RIB DURO: Construction state

8.0 Reinforced concrete / reinforced concrete pressure pipe

Soil class:

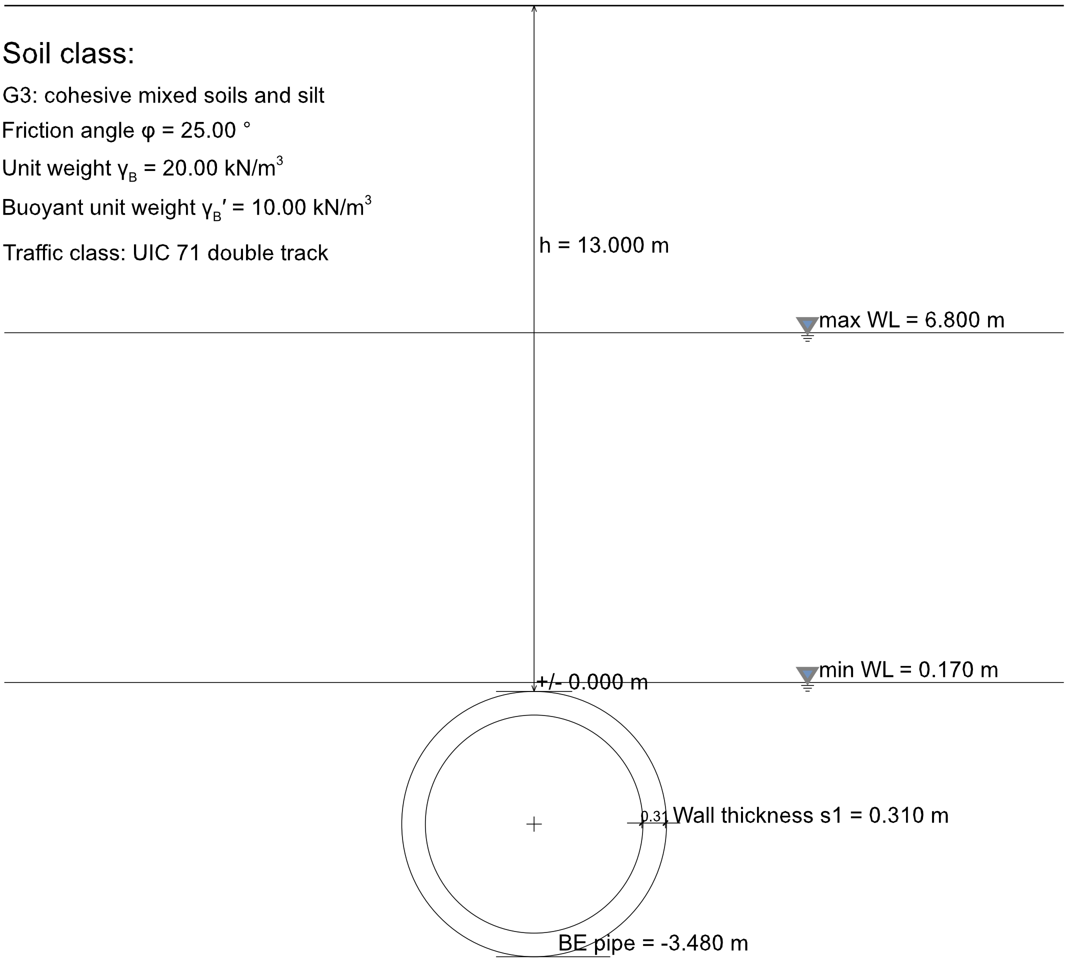
G3: cohesive mixed soils and silt

Friction angle φ = 25.00 °

Unit weight γ_B = 20.00 kN/m^3

Buoyant unit weight γ_B' = 10.00 kN/m^3

Traffic class: UIC 71 double track



RIB DURO: Operating state

8.0 Reinforced concrete / reinforced concrete pressure pipe

Soil class:

