**CALCULATION OF FLANGE CONNECTIONS ACCORDING TO RtoD D0701**

Calculation made with CodeX

RTOD Issue 05-09

**Name** : AKZO 4" 150# node 2040

**Order n°** : 03110.16.1409.5001

**Description** : Linenr 4"-8"-ES16-33.023

**Type of flange : 3.1 Flange with conical hub**

**Flange material:**

Code : ASME II Part D SA-105

Name : SA-105 (K03504)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **t(°C)** | **Rtp0.2** | **Rtp1.0** | **Rtm** | **Rtmg/100k** |  |
| 20.00 | 248.211 | 0.000 | 482.633 | 0.000 | **N/mm²** |
| 150.00 | 220.000 | 0.000 | 482.633 | 0.000 | **N/mm²** |

Min( 1.25·Re ; 0.84·Rm ) ffm (D0701) = 310.264 N/mm²

Min( 1.15·Re ; 0.77·Rm ) fft (D0701) = 285.443 N/mm²

Min( Re(vm); 0.67·Rm; Rmg ) ffw (D0701) = 220.000 N/mm²

**Flange dimensions**

Outside diameter of flange Df = 230.00 mm

Inside diameter of cylindrical part Di = 102.26 mm

Flange width bf = 63.87 mm

Thickness of flange df = 22.20 mm

Diameter of bolt circle Dfl = 190.50 mm

Diameter of bolt hole Df2 = 19.10 mm

Wall thickness of cylindrical part df1 = 6.02 mm

Thickness of hub at back of flange df2 = 16.35 mm

Height of the conical hub h = 52.40 mm

Length of cylindrical part l1,fl = 0.00 mm

**Allowance (Di/df1/df2)**

Tolerance = 0.000 mm

Internal corrosion = 1.000 mm

External corrosion = 0.000 mm

**Allowance (Df)**

Tolerance = 0.000 mm

Corrosion = 0.000 mm

**Bolt material:** SA-193 B7 (<= 2 1/2) (G41400) ASME II Part D SA-193

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **t(°C)** | **Rtp0.2** | **Rtp1.0** | **Rtm** | **Rtmg/100k** |  |
| 20.00 | 723.949 | 0.000 | 861.845 | 0.000 | **N/mm²** |
| 150.00 | 453.000 | 0.000 | 861.845 | 0.000 | **N/mm²** |

Min( 0.79·Re ; 0.59·Rm ) fbm (D0701) = 508.488 N/mm²

Min( 0.72·Re ; 0.54·Rm ) fbt (D0701) = 465.396 N/mm²

Min( 0.63·Re(vm); 0.47·Rm; 0.63·Rmg fbw (D0701) = 285.390 N/mm²

**Bolt dimensions**

Nominal thread diameter of bolt Ddb = 15.88 mm

Boltdiameter at root of the thread Dbk = 12.70 mm

Boltdiam. smallest cross-sect. area Dbmin = 12.70 mm

Number of bolts nb = 8

**The bolts are tightened in a controlled way**

**Pipe material:** SA-106 B (K03006) ASME II Part D SA-106

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **t(°C)** | **Rtp0.2** | **Rtp1.0** | **Rtm** | **Rtmg/100k** |  |
| 20.00 | 241.316 | 0.000 | 413.685 | 0.000 | **N/mm²** |
| 150.00 | 198.000 | 0.000 | 413.685 | 0.000 | **N/mm²** |

Min( f1; f2 ; f3 ; f4 ) f (D0201) = 132.660 N/mm²

Min( 0.67·Re(vm) ; 0.44·Rm ) f1 (D0201) = 132.660 N/mm²

Min( 1.25·Re ; 0.84·Rm ) fcm (D0701) = 301.646 N/mm²

Min( 1.15·Re ; 0.77·Rm ) fct (D0701) = 277.514 N/mm²

Min( Re(vm); 0.67·Rm; Rmg ) fcw (D0701) = 198.000 N/mm²

**Pipe dimensions**

Outside diameter of pipe Dep,nom = 114.30 mm

Wall thickness of pipe dp,nom = 6.02 mm

Length of pipe l1,p = 1000.00 mm

Strength reduction coefficient z = 1.00 -

Allowance:

