

sisKMR 19.2.0.0**sisKMR-Projekt: Paderewskiego_Gdansk**

Static calculation of 3-dimensional pipe systems considering nonlinear bedding functions

- * FR' (wv,ww) - Raising the axial frictional force FRg'
- * Q' (wv,ww) - Additional lateral longitudinal force
- * MR' (pu) - Frictional moment

Calculation basis

- EN 13941: 2010-12 for underground pipes
- EN 13480 (08/2002) for pipes aboveground
- Reducing process with more intensive separation of the static unknowns (to guarantee numerical stability)
- Constant-force process for the iterative determination of the friction
- Dimensioning of wall thicknesses under internal pressure must always be performed in accordance with the special standards.

Input data

Commisson -No.: 7_2020
Customer: MP INSTAL
Gdansk ul. Paderewskiego

Minimum operating temperature	10,00 ° C
Reducing factors for friction force	1,00 1,00 1,00
Heat conductivity ground	1,00 W/mK
Heat conductivity expansion cushion	0,07 W/mK
Heat conductivity PE-casing	0,43 W/mK
Heat conductivity pur foam at 50 degr. C	0,03 W/mK
Changing of heat conductivity PUR per ° C	0,0001 W/mK _l
Heat conductivity steel	76,00 W/mK
Allowable casing temperature	50,00 ° C
Distance between supply and return	0,20 m
Set-up expansion cushion	on both sides
Outer temperature	-16,00 ° C
Constant temperature of soil	8,00 ° C
Depth for constant soil temperature	1,50 m

Line: 1 / Section: 1

Section - starting point	AP , Point type: NFP
Project class	C with 100 load cycles
Outer diameter	610,00 mm
Wall thickness	7,10 mm
Diameter casing	800,00 mm
Medium pipe material	P235GH
E-Modulus	206,57 kN/mm _l
Coefficient of expansion	1,24 E-05 1/K
Yield strength	191,40 N/mm _l
Tensile strength	360,00 N/mm _l
Section mass	399,53 kg/m
Maximum operating temperature	130,00 ° C
Installation temperature	10,00 ° C
Internal overpressure	16,00 bar
Allowable PUR compressive stress	0,15 N/mm _l
Cover at section end point	1,15 m
Friction angle of soil	32,50 °
Specicfic weight of soil	19,00 kN/m _l
Horizontal length component	18,00 m

Local pre-stressing	0,00 mm	
Division	36	
Bedding type	High compaction bedding	Line: 1 / Section: 2
Section - starting point	A010	
Horizontal length component	0,20 m	
Division	1	
Bedding type	Soil without lateral displacement	Line: 1 / Section: 3
Section - starting point	A020	
E-Modulus	204,60 kN/mm ₂	
Coefficient of expansion	1,27 E-05 1/K	
Horizontal length component	0,86 m	
Division	1	
Bedding type	Air bedding	Line: 1 / Section: 4
Section - starting point	T1	
Horizontal length component	0,48 m	
Division	1	
Bedding type	Air bedding	Line: 1 / Section: 5
Section - starting point	T2	
Horizontal length component	0,48 m	
Division	1	
Bedding type	Air bedding	Line: 1 / Section: 6
Section - starting point	A030	
Horizontal length component	1,72 m	
Division	1	
Bedding type	Air bedding	Line: 1 / Section: 7
Section - starting point	A040	
E-Modulus	206,57 kN/mm ₂	
Coefficient of expansion	1,24 E-05 1/K	
Cover at section end point	1,15 m	
Friction angle of soil	32,50 °	
Specific weight of soil	19,00 kN/m ³	
Horizontal length component	0,20 m	
Division	1	
Bedding type	Soil without lateral displacement	Line: 1 / Section: 8
Section - starting point	A050	
Cover at section end point	0,90 m	
Horizontal length component	6,50 m	
Division	13	
Bedding type	High compaction bedding	Line: 1 / Section: 9
Section - starting point	A060	
Cover at section end point	0,84 m	
Horizontal length component	2,00 m	
Division	4	
Bedding type	N040	

Line: 1 / Section: 10

Section - starting point A070
 Cover at section end point 0,83 m
 Horizontal length component 2,00 m
 Division 4
 Bedding type N080

Line: 1 / Section: 11

Section - starting point A075
 Cover at section end point 0,80 m
 Horizontal length component 2,00 m
 Horizontal angular deviation -70,00 °
 Angular deviation in space 70,00 °
 Bend radius 914,00 mm
 Bend wall thickness 7,10 mm
 Division 3
 Bedding type N120

Line: 1 / Section: 12

Section - starting point B
 Cover at section end point 0,90 m
 Horizontal length component 2,00 m
 Horizontal angular deviation 0,00 °
 Angular deviation in space 3,32 °
 Bend radius 914,00 mm
 Bend wall thickness 7,10 mm
 Division 3
 Bedding type N120

Line: 1 / Section: 13

Section - starting point A077
 Cover at section end point 0,95 m
 Horizontal length component 2,00 m
 Vertical length component -0,12 m
 Length in space 2,00 m
 Division 3
 Bedding type N080

Line: 1 / Section: 14

Section - starting point A080
 Cover at section end point 1,12 m
 Horizontal length component 2,00 m
 Vertical length component -0,12 m
 Length in space 2,00 m
 Division 4
 Bedding type N040

Line: 1 / Section: 15

Section - starting point A090
 Cover at section end point 1,48 m
 Horizontal length component 7,50 m
 Vertical length component -0,43 m
 Length in space 7,51 m
 Division 15
 Bedding type High compaction bedding

