm²
Admissible tensile bending strength, long term, design:	$\sigma_{bZ,L,d}$	125.93	N/mm²
Admissible tensile strength, long term:	$\sigma_{Z,L}$	0.00	N/mm²
Admissible tensile strength, long term, design:	$\sigma_{Z,L,d}$	0.00	N/mm²

1.2.1.2 Deformation proof (Characteristic load)

Relevant diameter for percentage deformation:	d_v	500.00	mm
Annular gap absolute (const. value):	w_s	1.24	mm
Local imperfection absolute:	w_v	4.97	mm
Global imperfection absolute, one side:	$w_{GR,v}$	7.46	mm
Elastic deformation absolute:	w_{el}	9.0	mm
Relative elastic deformation:	$\delta_{v,el}$	1.79	%
Allowed elastic deformation:	zul $\delta_{v,el}$	3.00	%

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

Total diameter deviation:	w	28.86	mm
Relative total deformation:	δ_v	5.77	%
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:	$p_{a,d}$	22.50	kN/m²
Critical external water pressure (snap-through load):	krit p_a	23.55	kN/m²
Utilisation simplified buckling proof:	U_{pa}	95.5	%

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 seccond order theory under consideration of the prestrain (imperfection) and the annular gap. Here is numerically tested if the elastic stability failiure ocurrs 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 1.50 m

Surface (wallthickness):	A	2.60	mm²/mm

outside

		compression	tensile	
Stress in element	Max σ_d	-75.27	35.07	N/mm²
Max. allowed stress, Long term, Design:	$\sigma_{L,d}$	-125.93	125.93	N/mm²
Utilisation stress	U_σ	59.8	27.9	%

The outside stress proof is ok.

inside

		compression	tensile	
Stress in element	Max σ_d	-41.11	69.83	N/mm²

checked by comparative calculation

Max. allowed stress, Long term, Design:	$\sigma_{L,d}$	-125.93	125.93	N/mm²
Utilisation stress	U_σ	32.6	55.5	%

The inside stress proof is ok.

The stress proof is ok.

All necessary proofs are ok.

checked by comparative calculation