Internal corrosion CAint = 0.00 mm

Tolerance Tol = 0.00 mm

**Gasket**

**Type of gasket: soft flat gasket / reinforced graphite,5dg<=bg<7.5dg**

Outside diameter of gasket Do = 157.20 mm

Gasket contact width bg = 21.50 mm

Diameter of effective sealing circle Dg = 135.70 mm

Gasket factor cg = 1.30 -

Maximum temperature of gasket Tmax = 500.00 °C

Minimum pressure to seat the gasket Pgm;min = 15.00 N/mm²

Maximum pressure to seat the gasket Pgm;max = 100.00 N/mm²

Maximum operating gasket pressure Pgw;max = 100.00 N/mm²

Optimal pressure to seat the gasket Pgm;opt = 15.00 N/mm²

**Calculation of flange connections (D0701)**

Description : Case 1

Design condition : Operating

Design pressure Pd = 0.30 MPa

Test pressure Pt = 4.20 bar

Design temperature T = 150.00 °C

**Influence of external loadings are taken into account for operating only.**

External Force Fe = 0.00 N

External Moment Me = 2000000.00 N·mm

Calculation in **corroded** condition.

**Forces in flange connection (section 2):**

**Cylindrical part Internal pressure Gasket force**

Gasket seating F1m = 0.00 N F2m = 0.00 N F3m = 137486.30 N

Testing F1t = 3585.71 N F2t = 2488.63 N F3t = 5004.50 N

Operating F1w = 44555.97 N F2w = 1777.59 N F3w = 4289.57 N

**Reaction force F1 used for the calculation of the wallthickness of the cylindrical part d1 in Section 3:**

Gasket seating F1m,d1 = 0.00 N

Testing F1t,d1 = 3585.71 N

Operating F1w,d1 = 75767.66 N

**Reaction force F1 used for the calculation of the radial bending moment M in point 3.1.1:**

Gasket seating F1m.M = 0.00 N

Testing F1t,M = 3585.71 N

Operating F1w,M = 23835.99 N

**Koves factor**

Gasket seating Kvm = 1.00 -

Testing Kvt = 1.00 -

Operating Kvw = 3.02 -

**Gasket seating force Bolt force**

F3m,1 = 137486.30 N Minimum bolt force F4m\* = 564741.24 N

F3m,2 = 12186.72 N Design load F4m = 233726.71 N

F3m,3 = 60747.76 N

F3m taken as the greater of these 3 values:

F3m = 137486.30 N

**Moment and section modulus (section 3):**

**Radial bending moment Tangential bending moment**

Gasket seating Mm = 599556.53 N·mm MCCm = 3817994.68 N·mm

Testing Mt = 58964.99 N·mm MCCt = 307659.34 N·mm

Operating Mw = 182740.40 N·mm MCCw = 1405804.47 N·mm

Extra testing Mt\* = 1029897.95 N·mm MCCt\* = 6490590.74 N·mm

**Section moduli** **(calculated with actual thickness df = 22.20 mm)**

**Against radial bending:**

Gasket seating WAAm = 15559.46 mm³ WBBm = 6107.41 mm³

Testing WAAt = 15559.45 mm³ WBBt = 6107.39 mm³

Operating WAAw = 15532.70 mm³ WBBw = 6095.02 mm³

Extra testing WAAt\* = 16568.93 mm³ WBBt\* = 7319.12 mm³

**Against tangential bending:**

WCC = 34826.48 mm³

**Cylindrical part**

Minimum thickness dpmin = 0.13 mm **OK**

Minimum length l1min = 18.74 mm 0.8√(df1·(Di+df1))

Length l1 = 1000.00 mm

Correction factor (max = 1.0) Design stress fc

Gasket seating cfm = 0.97 fcm = 301.65 N/mm²

Testing cft = 0.97 fct = 277.51 N/mm²

Operating cfw = 0.90 fcw = 198.00 N/mm²

**Miscellaneous results**

Calculation outside diameter Df = 230.00 mm

Calculation inside diameter Di = 104.26 mm

Calculation width of flange bf = 62.87 mm

calculation thickness of cyl. part df1 = 5.02 mm

Calculation thickness of hub df2 = 15.35 mm

Reduced bolthole diameter D\*f2 = 17.11 mm

**Areas**

Contrib. area flange A1 = 1015.90 mm² df·(bf-D\*f2)

