



Project summary

Project : Catliq Demo

ID No. Flange

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References

European Standard EN 1591-1
 Standard title Flanges and their joints
 Standard subtitle Design rules for gasketed circular flange connections
 Standard edition Issue 1
 Standard dated April 2001
 ICS number ICS 23.040.60
 Program version Version 1.0
 Program build Build 015 12-01-2009
 Program development Danish Exergy Technology - DXT

Nomenclature, equation numbers and figure numbers are made with direct reference to the English printed version of this European Standard.

Component type	Component name	Component ID	Mat. code	Mat. grade	Status
Hubbed threaded flange			EN10028-3	P460NH	OK
Hubbed threaded flange			EN10028-3	P460NH	OK
Cylindrical Shell	Shell flange 1		VdTÜV 499	NiCr22Mo9Nb (F)	--
Cylindrical Shell	Shell flange 2		VdTÜV 499	NiCr22Mo9Nb (F)	--
Solid metal gaskets					OK
Bolts - ISO M24			EN10269	1.1181	OK



EN1591 ver 1.0

CALCULATION OF FLANGES AND THEIR JOINTS ACCORDING TO EN1591-1

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Main body design code	--	EN13480
Medium	--	Other
Fluid state	--	Gas
Fluid gruppe	--	1
Maximum operation pressure (Po)	barg	300,0
Maximum operation temperature (to)	°C	250,0
Number of full load cycles	pcs	500
Temperature gradient during start-up	°C/min	1,0
Component lifetime (T)	h	200000
Lifetime monitoring system provided	--	NO
Max allowable internal pressure (PSmax)	barg	325,0
Internal calculation pressure (P)	barg	325,0
Minimum allowable temperature (TSmin)	°C	20,0
Maximum allowable temperature (TSmax)	°C	400,0
Calculation temperature (tc)	°C	400,0
Max allowable external pressure (PSmax)	barg	0,0
External calculation pressure (P)	barg	0,0
Minimum allowable temperature (TSmin)	°C	0,0
Maximum allowable temperature (TSmax)	°C	50,0
Calculation temperature (tc)	°C	30,0

**Project Catliq Demo****Component : Flange****ID No.**

Flange number		First flange in joint
Flange type		Hubbed threaded flange
Flange code		NA
Flange serie		NA
Flange material code		EN10028-3
Flange material grade		P460NH
Inside diameter of flange (d0)	mm	24,0
Average diameter of hub at thin end (d1)	mm	NA
Average diameter if hub at thick end (d2)	mm	NA
Bolt circle diameter (d3)	mm	80,0
Outside diameter of flange (d4)	mm	115,0
Diameter of bolt hole (d5)	mm	24,0
Inside diameter of loose flange (d6)	mm	42,4
Diameter of reaction between flange and stub or collar (d7)	mm	42,4
Outside diameter of collar (d8)	mm	42,4
Diameter of central hole in blank flange (d9)	mm	NA
Thickness of central plate of blank flange (e0)	mm	NA
Thickness of hub at thin end (e1)	mm	NA
Thickness of hub at thick end (e2)	mm	NA
Length of hub (IH)	mm	NA
Effective axial thickness of flange (eF)	mm	25,0
Thickness (ep)	mm	25,0
Cross-section area of ring (AF)	mm ²	230,0
Shell material code	--	VdTÜV 499
Shell material number	--	Cr22Mo9Nb (F)
Shell form	--	Cylindrical
Diameter of shell at junction (ds)	mm	32,4
Thickness of shell (es)	mm	9,5
Angle of inclination of connected shell (PsiS)	°	0,0
Pitch between bolts (pB)	mm	31,4
Effective diameter of bolt holes (d5e)	mm	21,0
Effective bolt circle diameter (d3e)	mm	77,5
Average diameter of flange (dF)	mm	33,2
Effective width of flange (bF)	mm	9,2
Effective axial thickness of flange (eF)	mm	25,0
Part of flange thickness with radial pressure loading (eP)	mm	25,0
Part of flange thickness without radial pressure loading (eQ)	mm	0,0
Wall thickness of equivalent cylinder for load calculations (eE)	mm	9,5
Average diameter equivalent cylinder for load calculation (dE)	mm	32,4
Lever arm correction (hP)	mm	30,59
Lever arm correction (hG)	mm	2,70
Calculation factor (Gamma)	--	1,06
Calculation factor (Theta)	--	0,39
Calculation factor (Lambda)	--	0,00
Calculation factor (cF)	--	0,35
Lever arm correction (hS)	mm	14,65
Lever arm correction (hT)	mm	14,95
Lever arm correction (hQ)	mm	27,68
Lever arm correction (hR)	mm	-2,20
Calculation factor (kQ)	--	0,85
Calculation factor (kR)	--	-0,15
Rotational flexibility modulus of flange (ZF) *1,0E5	1/mm ³	0,00