Line: 1 / Section: 16

Section - starting point	B1
Cover at section end point	2,08 m
Horizontal length component	12,00 m
Vertical length component	-0,70 m
Length in space	12,02 m
Division	24
Bedding type	High compaction bedding

Line: 1 / Section: 17

Section - starting point	B2
Horizontal length component	27,90 m
Vertical length component	-1,62 m
Length in space	27,95 m
Division	56
Bedding type	High compaction bedding

Line: 1 / Section: 18

Section - starting point	B3
Cover at section end point	0,91 m
Horizontal length component	12,00 m
Vertical length component	-0,70 m
Length in space	12,02 m
Division	24
Bedding type	High compaction bedding

Line: 1 / Section: 19

Section - starting point	B4
Cover at section end point	0,84 m
Horizontal length component	7,00 m
Vertical length component	-0,41 m
Length in space	7,01 m
Division	14
Bedding type	High compaction bedding

Line: 1 / Section: 20

Section - starting point	A110
Cover at section end point	0,82 m
Horizontal length component	2,00 m
Vertical length component	-0,12 m
Length in space	2,00 m
Division	4
Bedding type	N040

Line: 1 / Section: 21

Section - starting point	A120
Cover at section end point	0,80 m
Horizontal length component	3,00 m
Vertical length component	-0,17 m
Length in space	3,01 m
Horizontal angular deviation	90,00 °
Angular deviation in space	88,80 °
Bend radius	914,00 mm
Bend wall thickness	7,10 mm
Division	6
Bedding type	N080

Line: 1 / Section: 22

Section - starting point	C
Cover at section end point	0,84 m
Horizontal length component	3,00 m
Vertical length component	-1,17 m
Length in space	3,22 m
Division	5
Bedding type	N080

Line: 1 / Section: 23

Section - starting point	A130
Cover at section end point	0,85 m
Horizontal length component	2,00 m
Vertical length component	-0,78 m
Length in space	2,15 m
Division	4
Bedding type	N040

Line: 1 / Section: 24

Section - starting point	A140
Cover at section end point	0,86 m
Horizontal length component	1,40 m
Vertical length component	-0,54 m
Length in space	1,50 m
Division	3
Bedding type	N040

Line: 1 / Section: 25

Section - starting point	A150
Cover at section end point	0,90 m
Horizontal length component	2,00 m
Vertical length component	-0,78 m
Length in space	2,15 m
Division	4
Bedding type	N080

Line: 1 / Section: 26

Section - starting point	A160
Cover at section end point	0,95 m
Horizontal length component	2,00 m
Vertical length component	-0,78 m
Length in space	2,15 m
Horizontal angular deviation	-70,00 °
Angular deviation in space	67,39 °
Bend radius	914,00 mm
Bend wall thickness	7,10 mm
Division	3
Bedding type	N120

Line: 1 / Section: 27

Section - starting point	D
Cover at section end point	0,99 m
Horizontal length component	2,00 m
Vertical length component	-0,41 m
Length in space	2,04 m
Division	3
Bedding type	N120

Line: 1 / Section: 28

Section - starting point	A170
Cover at section end point	1,04 m
Horizontal length component	2,00 m
Vertical length component	-0,41 m
Length in space	2,04 m
Division	4
Bedding type	N080

Line: 1 / Section: 29

Section - starting point	A180
Cover at section end point	1,08 m
Horizontal length component	2,00 m
Vertical length component	-0,41 m
Length in space	2,04 m
Division	4
Bedding type	N040

Line: 1 / Section: 30

Section - starting point	A190
Cover at section end point	0,83 m
Horizontal length component	12,00 m
Vertical length component	-2,44 m
Length in space	12,24 m
Division	24
Bedding type	High compaction bedding

Line: 1 / Section: 31

Section - starting point	D2
Cover at section end point	1,54 m
Horizontal length component	12,00 m
Vertical length component	-2,44 m
Length in space	12,24 m
Horizontal angular deviation	0,00 °
Angular deviation in space	1,66 °
Bend radius	457,50 mm
Bend wall thickness	7,10 mm
Division	24
Bedding type	High compaction bedding

Line: 1 / Section: 32

Section - starting point	D3
Cover at section end point	1,99 m
Horizontal length component	12,00 m
Vertical length component	-2,08 m
Length in space	12,18 m
Horizontal angular deviation	0,00 °
Angular deviation in space	2,69 °
Bend radius	457,50 mm
Bend wall thickness	7,10 mm
Division	24
Bedding type	High compaction bedding

Line: 1 / Section: 33

Section - starting point	D3.1
Cover at section end point	1,20 m
Horizontal length component	12,00 m
Vertical length component	-1,50 m
Length in space	12,09 m
Horizontal angular deviation	0,00 °
Angular deviation in space	2,55 °
Bend radius	457,50 mm
Bend wall thickness	7,10 mm
Division	24
Bedding type	High compaction bedding

Line: 1 / Section: 34

Section - starting point	D3.2
Cover at section end point	1,35 m
Horizontal length component	18,80 m
Vertical length component	-1,50 m
Length in space	18,86 m
Horizontal angular deviation	0,00 °
Angular deviation in space	0,68 °
Bend radius	457,50 mm
Bend wall thickness	7,10 mm
Division	38
Bedding type	High compaction bedding