Contrib. area conicalpart hub A2 = 270.65 mm² (h/2)·(df2-df1)

Contrib. area cylindricalpart hub A3 = 263.05 mm² h·df1

Dist.neutral line to sealing face s = 22.42 mm (A1·(df1/2)+A2·(df+h/3)+A3·(df+h/2))/(A1+A2+A3)

**Part of wallthickness of the cylindrical part reserved to absorb axial force F1**

Gasket seating d1m = 0.00 mm

Operating d1w = 1.11 mm

Testing d1t = 0.04 mm

**Assessment of flange stress according D0701 section 4.1:**

Irregularity factor cb = 1.11 (Minimum value = 1.00)

**AA BB CC Design stress ff**

m 42.88 **OK**  109.25 **OK**  122.01 **OK**  310.26 N/mm²

w 13.09 **OK**  33.37 **OK**  44.92 **OK**  220.00 N/mm²

t 4.22 **OK**  10.74 **OK**  9.83 **OK**  285.44 N/mm²

**Assessment of shape stability according D0701 section 4.2:**

**AA BB CC Allowable 1.35\*Re**

t\* 69.18 **OK**  156.60 **OK**  207.41 **OK**  335.09 N/mm²

Fibre distance s1 = 26.10 mm

Calculated elastic rotation  = 0.19° (May not exceed 1°)**OK**

Minimum thickness of the flange df,min = 17.80 mm

**Assessment of the bolts (section 5)**

**b Design stress fb**

m 135.71 508.49 N/mm² **OK**

w 49.97 285.39 N/mm² **OK**

t 10.94 465.40 N/mm² **OK**

Cross section area at root of thread Abk = 126.64 mm²

Smallest cross-sectional area of bolt Abmin = 126.64 mm²

Minimum number of bolts for this condition nb,min = 4 **OK**

The bolts are tightened in a controlled way

**Assessment of the gasket (section 6)**

Gasket pressure Pg = 25.50 N/mm²

Minimum required gasketpressure seating Pgm:min = 15.00 N/mm²

Maximum allowed gasketpressure operating Pgw:max = 100.00 N/mm²

For the gasket seating condition following must be satisfied:

F3m

-──────  Pg  Pgm:max N/mm²

\*Dg\*bg

15.00  25.50  100.00 N/mm²

**Conclusion:**

**The design according RTOD D0701 is satisfactory.**

**CALCULATION OF FLANGE CONNECTIONS ACCORDING TO RtoD D0701**

Calculation made with CodeX

RTOD Issue 05-09

**Name** : AKZO 3" 300# node 2140

**Order n°** : 03110.16.1409.5001

**Description** : Linenr 4"-HS16-33.022

**Type of flange : 3.1 Flange with conical hub**

**Flange material:**

Code : ASME II Part D SA-105

Name : SA-105 (K03504)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **t(°C)** | **Rtp0.2** | **Rtp1.0** | **Rtm** | **Rtmg/100k** |  |
| 20.00 | 248.211 | 0.000 | 482.633 | 0.000 | **N/mm²** |
| 265.00 | 199.200 | 0.000 | 482.633 | 0.000 | **N/mm²** |