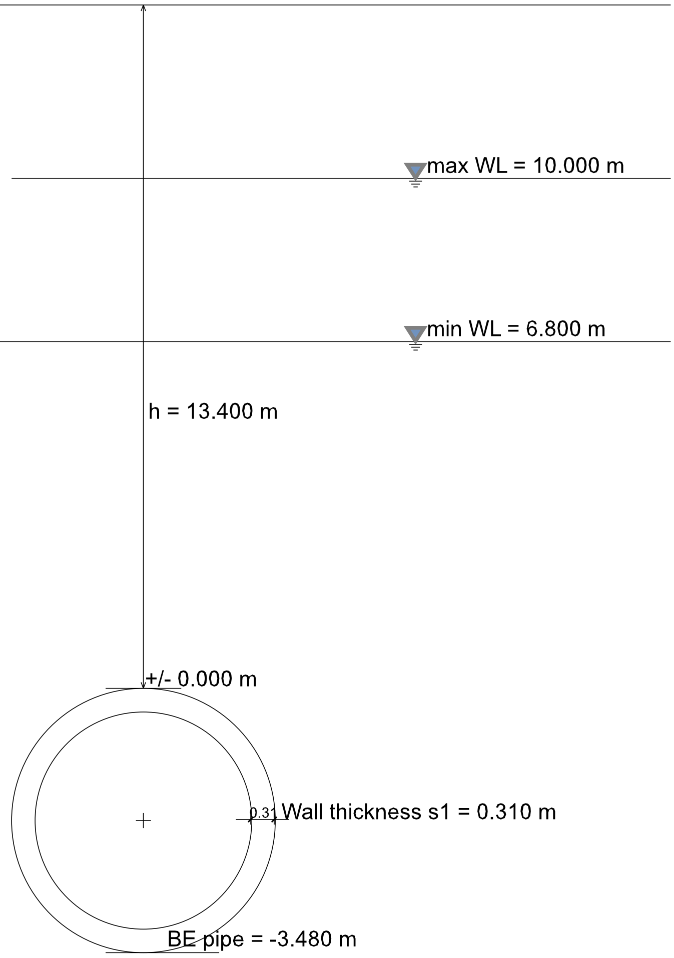
G3: cohesive mixed soils and silt

Friction angle φ = 25.00 °

Unit weight γ_B = 20.00 kN/m^3

Buoyant unit weight γ_B' = 10.00 kN/m^3

Traffic class: UIC 71 double track



```
BSP. A161 neu EC2 2-lagig C60/75


Check of minimum wall thickness acc. to DWA-A161: Tab.19 and 20
-----------------------------------------------------------------------
Outer diameter              Da =    3480.0 mm
Mean radius                 Rm =    1585.0 mm
Min. wall thickness      t.min =     249.0 mm
Exis. wall thickness t.exis =     310.0 mm
```

STRUCTURAL ANALYSIS OF JACKING PIPES

```
------------------------------------------------------------------------
Acc. to DVGW Merkblatt GW312 resp. DWA Arbeitsblatt A161, March 2014

Structural design calculation of jacking pipes of type
Reinforced concrete pressure pipe DIN EN 639 and DIN EN 640
------------------------------------------------------------------------
```

Record of input data:

```
------------------------------------------------------------------------
Dimensions and material data:

  Nominal diameter       DN 2900
  Outer diameter         Da =   3480 mm
  Inner diameter          Di =   2860 mm
  Wall thickness         t  =    310 mm

  Rebated depth in range of pipe connection:
  ext. delta.t =     50 mm
  int. delta.t =     50 mm
```

Reinforcement double-layer

```
  Circular reinforcement BSt 500
  int.As,ring  =   16.0 Diameter  12.0 mm/m ( 18.1 cm2/m)
  ext.As,ring  =   12.0 Diameter  12.0 mm/m ( 13.6 cm2/m)
  Longitudinal reinforcement
  int.As,long. =     30 Diameter   7.0 mm/Circumference
  ext.As,long. =     30 Diameter   7.0 mm/Circumference
  Concrete cover int.c-nom/ext.c-nom = 25/25 mm

W*** Dufo8a: Spacing of the long. reinf. too large acc. to DWA-A161/7.3
```

Material properties:

```
  Concrete (Strength class of concrete)        = C60/75
  Unit weight of pipe material  UnitWeight.R = 25.000 kN/m3
  Youngs modulus of the pipe              E.R =  38800 N/mm2
  Adm. comparable pipe stress sigma.VR,Rd =    7.5 N/mm2
  Fatigue strength of reinforcement
  delta.sigma,Rsk/gamma.s,fat (0.100E+09 Lastzyk) = 29.4 N/mm2
```

BSP. A161 neu EC2 2-lagig C60/75

Partial safety factors (PSF):

```
Design value for permanent actions    gamma.G      = 1.35
Design value for transient actions    gamma.Q      = 1.35
PS factor for concrete                gamma.c      = 1.50
PS factor for reinforcement steel     gamma.s      = 1.15
Factor for concrete strength decrease alpha.D      = 0.85
Bearing capacity coefficient          gamma.R      = 1.35
Used for fatigue analysis are:
PS factor for actions                 gamma.F,fat  = 1.00
PS factor for model insecurities      gamma.Ed,fat = 1.00
PS factor for reinforcement steel     gamma.s,fat  = 1.15
```

Pipe joints:

The planned jacking alignment is bent. The construction company ensures with the pipe and joint design, that the compressive stresses are transferred in the compression area of the joint even for a joint opening measure of 0.41
The DVGW/ATV guideline is valid only for straight jacking sections without gaping joints. Special considerations and calculations are required for gaping joints according to the guideline.
The minimum design stress resultants are increased by 0.0 %
for the present calculation of jacking pipes.