Line: 1 / Section: 35

Section - starting point	D4
Cover at section end point	2,05 m
Horizontal length component	12,00 m
Vertical length component	-0,82 m
Length in space	12,03 m
Division	24
Bedding type	High compaction bedding

Line: 1 / Section: 36

Section - starting point	D5
Cover at section end point	2,78 m
Horizontal length component	12,00 m
Vertical length component	-0,82 m
Length in space	12,03 m
Division	24
Bedding type	High compaction bedding

Line: 1 / Section: 37

Section - starting point	D6
Cover at section end point	1,75 m
Horizontal length component	7,50 m
Vertical length component	-0,51 m
Length in space	7,52 m
Division	15
Bedding type	High compaction bedding

Line: 1 / Section: 38

Section - starting point	A200
Cover at section end point	1,45 m
Horizontal length component	2,00 m
Vertical length component	-0,14 m
Length in space	2,00 m
Division	4
Bedding type	N040

Line: 1 / Section: 39

Section - starting point	A210
Cover at section end point	1,20 m
Horizontal length component	2,00 m
Vertical length component	-0,14 m
Length in space	2,00 m
Division	4
Bedding type	N080

Line: 1 / Section: 40

Section - starting point	A220
Cover at section end point	0,80 m
Horizontal length component	2,00 m
Vertical length component	-0,14 m
Length in space	2,00 m
Horizontal angular deviation	90,00 °
Angular deviation in space	89,95 °
Bend radius	914,00 mm
Bend wall thickness	7,10 mm
Division	2
Bedding type	N120

Line: 1 / Section: 41

Section - starting point	E
Cover at section end point	0,82 m
Horizontal length component	2,00 m
Vertical length component	-0,03 m
Length in space	2,00 m
Division	2
Bedding type	N120

Line: 1 / Section: 42

Section - starting point	A230
Cover at section end point	0,86 m
Horizontal length component	2,00 m
Vertical length component	-0,03 m
Length in space	2,00 m
Division	4
Bedding type	N080

Line: 1 / Section: 43

Section - starting point	A240
Cover at section end point	0,89 m
Horizontal length component	2,00 m
Vertical length component	-0,03 m
Length in space	2,00 m
Division	4
Bedding type	N040

Line: 1 / Section: 44

Section - starting point	A250
Cover at section end point	0,93 m
Horizontal length component	2,30 m
Vertical length component	-0,03 m
Length in space	2,30 m
Division	5
Bedding type	High compaction bedding

Line: 1 / Section: 45

Section - starting point	A260
Cover at section end point	0,95 m
Horizontal length component	2,00 m
Vertical length component	-0,03 m
Length in space	2,00 m
Division	4
Bedding type	N040

Line: 1 / Section: 46

Section - starting point	A265
Cover at section end point	0,98 m
Horizontal length component	3,00 m
Vertical length component	-0,04 m
Length in space	3,00 m
Horizontal angular deviation	-80,00 °
Angular deviation in space	79,97 °
Bend radius	914,00 mm
Bend wall thickness	7,10 mm
Division	6
Bedding type	N080

Line: 1 / Section: 47

Section - starting point	F
Cover at section end point	0,99 m
Horizontal length component	3,00 m
Vertical length component	-0,23 m
Length in space	3,01 m
Division	4
Bedding type	N080

Line: 1 / Section: 48

Section - starting point	A275
Cover at section end point	1,00 m
Horizontal length component	2,00 m
Vertical length component	-0,15 m
Length in space	2,01 m
Division	4
Bedding type	N040

Line: 1 / Section: 49

Section - starting point	A285
Cover at section end point	1,19 m
Horizontal length component	38,20 m
Vertical length component	-2,87 m
Length in space	38,31 m
Division	77
Bedding type	High compaction bedding

Line: 1 / Section: 50

Section - starting point	F1
Cover at section end point	0,92 m
Horizontal length component	16,90 m
Vertical length component	-1,27 m
Length in space	16,95 m
Division	34
Bedding type	High compaction bedding

Line: 1 / Section: 51

Section - starting point	A295
Cover at section end point	0,85 m
Horizontal length component	2,00 m
Vertical length component	-0,15 m
Length in space	2,01 m
Division	4
Bedding type	N040

Line: 1 / Section: 52

Section - starting point	A305
Cover at section end point	0,80 m
Horizontal length component	3,30 m
Vertical length component	-0,25 m
Length in space	3,31 m
Horizontal angular deviation	90,00 °
Angular deviation in space	89,85 °
Bend radius	914,00 mm
Bend wall thickness	7,10 mm
Division	5
Bedding type	N080

Line: 1 / Section: 53

Section - starting point	G
Cover at section end point	1,24 m
Horizontal length component	5,30 m
Vertical length component	-0,18 m
Length in space	5,30 m
Horizontal angular deviation	-90,00 °
Angular deviation in space	89,93 °
Bend radius	914,00 mm
Bend wall thickness	7,10 mm
Division	7
Bedding type	N080

Line: 1 / Section: 54

Section - starting point	H
Cover at section end point	1,25 m
Horizontal length component	2,60 m
Vertical length component	-0,09 m
Length in space	2,60 m
Division	3
Bedding type	N040

Line: 1 / Section: 55

Section - starting point	A315
Cover at section end point	1,26 m
Horizontal length component	2,00 m
Vertical length component	-0,07 m
Length in space	2,00 m
Horizontal angular deviation	-90,00 °
Angular deviation in space	89,63 °
Bend radius	914,00 mm
Bend wall thickness	7,10 mm
Division	4
Bedding type	N080