Min( 1.25·Re ; 0.84·Rm ) ffm (D0701) = 310.264 N/mm²

Min( 1.15·Re ; 0.77·Rm ) fft (D0701) = 285.443 N/mm²

Min( Re(vm); 0.67·Rm; Rmg ) ffw (D0701) = 199.200 N/mm²

**Flange dimensions**

Outside diameter of flange Df = 209.55 mm

Inside diameter of cylindrical part Di = 77.92 mm

Flange width bf = 65.81 mm

Thickness of flange df = 26.99 mm

Diameter of bolt circle Dfl = 168.28 mm

Diameter of bolt hole Df2 = 22.23 mm

Wall thickness of cylindrical part df1 = 5.49 mm

Thickness of hub at back of flange df2 = 19.78 mm

Height of the conical hub h = 50.80 mm

Length of cylindrical part l1,fl = 0.00 mm

**Allowance (Di/df1/df2)**

Tolerance = 0.000 mm

Internal corrosion = 1.000 mm

External corrosion = 0.000 mm

**Allowance (Df)**

Tolerance = 0.000 mm

Corrosion = 0.000 mm

**Bolt material:** SA-193 B7 (<= 2 1/2) (G41400) ASME II Part D SA-193

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **t(°C)** | **Rtp0.2** | **Rtp1.0** | **Rtm** | **Rtmg/100k** |  |
| 20.00 | 723.949 | 0.000 | 861.845 | 0.000 | **N/mm²** |
| 265.00 | 424.800 | 0.000 | 861.845 | 0.000 | **N/mm²** |

Min( 0.79·Re ; 0.59·Rm ) fbm (D0701) = 508.488 N/mm²

Min( 0.72·Re ; 0.54·Rm ) fbt (D0701) = 465.396 N/mm²

Min( 0.63·Re(vm); 0.47·Rm; 0.63·Rmg fbw (D0701) = 267.624 N/mm²

**Bolt dimensions**

Nominal thread diameter of bolt Ddb = 19.05 mm

Boltdiameter at root of the thread Dbk = 15.56 mm

Boltdiam. smallest cross-sect. area Dbmin = 15.56 mm

Number of bolts nb = 8

**The bolts are tightened in a controlled way**

**Pipe material:** SA-106 B (K03006) ASME II Part D SA-106

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **t(°C)** | **Rtp0.2** | **Rtp1.0** | **Rtm** | **Rtmg/100k** |  |
| 20.00 | 241.316 | 0.000 | 413.685 | 0.000 | **N/mm²** |
| 265.00 | 160.200 | 0.000 | 413.685 | 0.000 | **N/mm²** |

Min( f1; f2 ; f3 ; f4 ) f (D0201) = 107.334 N/mm²

Min( 0.67·Re(vm) ; 0.44·Rm ) f1 (D0201) = 107.334 N/mm²

Min( 1.25·Re ; 0.84·Rm ) fcm (D0701) = 301.646 N/mm²

Min( 1.15·Re ; 0.77·Rm ) fct (D0701) = 277.514 N/mm²

Min( Re(vm); 0.67·Rm; Rmg ) fcw (D0701) = 160.200 N/mm²

**Pipe dimensions**

Outside diameter of pipe Dep,nom = 88.90 mm

Wall thickness of pipe dp,nom = 5.49 mm

Length of pipe l1,p = 1000.00 mm

Strength reduction coefficient z = 1.00 -

Allowance:

Internal corrosion CAint = 0.00 mm

Tolerance Tol = 0.00 mm

**Gasket**

**Type of gasket: soft flat gasket / reinforced graphite,7.5dg<=bg<10dg**

Outside diameter of gasket Do = 127.00 mm

Gasket contact width bg = 19.10 mm

Diameter of effective sealing circle Dg = 107.90 mm

Gasket factor cg = 1.30 -

Maximum temperature of gasket Tmax = 500.00 °C

Minimum pressure to seat the gasket Pgm;min = 15.00 N/mm²

Maximum pressure to seat the gasket Pgm;max = 120.00 N/mm²

Maximum operating gasket pressure Pgw;max = 110.25 N/mm²

Optimal pressure to seat the gasket Pgm;opt = 15.00 N/mm²

**Calculation of flange connections (D0701)**

Description : Case 1

Design condition : Operating

Design pressure Pd = 2.40 MPa

Test pressure Pt = 33.20 bar

Design temperature T = 265.00 °C

**Influence of external loadings are taken into account for operating only.**

External Force Fe = 0.00 N

External Moment Me = 700000.00 N·mm

Calculation in **corroded** condition.