BSP. A161 neu EC2 2-lagig C60/75

MIN. REINFORCEMENT of jacking pipes acc. to DIN V 1201,
Section 5.3.7(2) as addition to DIN EN 1916

Minimum reinforcement as defined part of the concrete cross-section A-0,min, calculated from the minimum wall thickness acc. to DIN V 1201, Section 5.3.5.2

Mean pipe diameter: rm = (di + tmin)/2 = 1.554 m
Minimum wall thickness tmin, depending on the concrete strength fck and rm:
for tmin from the prerequisite tmin/rm = 0.16 follows tmin = 249 mm

Minimum concrete cross-section: A-0,min pro m 2490 cm2
Double-layer reinforcement:
Required minimum reinforcement outsde: 0.3 % of A-0,min
Required minimum reinforcement inside: 0.4 % of A-0,min

Section		Springline	Pipe crown	Pipe base
required	As,ring (cm2/m)	7.5	10.0	10.0
provided	As,ring (cm2/m)	13.6	18.1	18.1

MINIMUM DESIGN (Constraining forces in the construction state)

```
Sum M.Springing =  -45.0 * Rm2
Sum M.Crown     =   45.0 * Rm2
Sum M.Base      =   45.0 * Rm2
                                  z/da >= 0.41 < 1.0
Sum N.Springing = -270.0 * Rm
Sum N.Crown     = -135.0 * Rm
Sum N.Base      = -135.0 * Rm
```

BSP. A161 neu EC2 2-lagig C60/75

Section		Springline	Pipe crown	Pipe base
Cross-section values:				
Area	(cm2/m)	3575.01	3575.01	3575.01
Resistance moment	(cm3/m)	20132.23	20860.12	20860.12

Stress resultants

Moments	(kNm/m):			
Sum M.q = (total load)		-113.05	113.05	113.05

Normal forces	(kN/m):			
Sum N.q = (total load)		-427.95	-213.97	-213.97

BSP. A161 neu EC2 2-lagig C60/75

Design in condition II according to DIN EN 1992-1-1

with gamma.c = 1.50, gamma.s = 1.15, alpha.D = 0.85, gamma.R = 1.35
and fcd = 34.00

Section	Springline	Pipe crown	Pipe base
Wall thickness t / Depth d	310/272	310/279	310/279
DESIGN:			
Steel strain eps.s (0/00)	25.00	25.00	25.00
Conc. compres. eps.1 (0/00)	-2.76	-2.42	-2.42
Inner lever arm (cm)	26.20	27.00	27.00
required As,ring (cm2/m)	4.2	6.4	6.4
provided As,ring (cm2/m)	13.6	18.1	18.1

Pipe effective stress (sigma.VR) in condition I acc. to DIN V 1201 (N/mm2)
with gamma.G = 1.0, gamma.Q = 1.0 and gamma.R = 1.0

	Springline	Pipe crown	Pipe base
sigma.M =	4.160	4.014	4.014
sigma.N =	-0.887	-0.443	-0.443
sigma.N/sigma.M =	-0.213	-0.110	-0.110
Coefficient fR (DIN V 1201) =	0.987	1.079	1.079
existing sigma.VR,Ed =	3.231	3.852	3.852
admissi. sigma.VR,Rd =	7.543	7.543	7.543

Placing:
The assembly of the jacking pipes is done using the underground pipe jacking method. The jacking pipes are assembled behind a cutting tool in the jacking shaft and pushed into place by jacking force.
For the transfer of the jacking forces, wooden compensating rings are placed into the joints. Pressure sleeves are placed at the pipe joints for the guidance of the pipes.
The surveying and exact control as well as accurate soil excavation are requirements to get reliable results.
For the placing must be considered:
DVGW Merkblatt W304 resp. ATV Arbeitsblatt A125: Pipe jacking and related methods

OBSERVE ASSEMBLY SPECIFICATIONS:

Prerequisite for the usefulness of the following jacking pipe design results are
- A permanent bentonite lubrication during the jacking works
- as well as a grouting of the annulus area between jacking pipe and soil after finishing the jacking.

```
Soil and jacking data in the construction state
-----------------------------------------------------------------------
```