Line: 1 / Section: 56

Section - starting point	I
Cover at section end point	2,04 m
Horizontal length component	5,10 m
Vertical length component	-0,97 m
Length in space	5,19 m
Horizontal angular deviation	89,00 °
Angular deviation in space	88,04 °
Bend radius	914,00 mm
Bend wall thickness	7,10 mm
Division	9
Bedding type	N080

Line: 1 / Section: 57

Section - starting point	J
Cover at section end point	1,52 m
Horizontal length component	2,00 m
Vertical length component	-0,18 m
Length in space	2,01 m
Division	2
Bedding type	N080

Line: 1 / Section: 58

Section - starting point	A325
Cover at section end point	1,78 m
Horizontal length component	2,00 m
Vertical length component	-0,18 m
Length in space	2,01 m
Division	4
Bedding type	N040

Line: 1 / Section: 59

Section - starting point	A335
Cover at section end point	2,46 m
Horizontal length component	7,00 m
Vertical length component	-0,64 m
Length in space	7,03 m
Division	14
Bedding type	High compaction bedding

Line: 1 / Section: 60

Section - starting point	K
Horizontal length component	0,20 m
Vertical length component	-0,02 m
Length in space	0,20 m
Division	1
Bedding type	Soil without lateral displacement

Line: 1 / Section: 61

Section - starting point A345
 Section - end point PS , Point type: FP
 E-Modulus 204,60 kN/mm₂
 Coefficient of expansion 1,27 E-05 1/K
 Horizontal length component 1,54 m
 Vertical length component -0,14 m
 Length in space 1,55 m
 Division 1
 Bedding type Air bedding

General view of lengths

	Start point	End point	Typ	Length	Line length
Line 01	AP	B	Bend	34,4	34,4
	B	A077	Bend	2,0	36,4
	A077	C	Bend	75,5	112,0
	C	D	Bend	11,2	123,1
	D	D3	Deviation	30,6	153,7
	D3	D3.1	Deviation	12,2	165,9
	D3.1	D3.2	Deviation	12,1	178,0
	D3.2	D4	Deviation	18,9	196,9
	D4	E	Bend	37,6	234,5
	E	F	Bend	13,3	247,8
	F	G	Bend	65,6	313,3
	G	H	Bend	5,3	318,6
	H	I	Bend	4,6	323,2
	I	J	Bend	5,2	328,4
	J	PS	End	12,8	341,2

Results Load condition 2: Hot loading case (adt=adt_warm)Coordinate system

u,v,w - Local coordinate system (orthogonal system)
 u - axial positive in direction of calculation
 v - horizontal to right
 w - vertical down
 (for v and w special definition for bends and vertical sections, see manual)

Extract of results (maximum values)**1. PUR foam and casing**

ANR - Section number EC-thickness - EC-thickness in mm
 TAUPUR - PUR shear stress in MPa TM - Temperature of casing in ° C
 SIGPUR - PUR compressive stress in MPa TM' - ditto at tEC/2 in ° C
 FRg' - Resulting frictional force from FR' (wu) and MR' (pu) in kN/m
 Qg'(v,w) - Resulting lateral compression from Q' (wv) and Q' (ww) in kN/m

ANR KZ	FRg'	TAUPUR	Qg'	SIGPUR existing	SIGPUR allowable	EC-thicknes	TM	TM'
Line 1 Section 1								AP A010
1 G	19,3	0,010	0,0	0,000	0,150	0	45,5	45,5
Line 1 Section 2								A010 A020
2 G	19,3	0,010	0,0	0,000	0,150	0	45,5	45,5
Line 1 Section 3								A020 T1
3 G	0,0	0,000	0,0	0,000	0,150	0	45,5	45,5
Line 1 Section 4								T1 T2
4 G	0,0	0,000	0,0	0,000	0,150	0	45,5	45,5
Line 1 Section 5								T2 A030
5 G	0,0	0,000	0,0	0,000	0,150	0	45,5	45,5
Line 1 Section 6								A030 A040
6 G	0,0	0,000	0,0	0,000	0,150	0	45,5	45,5
Line 1 Section 7								A040 A050
7 G	19,3	0,010	0,0	0,000	0,150	0	45,5	45,5
Line 1 Section 8								A050 A060
8 G	37,1	0,019	53,1	0,087	0,150	0	40,5	40,5
Line 1 Section 9								A060 A070
9 G	31,2	0,016	39,7	0,065	0,150	40	44,0	41,6
Line 1 Section 10								A070 A075
10 G	25,2	0,013	24,4	0,040	0,150	80	47,8	43,7
Line 1 Section 11								A075 B
11 G	22,4	0,012	17,3	0,028	0,150	120	50,7*	45,2
11 B	29,9	0,016	36,9	0,061	0,150	120		
Line 1 Section 12								B A077
12 G	23,0	0,012	17,6	0,029	0,150	120	52,7*	47,4
12 B	26,5	0,014	24,4	0,040	0,150	120		
Line 1 Section 13								A077 A080
13 G	25,9	0,014	23,9	0,039	0,150	80	50,3*	46,4
Line 1 Section 14								A080 A090