**Forces in flange connection (section 2):**

**Cylindrical part Internal pressure Gasket force**

Gasket seating F1m = 0.00 N F2m = 0.00 N F3m = 97117.15 N

Testing F1t = 16654.78 N F2t = 13703.06 N F3t = 27943.84 N

Operating F1w = 28678.54 N F2w = 9905.83 N F3w = 24240.44 N

**Reaction force F1 used for the calculation of the wallthickness of the cylindrical part d1**

**in Section 3:**

Gasket seating F1m,d1 = 0.00 N

Testing F1t,d1 = 16654.78 N

Operating F1w,d1 = 45211.03 N

**Reaction force F1 used for the calculation of the radial bending moment M in point 3.1.1:**

Gasket seating F1m.M = 0.00 N

Testing F1t,M = 16654.78 N

Operating F1w,M = 23811.13 N

**Koves factor**

Gasket seating Kvm = 1.00 -

Testing Kvt = 1.00 -

Operating Kvw = 2.42 -

**Gasket seating force Bolt force**

F3m,1 = 97117.15 N Minimum bolt force F4m\* = 847459.37 N

F3m,2 = 64131.85 N Design load F4m = 288927.58 N

F3m,3 = 75389.76 N

F3m taken as the greater of these 3 values:

F3m = 97117.15 N

**Moment and section modulus (section 3):**

**Radial bending moment Tangential bending moment**

Gasket seating Mm = 466637.02 N·mm MCCm = 2466775.69 N·mm

Testing Mt = 326520.86 N·mm MCCt = 1480862.71 N·mm

Operating Mw = 334016.37 N·mm MCCw = 1595749.98 N·mm

Extra testing Mt\* = 1434652.41 N·mm MCCt\* = 7338760.53 N·mm

**Section moduli** **(calculated with actual thickness df = 26.99 mm)**

**Against radial bending:**

Gasket seating WAAm = 18080.84 mm³ WBBm = 8286.81 mm³

Testing WAAt = 18080.49 mm³ WBBt = 8286.39 mm³

Operating WAAw = 18050.60 mm³ WBBw = 8277.49 mm³

Extra testing WAAt\* = 18788.57 mm³ WBBt\* = 10067.67 mm³

**Against tangential bending:**

WCC = 44809.32 mm³

**Cylindrical part**

Minimum thickness dpmin = 0.98 mm **OK**

Minimum length l1min = 15.57 mm 0.8√(df1·(Di+df1))

Length l1 = 1000.00 mm

Correction factor (max = 1.0) Design stress fc

Gasket seating cfm = 0.97 fcm = 301.65 N/mm²

Testing cft = 0.97 fct = 277.51 N/mm²

Operating cfw = 0.80 fcw = 160.20 N/mm²

**Miscellaneous results**

Calculation outside diameter Df = 209.55 mm

Calculation inside diameter Di = 79.92 mm

Calculation width of flange bf = 64.81 mm

calculation thickness of cyl. part df1 = 4.49 mm

Calculation thickness of hub df2 = 18.78 mm

Reduced bolthole diameter D\*f2 = 20.45 mm

**Areas**

Contrib. area flange A1 = 1197.32 mm² df·(bf-D\*f2)

Contrib. area conicalpart hub A2 = 362.97 mm² (h/2)·(df2-df1)

Contrib. area cylindricalpart hub A3 = 228.09 mm² h·df1

Dist.neutral line to sealing face s = 24.63 mm (A1·(df1/2)+A2·(df+h/3)+A3·(df+h/2))/(A1+A2+A3)

**Part of wallthickness of the cylindrical part reserved to absorb axial force F1**

Gasket seating d1m = 0.00 mm

Operating d1w = 1.06 mm

Testing d1t = 0.23 mm

**Assessment of flange stress according D0701 section 4.1:**

Irregularity factor cb = 1.00 (Minimum value = 1.00)