SOIL DATA:

```
---------
Decisive soil type according to GW312/A161-Tab.1: soil group G3

The soil groups signify
 Group 1: non-cohesive sands and gravel
 Group 2: slightly cohesive sands and gravel
 Group 3: cohesive mixed soils and silt
 Group 4: cohesive soils

Pipe jacking in loose sediments
with support angle                2alpha =   180 Deg.
Unit weight above water Gamma-numerical  = 20.00 kN/m3
Unit weight below water Gamma-buoyancy   = 10.00 kN/m3

EarthPressure ratio above pipe crown K1  =  0.700
    below pipe crown K2 in constr. state =  0.400
Angle of internal friction          Phi' =  25.00 Deg.
Friction angle in the shear joint   Del' =   0.00 Deg.
Consistency     in constr. state    I.c  =  0.40
1. Factor for deform. modulus         f1 =  0.10
2. Factor for deform. modulus  in CS  f2 =  1.00
Deformation module in constr. state  E.B =   5.17 N/mm2

Reduction factor for arching in the constr. state Kappa = 1.000
Reduction factor for arching
        under loading in the construction state Kappa.0 = 1.000
```

CALCULATION OF THE CONSTRUCTION STATE (CS)

```
Load assumptions:
  Soil cover height                h  = 13.00 m
  Traffic load type                   = LM 71 - multiple-track
  Maximum ground water level max GW =   6.80 m above Pipe crown
  Minimum ground water level min GW =   0.17 m above Pipe crown
  Internal overpressure            int.pe =   1.03 bar
  Pipe empty
```

LOAD DATA

```
Soil loads with buoyancy
          Averaged over the loading height
          Unit weight of soil       =  19.9 kN/m3
          Vertical earth load    ev = 322.9 kN/m2
          Surcharge              p0 =   0.0 kN/m2
          Horizon. earth load    eh = 136.1 kN/m2
Traffic loads
          Traffic load          p   =  15.00 kN/m2
          Impact coefficientwir.phi =   1.10
          Impact coefficient   phi0 =   1.10
          statically acting     pV  =  16.5 kN/m2
          statically acting     pH  =   6.3 kN/m2

Maximum total loading           qv  = 339.4 kN/m2
                                qh  = 142.4 kN/m2
```

BSP. A161 neu EC2 2-lagig C60/75

Section		Springline	Pipe crown	Pipe base
Cross-section values:				
Area	(cm2/m)	3575.01	3575.01	3575.01
Resistance moment	(cm3/m)	20132.23	20860.12	20860.12

Stress resultants acc. to section 7 and 8

Moments (kNm/m):	Springline	Pipe crown	Pipe base
M.G = (Dead load)	-8.508	7.476	13.746
M.w = (WaterCont./Groundw.)	0.000	0.000	0.000
M.ev = (Soil load vertical)	-135.459	135.459	135.459
M.eh = (SoilLoad horizontal)	57.104	-57.104	-57.104
M.pV = (Live load vertical)	-10.363	10.363	10.363
M.pH = (LiveLoad horizontal)	3.957	-3.957	-3.957
M.pe = (Excess pressure)	0.805	0.805	0.805
M.auf= (Buoyancy)	8.720	-7.645	-14.056
Sum M.q = (total load)	-83.745	85.398	85.256
M.Gk (Sum permanent load)	-77.339	78.992	78.850
M.Qk (Sum variable load)	-6.406	6.406	6.406
M.Gd=gamma.G*M.Gk=1.35*M.Gk	-104.407	106.639	106.448
M.Qd=gamma.Q*M.Qk=1.35*M.Qk	-8.648	8.648	8.648
M.Ed = M.Gd + M.Qd	-113.055	115.287	115.096

Normal forces (kN/m):	Springline	Pipe crown	Pipe base
N.g = (Dead load)	-19.298	3.071	-17.541
N.w = (WaterCont./Groundw.)	0.000	0.000	0.000
N.ev = (Soil load vertical)	-341.342	-170.415	-170.415
N.eh = (SoilLoad horizontal)	-71.840	-143.895	-143.895
N.pV = (Live load vertical)	-26.152	0.000	0.000
N.pH = (LiveLoad horizontal)	0.000	-9.985	-9.985
N.pe = (Excess pressure)	144.332	144.332	144.332
N.auf= (Buoyancy)	-5.401	-15.701	-19.746
Sum N.q = (total load)	-319.701	-192.594	-217.251
N.Gk (Sum permanent load)	-293.548	-182.608	-207.265
N.Qk (Sum variable load)	-26.152	-9.985	-9.985
N.Gd=gamma.G*N.Gk=1.35*N.Gk	-396.290	-246.521	-279.808
N.Qd=gamma.Q*N.Qk=1.35*N.Qk	-35.306	-13.480	-13.480
N.Ed = N.Gd + N.Qd	-431.596	-260.002	-293.288