ANR KZ	FRg'	TAUPUR	Qg'	SIGPUR existing	SIGPUR allowable	EC-thicknes	TM	TM'
14 G	32,2	0,017	39,3	0,064	0,150	40	49,7	47,5
Line 1 Section 15							A090	B1
15 G	39,9	0,021	52,4	0,086	0,150	0	48,2	48,2
Line 1 Section 16							B1	B2
16 G	32,0	0,017	6,6	0,011	0,150	0	52,0*	52,0
Line 1 Section 17							B2	B3
17 G	34,4	0,018	0,1	0,000	0,150	0	52,0*	52,0
Line 1 Section 18							B3	B4
18 G	32,3	0,017	2,2	0,004	0,150	0	40,7	40,7
Line 1 Section 19							B4	A110
19 G	24,4	0,013	18,8	0,031	0,150	0	39,0	39,0
Line 1 Section 20							A110	A120
20 G	19,2	0,010	8,2	0,013	0,150	40	43,5	41,1
Line 1 Section 21							A120	C
21 G	18,6	0,010	7,4	0,012	0,150	80	47,2	43,0
21 B	28,7	0,015	35,7	0,058	0,150	80		
Line 1 Section 22							C	A130
22 G	26,8	0,014	27,8	0,046	0,150	80	48,0	44,0
Line 1 Section 23							A130	A140
23 G	23,4	0,012	18,2	0,030	0,150	40	44,2	41,8
Line 1 Section 24							A140	A150
24 G	19,5	0,010	28,3	0,046	0,150	40	44,4	42,1
Line 1 Section 25							A150	A160
25 G	32,3	0,017	38,7	0,063	0,150	80	49,3	45,3
Line 1 Section 26							A160	D
26 G	28,9	0,015	28,6	0,047	0,150	120	53,7*	48,4
26 B	29,1	0,015	30,8	0,051	0,150	120		
Line 1 Section 27							D	A170
27 G	22,1	0,012	10,0	0,016	0,150	120	54,4*	49,3
Line 1 Section 28							A170	A180
28 G	23,0	0,012	11,1	0,018	0,150	80	52,1*	48,3
Line 1 Section 29							A180	A190
29 G	24,4	0,013	12,5	0,020	0,150	40	49,1	46,9
Line 1 Section 30							A190	D2
30 G	34,2	0,018	32,5	0,053	0,150	0	38,8	38,8
Line 1 Section 31							D2	D3
31 G	26,8	0,014	5,3	0,009	0,150	0	48,7	48,7
31 K	26,8	0,014	5,3	0,009	0,150	0		
Line 1 Section 32							D3	D3.1
32 G	35,0	0,018	9,7	0,016	0,150	0	51,5*	51,5
32 K	35,0	0,018	9,7	0,016	0,150	0		
Line 1 Section 33							D3.1	D3.2
33 G	33,6	0,018	10,3	0,017	0,150	0	45,9	45,9
33 K	24,8	0,013	10,3	0,017	0,150	0		
Line 1 Section 34							D3.2	D4
34 G	24,9	0,013	9,6	0,016	0,150	0	47,2	47,2
34 K	23,0	0,012	2,7	0,005	0,150	0		
Line 1 Section 35							D4	D5
35 G	31,7	0,017	2,7	0,005	0,150	0	51,9*	51,9
Line 1 Section 36							D5	D6

ANR KZ	FRg'	TAUPUR	Qg'	SIGPUR existing	SIGPUR allowable	EC-thicknes	TM	TM'
36 G	42,4	0,022	1,6	0,003	0,150	0	55,2*	55,2
Line 1 Section 37								D6 A200
37 G	42,4	0,022	13,9	0,023	0,150	0	50,1*	50,1
Line 1 Section 38								A200 A210
38 G	29,3	0,015	6,2	0,010	0,150	40	52,2*	50,2
Line 1 Section 39								A210 A220
39 G	25,4	0,013	5,8	0,010	0,150	80	54,0*	50,4
Line 1 Section 40								A220 E
40 G	22,3	0,012	5,4	0,009	0,150	120	50,7*	45,2
40 B	21,6	0,011	16,1	0,026	0,150	120		
Line 1 Section 41								E A230
41 G	21,8	0,011	15,0	0,025	0,150	120	51,1*	45,6
Line 1 Section 42								A230 A240
42 G	25,0	0,013	22,3	0,037	0,150	80	48,5	44,4
Line 1 Section 43								A240 A250
43 G	30,7	0,016	35,0	0,057	0,150	40	45,1	42,8
Line 1 Section 44								A250 A260
44 G	28,7	0,015	41,7	0,068	0,150	0	41,2	41,2
Line 1 Section 45								A260 A265
45 G	28,2	0,015	26,6	0,044	0,150	40	46,4	44,1
Line 1 Section 46								A265 F
46 G	25,1	0,013	17,9	0,029	0,150	80	50,9*	47,0
46 B	26,0	0,014	20,0	0,033	0,150	80		
Line 1 Section 47								F A275
47 G	20,5	0,011	7,4	0,012	0,150	80	51,1*	47,2
Line 1 Section 48								A275 A285
48 G	20,6	0,011	8,1	0,013	0,150	40	47,5	45,2
Line 1 Section 49								A285 F1
49 G	25,9	0,014	21,5	0,035	0,150	0	45,9	45,9
Line 1 Section 50								F1 A295
50 G	20,4	0,011	10,8	0,018	0,150	0	41,0	41,0
Line 1 Section 51								A295 A305
51 G	17,7	0,009	5,3	0,009	0,150	40	44,2	41,8
Line 1 Section 52								A305 G
52 G	17,1	0,009	5,0	0,008	0,150	80	47,2	43,0
52 B	22,1	0,012	17,9	0,029	0,150	80		
Line 1 Section 53								G H
53 G	23,4	0,012	16,6	0,027	0,150	80	54,3*	50,7
53 B	23,7	0,012	6,5	0,011	0,150	80		
Line 1 Section 54								H A315
54 G	23,4	0,012	6,2	0,010	0,150	40	50,8*	48,7
Line 1 Section 55								A315 I
55 G	22,8	0,012	4,5	0,007	0,150	80	54,5*	50,8
55 B	23,4	0,012	4,9	0,008	0,150	80		
Line 1 Section 56								I J
56 G	33,8	0,018	7,6	0,012	0,150	80	58,9*	55,7
56 B	34,6	0,018	7,2	0,012	0,150	80		
Line 1 Section 57								J A325
57 G	31,3	0,016	5,2	0,009	0,150	80	56,2*	52,7
Line 1 Section 58								A325 A335