**AA BB CC Design stress ff**

m 25.81 **OK**  56.31 **OK**  55.05 **OK**  310.26 N/mm²

w 18.50 **OK**  40.35 **OK**  35.61 **OK**  199.20 N/mm²

t 18.06 **OK**  39.40 **OK**  33.05 **OK**  285.44 N/mm²

**Assessment of shape stability according D0701 section 4.2:**

**AA BB CC Allowable 1.35\*Re**

t\* 76.36 **OK**  142.50 **OK**  163.78 **OK**  335.09 N/mm²

Fibre distance s1 = 28.56 mm

Calculated elastic rotation  = 0.15° (May not exceed 1°)**OK**

Minimum thickness of the flange df,min = 19.06 mm

**Assessment of the bolts (section 5)**

**b Design stress fb**

m 63.88 508.49 N/mm² **OK**

w 41.32 267.62 N/mm² **OK**

t 38.35 465.40 N/mm² **OK**

Cross section area at root of thread Abk = 190.03 mm²

Smallest cross-sectional area of bolt Abmin = 190.03 mm²

Minimum number of bolts for this condition nb,min = 4 **OK**

The bolts are tightened in a controlled way

**Assessment of the gasket (section 6)**

Gasket pressure Pg = 44.63 N/mm²

Minimum required gasketpressure seating Pgm:min = 15.00 N/mm²

Maximum allowed gasketpressure operating Pgw:max = 110.25 N/mm²

For the gasket seating condition following must be satisfied:

F3m

-──────  Pg  Pgm:max N/mm²

\*Dg\*bg

15.00  44.63  120.00 N/mm²

**Conclusion:**

**The design according RTOD D0701 is satisfactory.**

**CALCULATION OF FLANGE CONNECTIONS ACCORDING TO RtoD D0701**

Calculation made with CodeX

RTOD Issue 05-09

**Name** : AKZO 4" 300# node 2210

**Order n°** : 03110.16.1409.5001

**Description** : 4"-HS16-33.022

**Type of flange : 3.1 Flange with conical hub**

**Flange material:**

Code : ASME II Part D SA-105

Name : SA-105 (K03504)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **t(°C)** | **Rtp0.2** | **Rtp1.0** | **Rtm** | **Rtmg/100k** |  |
| 20.00 | 248.211 | 0.000 | 482.633 | 0.000 | **N/mm²** |
| 265.00 | 199.200 | 0.000 | 482.633 | 0.000 | **N/mm²** |

Min( 1.25·Re ; 0.84·Rm ) ffm (D0701) = 310.264 N/mm²

Min( 1.15·Re ; 0.77·Rm ) fft (D0701) = 285.443 N/mm²

Min( Re(vm); 0.67·Rm; Rmg ) ffw (D0701) = 199.200 N/mm²

**Flange dimensions**

Outside diameter of flange Df = 254.00 mm

Inside diameter of cylindrical part Di = 102.26 mm

Flange width bf = 75.87 mm

Thickness of flange df = 30.16 mm

Diameter of bolt circle Dfl = 200.03 mm

Diameter of bolt hole Df2 = 22.00 mm

Wall thickness of cylindrical part df1 = 6.02 mm

Thickness of hub at back of flange df2 = 21.90 mm

Height of the conical hub h = 53.98 mm

Length of cylindrical part l1,fl = 0.00 mm

**Allowance (Di/df1/df2)**

Tolerance = 0.000 mm

Internal corrosion = 1.000 mm

External corrosion = 0.000 mm

**Allowance (Df)**

Tolerance = 0.000 mm

Corrosion = 0.000 mm

**Bolt material:** SA-193 B7 (<= 2 1/2) (G41400) ASME II Part D SA-193

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **t(°C)** | **Rtp0.2** | **Rtp1.0** | **Rtm** | **Rtmg/100k** |  |
| 20.00 | 723.949 | 0.000 | 861.845 | 0.000 | **N/mm²** |
| 265.00 | 424.800 | 0.000 | 861.845 | 0.000 | **N/mm²** |