BSP. A161 neu EC2 2-lagig C60/75

Design in condition II according to DIN EN 1992-1-1

with gamma.c = 1.50, gamma.s = 1.15, alpha.D = 0.85, gamma.R = 1.35
and fcd = 34.00

Section	Springline	Pipe crown	Pipe base
Wall thickness t / Depth d	310/272	310/279	310/279
DESIGN:			
Steel strain eps.s (0/00)	25.00	25.00	25.00
Conc. compres. eps.1 (0/00)	-2.76	-2.52	-2.56
Inner lever arm (cm)	26.20	27.00	27.00
required As,ring (cm2/m)	4.1	6.1	5.7
provided As,ring (cm2/m)	13.6	18.1	18.1

Pipe effective stress (sigma.VR) in condition I acc. to DIN V 1201 (N/mm2)
with gamma.G = 1.0, gamma.Q = 1.0 and gamma.R = 1.0

	Springline	Pipe crown	Pipe base
sigma.M =	4.160	4.094	4.087
sigma.N =	-0.894	-0.539	-0.608
sigma.N/sigma.M =	-0.215	-0.132	-0.149
Coefficient fR (DIN V 1201) =	0.986	1.061	1.046
existing sigma.VR,Ed =	3.218	3.770	3.638
admissi. sigma.VR,Rd =	7.543	7.543	7.543

Stability verification for CS not applicable

Soil and jacking data in the operation state

SOIL DATA:

Decisive soil type according to GW312/A161-Tab.1: soil group G3

The soil groups signify
- Group 1: non-cohesive sands and gravel
- Group 2: slightly cohesive sands and gravel
- Group 3: cohesive mixed soils and silt
- Group 4: cohesive soils

Pipe jacking in loose sediments
with support angle 2alpha = 180 Deg.
Unit weight above water Gamma-numerical = 20.00 kN/m3
Unit weight below water Gamma-buoyancy = 10.00 kN/m3

BSP. A161 neu EC2 2-lagig C60/75

```
EarthPressure ratio above pipe crown K1  =  0.700
  below pipe crown K2 in operation state =  0.500
Angle of internal friction          Phi' =  25.00 Deg.
Friction angle in the shear joint   Del' =   0.00 Deg.
Consistency     in operating state  I.c  =  0.40
1. Factor for deform. modulus         f1 =  0.10
2. Factor for deform. modulus  in OS  f2 =  1.00
Deformation module in operat. state  E.B =   4.00 N/mm2

Reduction factor for arching in the operation state Kappa = 1.000
Reduction factor for arching
             under loading in the operation state Kappa.0 = 1.000
```

BSP. A161 neu EC2 2-lagig C60/75

```
CALCULATION OF THE OPERATIONAL STATE (OS)
------------------------------------------------------------------------

Load assumptions:
  Soil cover height               h  = 13.40 m
  Traffic load type                  = LM 71 - multiple-track
  Maximum ground water level max GW =  10.00 m above Pipe crown
  Minimum ground water level min GW =   6.80 m above Pipe crown
  Internal overpressure           int.pe =   1.32 bar
```

LOAD DATA

```
------------------------------------------------------------------------
Soil loads with buoyancy
          Averaged over the loading height
          Unit weight of soil         =  14.9 kN/m3
          Vertical earth load     ev = 200.0 kN/m2
          Surcharge               p0 =   0.0 kN/m2
          Horizon. earth load     eh = 108.7 kN/m2
Traffic loads
          Traffic load           p   =  15.00 kN/m2
          Impact coefficientwir.phi =   1.10
          Impact coefficient   phi0 =   1.10
          statically acting      pV  =  16.5 kN/m2
          statically acting      pH  =   7.9 kN/m2

Maximum total loading            qv  = 216.5 kN/m2
                                 qh  = 116.6 kN/m2
```

BSP. A161 neu EC2 2-lagig C60/75

Section		Springline	Pipe crown	Pipe base
Cross-section values:				
Area	(cm2/m)	3575.01	3575.01	3575.01
Resistance moment	(cm3/m)	20132.23	20860.12	20860.12