ANR KZ	FRg'	TAUPUR	Qg'	SIGPUR existing	SIGPUR allowable	EC-thicknes	TM	TM'
58 G Line 1 Section 59	30,0	0,016	5,5	0,009	0,150	40	54,3*	52,4 A335 K
59 G Line 1 Section 60	37,4	0,020	10,3	0,017	0,150	0	53,9*	53,9 K A345
60 G Line 1 Section 61	37,4	0,020	0,0	0,000	0,150	0	53,9*	53,9 A345 PS
61 G	0,0	0,000	0,0	0,000	0,150	0	53,9*	53,9
Allowable values		0,040					50,0	

Explanation of TM'

Thickness of expansion cushion effects too high casing temperatures.

With half the thickness of expansion cushion, TM' 'can be reached. For this, the expansion cushion must be pre-stressed. A new calculation for this is not necessary. See manual for explanation.

2. Medium pipe

2.1. Axial stress caused by friction

The maximum axial stress amounts to -82,3 MPa and occurs in line 1, section 34, section number 7

The allowable axial stress of 190,0 MPa is not exceeded.

Results Load condition 3: Cold condition (adt=adt_kalt)Coordinate system

u,v,w - Local coordinate system (orthogonal system)
 u - axial positive in direction of calculation
 v - horizontal to right
 w - vertical down
 (for v and w special definition for bends and vertical sections, see manual)

Extract of results (maximum values)**1. PUR foam and casing**

ANR - Section number EC-thickness - EC-thickness in mm
 TAUPUR - PUR shear stress in MPa TM - Temperature of casing in ° C
 SIGPUR - PUR compressive stress in MPa TM' - ditto at tEC/2 in ° C
 FRg' - Resulting frictional force from FR' (wu) and MR' (pu) in kN/m
 Qg'(v,w) - Resulting lateral compression from Q' (wv) and Q' (ww) in kN/m

ANR KZ	FRg'	TAUPUR	Qg'	SIGPUR existing	SIGPUR allowable	EC-thicknes	TM	TM'
Line 1 Section 1								AP A010
1 G	19,3	0,010	0,0	0,000	0,150	0	8,5	8,5
Line 1 Section 2								A010 A020
2 G	19,3	0,010	0,0	0,000	0,150	0	8,5	8,5
Line 1 Section 3								A020 T1
3 G	0,0	0,000	0,0	0,000	0,150	0	8,5	8,5
Line 1 Section 4								T1 T2
4 G	0,0	0,000	0,0	0,000	0,150	0	8,5	8,5
Line 1 Section 5								T2 A030
5 G	0,0	0,000	0,0	0,000	0,150	0	8,5	8,5
Line 1 Section 6								A030 A040
6 G	0,0	0,000	0,0	0,000	0,150	0	8,5	8,5
Line 1 Section 7								A040 A050
7 G	19,3	0,010	0,0	0,000	0,150	0	8,5	8,5
Line 1 Section 8								A050 A060
8 G	19,3	0,010	0,5	0,001	0,150	0	6,0	6,0
Line 1 Section 9								A060 A070
9 G	16,5	0,009	3,5	0,006	0,150	40	5,4	5,3
Line 1 Section 10								A070 A075
10 G	16,3	0,008	3,6	0,006	0,150	80	5,5	5,3
Line 1 Section 11								A075 B
11 G	16,2	0,008	3,5	0,006	0,150	120	5,3	5,0
11 B	15,9	0,008	3,7	0,006	0,150	120		
Line 1 Section 12								B A077
12 G	17,2	0,009	3,5	0,006	0,150	120	6,4	6,2
12 B	17,3	0,009	3,5	0,006	0,150	120		
Line 1 Section 13								A077 A080
13 G	17,8	0,009	3,5	0,006	0,150	80	6,9	6,8
Line 1 Section 14								A080 A090