Min( 0.79·Re ; 0.59·Rm ) fbm (D0701) = 508.488 N/mm²

Min( 0.72·Re ; 0.54·Rm ) fbt (D0701) = 465.396 N/mm²

Min( 0.63·Re(vm); 0.47·Rm; 0.63·Rmg fbw (D0701) = 267.624 N/mm²

**Bolt dimensions**

Nominal thread diameter of bolt Ddb = 19.05 mm

Boltdiameter at root of the thread Dbk = 15.56 mm

Boltdiam. smallest cross-sect. area Dbmin = 15.56 mm

Number of bolts nb = 8

**The bolts are tightened in a controlled way**

**Pipe material:** SA-106 B (K03006) ASME II Part D SA-106

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **t(°C)** | **Rtp0.2** | **Rtp1.0** | **Rtm** | **Rtmg/100k** |  |
| 20.00 | 241.316 | 0.000 | 413.685 | 0.000 | **N/mm²** |
| 265.00 | 160.200 | 0.000 | 413.685 | 0.000 | **N/mm²** |

Min( f1; f2 ; f3 ; f4 ) f (D0201) = 107.334 N/mm²

Min( 0.67·Re(vm) ; 0.44·Rm ) f1 (D0201) = 107.334 N/mm²

Min( 1.25·Re ; 0.84·Rm ) fcm (D0701) = 301.646 N/mm²

Min( 1.15·Re ; 0.77·Rm ) fct (D0701) = 277.514 N/mm²

Min( Re(vm); 0.67·Rm; Rmg ) fcw (D0701) = 160.200 N/mm²

**Pipe dimensions**

Outside diameter of pipe Dep,nom = 114.30 mm

Wall thickness of pipe dp,nom = 6.02 mm

Length of pipe l1,p = 1000.00 mm

Strength reduction coefficient z = 1.00 -

Allowance:

Internal corrosion CAint = 0.00 mm

Tolerance Tol = 0.00 mm

**Gasket**

**Type of gasket: soft flat gasket / reinforced graphite,5dg<=bg<7.5dg**

Outside diameter of gasket Do = 157.20 mm

Gasket contact width bg = 21.50 mm

Diameter of effective sealing circle Dg = 135.70 mm

Gasket factor cg = 1.30 -

Maximum temperature of gasket Tmax = 500.00 °C

Minimum pressure to seat the gasket Pgm;min = 15.00 N/mm²

Maximum pressure to seat the gasket Pgm;max = 100.00 N/mm²

Maximum operating gasket pressure Pgw;max = 90.25 N/mm²

Optimal pressure to seat the gasket Pgm;opt = 15.00 N/mm²

**Calculation of flange connections (D0701)**

Description : Case 1

Design condition : Operating

Design pressure Pd = 2.40 MPa

Test pressure Pt = 33.20 bar

Design temperature T = 265.00 °C

**Influence of external loadings are taken into account for operating only.**

External Force Fe = 0.00 N

External Moment Me = 300000.00 N·mm

Calculation in **corroded** condition.

**Forces in flange connection (section 2):**

**Cylindrical part Internal pressure Gasket force**

Gasket seating F1m = 0.00 N F2m = 0.00 N F3m = 137486.30 N

Testing F1t = 28344.15 N F2t = 19672.04 N F3t = 39559.39 N

Operating F1w = 26488.85 N F2w = 14220.75 N F3w = 34316.58 N

**Reaction force F1 used for the calculation of the wallthickness of the cylindrical part d1 in**

**Section 3:**

Gasket seating F1m,d1 = 0.00 N

Testing F1t,d1 = 28344.15 N

Operating F1w,d1 = 31470.71 N

**Reaction force F1 used for the calculation of the radial bending moment M in point 3.1.1:**

Gasket seating F1m.M = 0.00 N

Testing F1t,M = 28344.15 N

Operating F1w,M = 24170.96 N

**Koves factor**

Gasket seating Kvm = 1.00 -

Testing Kvt = 1.00 -

Operating Kvw = 2.67 -

**Gasket seating force Bolt force**

F3m,1 = 137486.30 N Minimum bolt force F4m\* = 847459.37 N

F3m,2 = 96333.14 N Design load F4m = 233726.71 N

F3m,3 = 90031.41 N

F3m taken as the greater of these 3 values:

F3m = 137486.30 N

**Moment and section modulus (section 3):**

**Radial bending moment Tangential bending moment**

Gasket seating Mm = 703822.47 N·mm MCCm = 3710645.37 N·mm

Testing Mt = 532519.21 N·mm MCCt = 2363594.81 N·mm

Operating Mw = 440817.16 N·mm MCCw = 2024896.51 N·mm

Extra testing Mt\* = 1280698.83 N·mm MCCt\* = 6308096.92 N·mm

**Section moduli** **(calculated with actual thickness df = 30.16 mm)**

**Against radial bending:**

Gasket seating WAAm = 24894.11 mm³ WBBm = 12917.00 mm³

Testing WAAt = 24893.33 mm³ WBBt = 12916.08 mm³

Operating WAAw = 24853.16 mm³ WBBw = 12913.58 mm³

Extra testing WAAt\* = 25919.62 mm³ WBBt\* = 15536.81 mm³

**Against tangential bending:**

WCC = 69561.29 mm³

**Cylindrical part**

Minimum thickness dpmin = 1.26 mm **OK**

Minimum length l1min = 18.74 mm 0.8√(df1·(Di+df1))

Length l1 = 1000.00 mm

Correction factor (max = 1.0) Design stress fc

Gasket seating cfm = 0.97 fcm = 301.65 N/mm²

Testing cft = 0.97 fct = 277.51 N/mm²

Operating cfw = 0.80 fcw = 160.20 N/mm²

**Miscellaneous results**

Calculation outside diameter Df = 254.00 mm

Calculation inside diameter Di = 104.26 mm

Calculation width of flange bf = 74.87 mm

calculation thickness of cyl. part df1 = 5.02 mm

Calculation thickness of hub df2 = 20.90 mm

Reduced bolthole diameter D\*f2 = 19.71 mm

**Areas**

Contrib. area flange A1 = 1663.74 mm² df·(bf-D\*f2)

Contrib. area conicalpart hub A2 = 428.49 mm² (h/2)·(df2-df1)

Contrib. area cylindricalpart hub A3 = 270.98 mm² h·df1

Dist.neutral line to sealing face s = 25.90 mm (A1·(df1/2)+A2·(df+h/3)+A3·(df+h/2))/(A1+A2+A3)

**Part of wallthickness of the cylindrical part reserved to absorb axial force F1**

Gasket seating d1m = 0.00 mm

Operating d1w = 0.57 mm

Testing d1t = 0.30 mm

**Assessment of flange stress according D0701 section 4.1:**

Irregularity factor cb = 1.03 (Minimum value = 1.00)

**AA BB CC Design stress ff**

m 29.10 **OK**  56.08 **OK**  54.90 **OK**  310.26 N/mm²

w 18.25 **OK**  35.13 **OK**  29.96 **OK**  199.20 N/mm²

t 22.02 **OK**  42.43 **OK**  34.97 **OK**  285.44 N/mm²

**Assessment of shape stability according D0701 section 4.2:**

**AA BB CC Allowable 1.35\*Re**

t\* 50.85 **OK**  84.84 **OK**  93.33 **OK**  335.09 N/mm²

Fibre distance s1 = 32.98 mm

Calculated elastic rotation  = 0.09° (May not exceed 1°)**OK**

Minimum thickness of the flange df,min = 16.73 mm

**Assessment of the bolts (section 5)**

**b Design stress fb**

m 90.44 508.49 N/mm² **OK**

w 49.35 267.62 N/mm² **OK**

t 57.61 465.40 N/mm² **OK**

Cross section area at root of thread Abk = 190.03 mm²

Smallest cross-sectional area of bolt Abmin = 190.03 mm²

Minimum number of bolts for this condition nb,min = 4 **OK**

The bolts are tightened in a controlled way

**Assessment of the gasket (section 6)**

Gasket pressure Pg = 25.50 N/mm²

Minimum required gasketpressure seating Pgm:min = 15.00 N/mm²

Maximum allowed gasketpressure operating Pgw:max = 90.25 N/mm²

For the gasket seating condition following must be satisfied:

F3m

-──────  Pg  Pgm:max N/mm²

\*Dg\*bg

15.00  25.50  100.00 N/mm²

**Conclusion:**

**The design according RTOD D0701 is satisfactory.**