Stress resultants acc. to section 7 and 8

Moments	(kNm/m):	Springline	Pipe crown	Pipe base
M.G = (Dead load)		-8.508	7.476	13.746
M.w = (WaterCont./Groundw.)		-8.720	7.645	14.056
M.ev = (Soil load vertical)		-125.611	125.611	125.611
M.eh = (SoilLoad horizontal)		68.270	-68.270	-68.270
M.pV = (Live load vertical)		-10.363	10.363	10.363
M.pH = (LiveLoad horizontal)		4.946	-4.946	-4.946
M.pe = (Excess pressure)		0.509	0.509	0.509
M.auf= (Buoyancy)		8.720	-7.645	-14.056
Sum M.q = (total load)		-70.758	70.743	77.013
M.Gk (Sum permanent load)		-65.341	65.326	71.596
M.Qk (Sum variable load)		-5.417	5.417	5.417
M.Gd=gamma.G*M.Gk=1.35*M.Gk		-88.211	88.191	96.654
M.Qd=gamma.Q*M.Qk=1.35*M.Qk		-7.313	7.313	7.313
M.Ed = M.Gd + M.Qd		-95.524	95.504	103.967

Normal forces	(kN/m):	Springline	Pipe crown	Pipe base
N.g = (Dead load)		-19.298	3.071	-17.541
N.w = (WaterCont./Groundw.)		5.401	15.701	19.746
N.ev = (Soil load vertical)		-317.000	0.000	0.000
N.eh = (SoilLoad horizontal)		0.000	-172.289	-172.289
N.pV = (Live load vertical)		-26.152	0.000	0.000
N.pH = (LiveLoad horizontal)		0.000	-12.482	-12.482
N.pe = (Excess pressure)		70.440	70.440	70.440
N.auf= (Buoyancy)		-5.401	-15.701	-19.746
Sum N.q = (total load)		-292.010	-111.260	-131.873
N.Gk (Sum permanent load)		-265.858	-98.779	-119.391
N.Qk (Sum variable load)		-26.152	-12.482	-12.482
N.Gd=gamma.G*N.Gk=1.35*N.Gk		-358.908	-133.351	-161.177
N.Qd=gamma.Q*N.Qk=1.35*N.Qk		-35.306	-16.851	-16.851
N.Ed = N.Gd + N.Qd		-394.214	-150.202	-178.028

BSP. A161 neu EC2 2-lagig C60/75

Design in condition II according to DIN EN 1992-1-1
with gamma.c = 1.50, gamma.s = 1.15, alpha.D = 0.85, gamma.R = 1.35
and fcd = 34.00

Section	Springline	Pipe crown	Pipe base
Wall thickness t / Depth d	310/272	310/279	310/279
DESIGN:			
Steel strain eps.s (0/00)	25.00	25.00	25.00
Conc. compres. eps.1 (0/00)	-2.49	-2.12	-2.26
Inner lever arm (cm)	26.30	27.10	27.10
required As,ring (cm2/m)	3.1	5.7	6.1
provided As,ring (cm2/m)	13.6	18.1	18.1

Pipe effective stress (sigma.VR) in condition I acc. to DIN V 1201 (N/mm2)
with gamma.G = 1.0, gamma.Q = 1.0 and gamma.R = 1.0

sigma.M =	3.515	3.391	3.692
sigma.N =	-0.817	-0.311	-0.369
sigma.N/sigma.M =	-0.232	-0.092	-0.100
Coefficient fR (DIN V 1201) =	0.969	1.094	1.088
existing sigma.VR,Ed =	2.615	3.371	3.614
admissi. sigma.VR,Rd =	7.543	7.543	7.543