ANR KZ	FRg'	TAUPUR	Qg'	SIGPUR existing	SIGPUR allowable	EC-thicknes	TM	TM'
14 G	19,4	0,010	3,5	0,006	0,150	40	8,6	8,5
Line 1 Section 15								A090 B1
15 G	24,0	0,013	0,7	0,001	0,150	0	8,5	8,5
Line 1 Section 16								B1 B2
16 G	32,1	0,017	0,3	0,001	0,150	0	8,6	8,6
Line 1 Section 17								B2 B3
17 G	32,6	0,017	0,0	0,000	0,150	0	8,6	8,6
Line 1 Section 18								B3 B4
18 G	32,2	0,017	0,2	0,000	0,150	0	6,1	6,1
Line 1 Section 19								B4 A110
19 G	16,0	0,008	0,8	0,001	0,150	0	5,2	5,2
Line 1 Section 20								A110 A120
20 G	15,8	0,008	2,2	0,004	0,150	40	5,2	5,1
Line 1 Section 21								A120 C
21 G	16,4	0,009	3,5	0,006	0,150	80	5,1	4,9
21 B	16,4	0,009	4,6	0,008	0,150	80		
Line 1 Section 22								C A130
22 G	16,6	0,009	4,6	0,008	0,150	80	5,6	5,4
Line 1 Section 23								A130 A140
23 G	16,8	0,009	4,4	0,007	0,150	40	5,5	5,5
Line 1 Section 24								A140 A150
24 G	12,7	0,007	4,2	0,007	0,150	40	5,7	5,6
Line 1 Section 25								A150 A160
25 G	18,0	0,009	4,6	0,007	0,150	80	6,3	6,2
Line 1 Section 26								A160 D
26 G	18,7	0,010	4,7	0,008	0,150	120	7,0	6,8
26 B	18,3	0,010	4,4	0,007	0,150	120		
Line 1 Section 27								D A170
27 G	19,2	0,010	4,4	0,007	0,150	120	7,4	7,3
Line 1 Section 28								A170 A180
28 G	19,3	0,010	3,8	0,006	0,150	80	7,9	7,8
Line 1 Section 29								A180 A190
29 G	19,4	0,010	3,3	0,005	0,150	40	8,3	8,3
Line 1 Section 30								A190 D2
30 G	18,7	0,010	0,8	0,001	0,150	0	5,1	5,1
Line 1 Section 31								D2 D3
31 G	25,4	0,013	1,7	0,003	0,150	0	8,5	8,5
31 K	25,8	0,013	2,6	0,004	0,150	0		
Line 1 Section 32								D3 D3.1
32 G	33,4	0,017	5,4	0,009	0,150	0	8,6	8,6
32 K	33,7	0,018	6,3	0,010	0,150	0		
Line 1 Section 33								D3.1 D3.2
33 G	33,7	0,018	7,9	0,013	0,150	0	8,5	8,5
33 K	23,9	0,012	7,9	0,013	0,150	0		
Line 1 Section 34								D3.2 D4
34 G	23,9	0,012	7,9	0,013	0,150	0	8,5	8,5
34 K	22,8	0,012	2,3	0,004	0,150	0		
Line 1 Section 35								D4 D5
35 G	31,7	0,017	1,9	0,003	0,150	0	8,6	8,6
Line 1 Section 36								D5 D6

ANR KZ	FRg'	TAUPUR	Qg'	SIGPUR existing	SIGPUR allowable	EC-thicknes	TM	TM'
36 G	41,9	0,022	0,1	0,000	0,150	0	8,6	8,6
Line 1 Section 37								D6 A200
37 G	41,9	0,022	0,8	0,001	0,150	0	8,6	8,6
Line 1 Section 38								A200 A210
38 G	27,8	0,015	1,6	0,003	0,150	40	8,6	8,6
Line 1 Section 39								A210 A220
39 G	24,1	0,013	2,8	0,005	0,150	80	8,6	8,6
Line 1 Section 40								A220 E
40 G	21,2	0,011	3,0	0,005	0,150	120	5,3	5,0
40 B	16,9	0,009	5,3	0,009	0,150	120		
Line 1 Section 41								E A230
41 G	17,4	0,009	5,5	0,009	0,150	120	5,5	5,3
Line 1 Section 42								A230 A240
42 G	17,5	0,009	5,7	0,009	0,150	80	5,8	5,7
Line 1 Section 43								A240 A250
43 G	17,8	0,009	5,9	0,010	0,150	40	6,0	6,0
Line 1 Section 44								A250 A260
44 G	1,8	0,001	9,7	0,016	0,150	0	6,4	6,4
Line 1 Section 45								A260 A265
45 G	17,9	0,009	3,4	0,006	0,150	40	6,8	6,7
Line 1 Section 46								A265 F
46 G	18,2	0,010	3,3	0,005	0,150	80	7,2	7,1
46 B	18,3	0,010	3,3	0,005	0,150	80		
Line 1 Section 47								F A275
47 G	17,3	0,009	0,9	0,001	0,150	80	7,4	7,2
Line 1 Section 48								A275 A285
48 G	17,2	0,009	0,4	0,001	0,150	40	7,4	7,3
Line 1 Section 49								A285 F1
49 G	19,8	0,010	0,1	0,000	0,150	0	8,5	8,5
Line 1 Section 50								F1 A295
50 G	19,8	0,010	0,1	0,000	0,150	0	6,2	6,2
Line 1 Section 51								A295 A305
51 G	16,1	0,008	0,2	0,000	0,150	40	5,5	5,5
Line 1 Section 52								A305 G
52 G	15,2	0,008	0,2	0,000	0,150	80	5,1	4,9
52 B	16,0	0,008	3,7	0,006	0,150	80		
Line 1 Section 53								G H
53 G	17,7	0,009	3,8	0,006	0,150	80	8,6	8,6
53 B	20,9	0,011	1,8	0,003	0,150	80		
Line 1 Section 54								H A315
54 G	20,2	0,011	1,8	0,003	0,150	40	8,6	8,5
Line 1 Section 55								A315 I
55 G	21,1	0,011	1,2	0,002	0,150	80	8,6	8,6
55 B	21,2	0,011	0,9	0,001	0,150	80		
Line 1 Section 56								I J
56 G	30,8	0,016	2,3	0,004	0,150	80	8,7	8,6
56 B	32,5	0,017	2,3	0,004	0,150	80		
Line 1 Section 57								J A325
57 G	28,7	0,015	0,5	0,001	0,150	80	8,6	8,6
Line 1 Section 58								A325 A335