Stability verification for OS not applicable

BSP. A161 neu EC2 2-lagig C60/75

```
Admissible jacking force F.j according to DWA-A 161: 2013
-----------------------------------------------------------------------

Initial data:
------------

Segment number:
Calculaton of   1. segment = 1. arc of range after hydraulic jack

Alignment geometry:
The alignment segment is a circular arc with radius 5000.00 [m]
Transition arcs exist.
It is not a matter of pilot pipe jacking.

Pipe geometry:
Length of indiviudal pipe = 3.000 [m]
Outer diameter    Da = 3480.0, smallest  da.min = 3380.0 [mm]
Inner diameter    Di = 2860.0, largest   di.max = 2960.0 [mm]
Wall thickness     t = 0.3100, smallest   t.min = 0.2100 [m]
                             at the spigot end t.ror = 0.2100 [m]
minimum area          A.R = 2.0914 [m2]

Pipe material:
E-modulus in axial dir.  E.axl =  36800.0 [N/mm2]
Long. compres. strength    f.k =     60.0 [N/mm2]
Mean tensile strength                f.tm =      4.1 [N/mm2]
Numerical strength value              f.d =     44.4 [N/mm2]
Partial safety factor for axial member resistance   Gamma.M.axl =  1.35

Pressure transfer ring (DUER):
Number of DUERs per pipe joint           n_duer = 1
DUER Outer diameter                     Da.duer =   3380. [mm]
Dist.DUER to pipe, outside, min         a.a =       0. [mm]
DUER Inner diameter                Di.duer =   2960. [mm]
Dist.DUER to pipe, inside, max          a.i =       0. [mm]
DUER-Width                          t.duer =   0.210 [m]
DUER-Area                           A.duer =   2.091 [m2]
1. DUER: Material no.  1,  Thickness s_d() =    30.0 [mm]
Specified initial loading = 30. % is preferential if > 0

Execution of construction work:
Partial safety factor for actions with longitudinal loading along the
axis and transient design situation (Tab. 12) gamma.f.axl = 1.15
Jacking force, estimated V_estim =  10000. [kN]
Measured or assured angular tolerances if >= 0: none entered
```

BSP. A161 neu EC2 2-lagig C60/75

Calculation

```
----------
Angular dev. due to alignment curvature  phi.R   =  0.000 [Degree]
Angular deviation due to control motions phi.St0 =  0.152 [Degree]
                                         phi.St  =  0.211 [Degree]

Maximum deviation of the pipe crown
from perpendicularity                          d.a.cal =   10.0 [mm]
hence bending due to fabrication tolerance phi.d.a.cal =  0.170 [Degree]
Calculated total bending per joint         phi.ges     =  0.305 [Degree]

(Distance between DUER and pipe wall)/t.min:
outsde a.a/t.min = at.a =  0.0000 [mm]
inside a.i/t.min = at.i =  0.0000 [mm]
average             at.m =  0.0000 [mm]
Coefficient acc. to fig. 15 kappa.R1 =  0.0000
Coefficient acc. to fig. 16 kappa.R2 =  0.0000
Maximum coefficient         kappa.R  =  0.0000
Coeff. for max.adm.Sigma     alfa.DT =  1.0000
t.Rohr.min/t.DUER            kappa.t =  1.0000
max.adm.Sigma in the pipe   sigm_cal =   44.44 [N/mm2]

Compressive stress in pipe  sigm.max =   44.44 [N/mm2]
Coefficient                 alfa.b   =  0.8116
Coefficient                 alfa.phi =  0.0000
Deformation factor          kappa.ab =  0.5000
Deformation of the pipe     delta.sR =  1.81 [mm]
```

BSP. A161 neu EC2 2-lagig C60/75

```
Iteration n_iter =  0: *********************************
Uniformly distributed stress   sig0.DUER =   4.78 [N/mm2]
Decisive preloading stress        sig1    =  13.33 [N/mm2]
DUER preloading VBi
in percent of sigm.cal:           VBi =  30.00 [%]
inputted VBi (may not be fallen below) = 30.00 [%]
The calculation is performed with VBi =  30.00 [%]
DUER Nr.                            1
Thickness                       30.00 [mm]
Material                   Solid wood
E-Modulus                     1148.50 [N/mm2]
linear reference modulus       225.93 [N/mm2]
Deformation quotient             5.90
DUER total deformation  delta.sD =  5.9 [mm]
Joint gaping dimension       z_k =  0.429 von 1.0
Integral                         =  0.2073 [m2]
Ratio of sigm.max to sigm.0  = smaxds0 =  5.04
Estimated jacking force         V_estim = 10000.0 [kN]
Admissible jacking force       adm. F.j = 16022.8 [kN]

Iteration n_iter =  1: *********************************
Uniformly distributed stress   sig0.DUER =   6.22 [N/mm2]
Decisive preloading stress        sig1    =  13.33 [N/mm2]
DUER preloading VBi
in percent of sigm.cal:           VBi =  30.00 [%]
The calculation is performed with VBi =  30.00 [%]
DUER Nr.                            1
Thickness                       30.00 [mm]
Material                   Solid wood
E-Modulus                     1148.50 [N/mm2]
linear reference modulus       225.93 [N/mm2]
Deformation quotient             5.90
DUER total deformation  delta.sD =  5.9 [mm]
Joint gaping dimension       z_k =  0.429 von 1.0
Integral                         =  0.2073 [m2]
Ratio of sigm.max to sigm.0  = smaxds0 =  5.04
Estimated jacking force         V_estim = 13011.4 [kN]
Admissible jacking force       adm. F.j = 16022.8 [kN]
```

BSP. A161 neu EC2 2-lagig C60/75

```
Iteration n_iter =  2: **********************************
Uniformly distributed stress   sig0.DUER =   7.66 [N/mm2]
Decisive preloading stress        sig1   =  15.32 [N/mm2]
DUER preloading VBi
in percent of sigm.cal:           VBi =  34.48 [%]
The calculation is performed with VBi =  34.48 [%]
DUER Nr.                         1
Thickness                    30.00 [mm]
Material               Solid wood
E-Modulus                  1330.35 [N/mm2]
linear reference modulus    243.16 [N/mm2]
Deformation quotient          5.48
DUER total deformation  delta.sD =  5.5 [mm]
Joint gaping dimension       z_k =  0.406 von 1.0
Integral                         =  0.1990 [m2]
Ratio of sigm.max to sigm.0  = smaxds0 =  5.25
Estimated jacking force        V_estim = 16022.8 [kN]
Admissible jacking force       adm. F.j = 15382.8 [kN]

Iteration n_iter =  3: **********************************
Uniformly distributed stress   sig0.DUER =   7.51 [N/mm2]
Decisive preloading stress        sig1   =  15.02 [N/mm2]
DUER preloading VBi
in percent of sigm.cal:           VBi =  33.79 [%]
The calculation is performed with VBi =  33.79 [%]
DUER Nr.                         1
Thickness                    30.00 [mm]
Material               Solid wood
E-Modulus                  1298.60 [N/mm2]
linear reference modulus    240.24 [N/mm2]
Deformation quotient          5.55
DUER total deformation  delta.sD =  5.5 [mm]
Joint gaping dimension       z_k =  0.409 von 1.0
Integral                         =  0.2003 [m2]
Ratio of sigm.max to sigm.0  = smaxds0 =  5.22
Estimated jacking force        V_estim = 15702.8 [kN]
Admissible jacking force       adm. F.j = 15485.9 [kN]
```

```
Iteration n_iter =  4: **********************************
Uniformly distributed stress   sig0.DUER =   7.46 [N/mm2]
Decisive preloading stress        sig1   =  14.91 [N/mm2]
DUER preloading VBi
in percent of sigm.cal:           VBi =  33.55 [%]
The calculation is performed with VBi =  33.55 [%]
DUER Nr.                         1
Thickness                    30.00 [mm]
Material               Solid wood
E-Modulus                  1288.15 [N/mm2]
linear reference modulus    239.27 [N/mm2]
Deformation quotient          5.57
DUER total deformation  delta.sD =  5.6 [mm]
Joint gaping dimension       z_k =  0.411 von 1.0
Integral                         =  0.2008 [m2]
Ratio of sigm.max to sigm.0  = smaxds0 =  5.21
Estimated jacking force        V_estim = 15594.4 [kN]
Admissible jacking force       adm. F.j = 15520.6 [kN]

Iteration n_iter =  5: **********************************
Uniformly distributed stress   sig0.DUER =   7.44 [N/mm2]
Decisive preloading stress        sig1   =  14.88 [N/mm2]
DUER preloading VBi
in percent of sigm.cal:           VBi =  33.48 [%]
The calculation is performed with VBi =  33.48 [%]
DUER Nr.                         1
Thickness                    30.00 [mm]
Material               Solid wood
E-Modulus                  1284.63 [N/mm2]
linear reference modulus    238.95 [N/mm2]
Deformation quotient          5.58
DUER total deformation  delta.sD =  5.6 [mm]
Joint gaping dimension       z_k =  0.411 von 1.0
Integral                         =  0.2009 [m2]
Ratio of sigm.max to sigm.0  = smaxds0 =  5.20
Estimated jacking force        V_estim = 15557.5 [kN]
Admissible jacking force       adm. F.j = 15532.3 [kN]
```

BSP. A161 neu EC2 2-lagig C60/75

```
Result after  5 iterations:
Estimated jacking force       VPRES    = 10000.0 [kN]
Admissible jacking force     adm. F.j = 15532.3 [kN]
Joint gaping dimension            z_k =    0.411 von 1.0
DUER preloading V                 VBi =    33.48 [%]
-----------------------------------------------------------------------
```

Steel weight without additions for socket or steel cutoff

```
Hoops                                                246.1 kg/m
Longitudinal reinforcement                                        18.1 kg/m
----------------------------------------------------------
Entire reinforcement                                      264.2 kg/m
----------------------------------------------------------

Number of errors: W =  1, E =  0, F =  0

Program Duro: End of calculation of _DURO.DUR
-----------------------------------------------------------------------
```