ANR KZ	FRg'	TAUPUR	Qg'	SIGPUR existing	SIGPUR allowable	EC-thicknes	TM	TM'
58 G	28,1	0,015	0,5	0,001	0,150	40	8,6	8,6
Line 1 Section 59								A335 K
59 G	37,4	0,020	0,3	0,001	0,150	0	8,6	8,6
Line 1 Section 60								K A345
60 G	37,4	0,020	0,0	0,000	0,150	0	8,6	8,6
Line 1 Section 61								A345 PS
61 G	0,0	0,000	0,0	0,000	0,150	0	8,6	8,6
Allowable values		0,040					50,0	

2. Medium pipe

2.1. Detailed stress analysis at the location with the max. composite stress in straights or bends

The maximum reference stresses in underground installation occurs in

STR	ANR	PKT	SNR	KZ	PHI	Fibre	Total stress [MPa]	Allowable stress [MPa]	Utilisation [%]
1	11	B	5	B	169	inner	439,8	889,1	49
1	33	D3.2	1	K	-	-	387,2	889,1	44
1	26	D	6	B	169	inner	379,4	889,1	43
1	34	D4	1	K	-	-	283,9	889,1	32
1	32	D3.1	1	K	-	-	278,3	889,1	31

The max. composite stresses for the S1-proof in aboveground installation occur in

STR	ANR	PKT	SNR	KZ	Total stress [MPa]	Allowable stress [MPa]	Utilisation [%]
1	3	A020	0	G	36,4	127,6	29
1	6	A040	1	G	36,4	127,6	29
1	5	A030	1	G	35,4	127,6	28
1	4	T2	1	G	35,2	127,6	28
1	61	A345	0	G	34,8	127,6	27

The max. composite stresses for the S4-proof in aboveground installation occur in

STR	ANR	PKT	SNR	KZ	Total stress [MPa]	Allowable stress [MPa]	Utilisation [%]
1	3	A020	0	G	36,9	301,3	12
1	6	A040	1	G	36,9	301,3	12
1	5	A030	1	G	35,9	301,3	12
1	4	T2	1	G	35,7	301,3	12
1	61	A345	0	G	34,9	301,3	12

2.2. Axial stress caused by friction

The maximum axial stress amounts to 100,7 MPa und occurs in line 1, section 34, section number 17

The allowable axial stress of 190,0 MPa is not exceeded.

3. Fix point table

Qu, Qv, Qw - Fixed point loads in kN
 Mu, Mv, Mw - Fixed point loads in kNm
 Qu-Np - Axial loads minus internal pressure in kN

STR	PKT	TYP	LF	wu pu	wv pv	ww pw	Qu Mu	Qv Mv	Qw Mw	Qu-Np
1	PS	FP	2	0,0	0,0	0,0	-51,80	0,00	3,02	394,28
				0,0	0,0	0,0	0,51	0,78	0,00	
			3	0,0	0,0	0,0	-337,99	0,00	3,02	-337,99
				0,0	0,0	0,0	0,16	0,78	0,00	

4. Bend table

wua,wva - Displacements at bend start in mm
 wvmax,wwmax - Maximum displacements in bend in mm
 wue,wve - Displacements at bend end in mm
 dSIGV - Reference stress range in N/mm₂ (or MPa)

STR	PKT	LF	wua	wva	wvmax	wwmax	wue	wve	dSIGV
1	B	2	46,3	-64,4	-82,4	1,4	-45,4	-64,8	
		3	2,9	-4,2	-5,4	0,1	-3,2	-4,0	439,8
1	A077	2	-43,5	-2,0	-2,0	-49,4	-43,4	0,5	
		3	-3,2	-0,1	0,1	-2,8	-3,2	0,1	129,4
1	C	2	56,1	-14,4	-54,6	0,2	-9,0	-51,2	
		3	7,8	-1,3	-7,4	-0,1	-0,9	-7,1	237,0
1	D	2	4,7	-77,4	-79,0	-0,4	-72,5	-37,5	
		3	-0,8	-9,6	-9,6	-0,1	-9,7	-3,2	379,4
1	E	2	64,0	-13,8	-62,0	-0,8	-9,3	-59,2	
		3	15,9	-1,1	-14,4	-0,3	-0,2	-14,1	195,7
1	F	2	7,8	-43,5	-45,8	-0,8	-43,4	-17,8	
		3	0,0	-2,0	-2,0	-0,1	-2,1	-0,3	224,2
1	G	2	47,2	-8,1	-43,7	-0,5	-3,0	-41,8	
		3	4,3	0,0	-3,7	-0,1	0,4	-3,7	221,2

STR	PKT	LF	wua	wva	wvmax	wwmax	wue	wve	dSIGV
1	H	2	2,1	2,5	-7,0	0,4	-2,1	-6,8	
		3	0,4	0,4	-0,5	0,0	0,0	-0,5	188,0
1	I	2	2,2	-5,7	-6,0	-0,8	-2,5	-0,7	
		3	0,0	-0,3	-0,3	0,0	-0,2	0,1	92,7
1	J	2	2,7	-16,3	-17,7	0,1	-17,5	-5,9	
		3	-0,2	-0,8	-0,8	0,0	-0,8	0,2	133,9