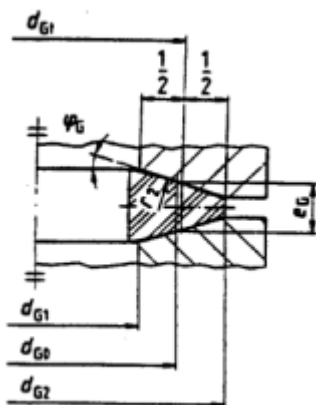
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Flange number		Second flange in joint
Flange type		Hubbed threaded flange
Flange code		NA
Flange serie		NA
Flange material code		EN10028-3
Flange material grade		P460NH
Inside diameter of flange (d0)	mm	24,0
Average diameter of hub at thin end (d1)	mm	NA
Average diameter if hub at thick end (d2)	mm	NA
Bolt circle diameter (d3)	mm	80,0
Outside diameter of flange (d4)	mm	115,0
Diameter of bolt hole (d5)	mm	24,0
Inside diameter of loose flange (d6)	mm	42,4
Diameter of reaction between flange and stub or collar (d7)	mm	42,4
Outside diameter of collar (d8)	mm	42,4
Diameter of central hole in blank flange (d9)	mm	NA
Thickness of central plate of blank flange (e0)	mm	NA
Thickness of hub at thin end (e1)	mm	NA
Thickness of hub at thick end (e2)	mm	NA
Length of hub (IH)	mm	NA
Effective axial thickness of flange (eF)	mm	25,0
Thickness (ep)	mm	25,0
Cross-section area of ring (AF)	mm ²	230,0
Shell material code	--	VdTÜV 499
Shell material number	--	3r22Mo9Nb (F)
Shell form	--	Cylindrical
Diameter of shell at junction (ds)	mm	32,4
Thickness of shell (es)	mm	9,5
Angle of inclination of connected shell (PsiS)	°	0,0
Pitch between bolts (pB)	mm	31,4
Effective diameter of bolt holes (d5e)	mm	21,0
Effective bolt circle diameter (d3e)	mm	77,5
Average diameter of flange (dF)	mm	33,2
Effective width of flange (bF)	mm	9,2
Effective axial thickness of flange (eF)	mm	25,0
Part of flange thickness with radial pressure loading (eP)	mm	25,0
Part of flange thickness without radial pressure loading (eQ)	mm	0,0
Wall thickness of equivalent cylinder for load calculations (eE)	mm	9,5
Average diameter equivalent cylinder for load calculation (dE)	mm	32,4
Lever arm correction (hP)	mm	30,59
Lever arm correction (hG)	mm	2,70
Calculation factor (Gamma)	--	1,06
Calculation factor (Theta)	--	0,39
Calculation factor (Lambda)	--	0,00
Calculation factor (cF)	--	0,35
Lever arm correction (hS)	mm	14,65
Lever arm correction (hT)	mm	14,95
Lever arm correction (hQ)	mm	27,68
Lever arm correction (hR)	mm	-2,20
Calculation factor (kQ)	--	0,85
Calculation factor (kR)	--	-0,15
Rotational flexibility modulus of flange (ZF) *1,0E5	1/mm ³	0,00

Project **Catliq Demo**Component : **Flange**

ID No :

Gasket group	Solid metal gaskets
Gasket type	Stainless steel, heat resistant
Gasket form	Metal gasket with curved surface - figure 3c
Gasket material	
Inside diameter of gasket (dG1)	mm 24,0
Outside diameter of gasket (dG2)	mm 37,0
Gasket width (bGt)	mm 6,5
Gasket thickness (eGt)	mm 11,0
Angle of inclination of sealing face (PsiG)	° 20,0
Radius of curvature in cross.section (r2)	mm 43,0
Maximum allowable operation temperature	°C 600,0
Minimum effective compressive stress in gasket for assembly conditions (Qmin)	MPa 300,0
Maximum allowable compressive stress in gasket for reference gasket Qmax,ref (at 20°C)	MPa 660,0
Yield stress characteristic of gasket material (Qmax,y) (eq. 4a)	MPa 660,0
Compressive modulus of elasticity of gasket at zero compressive stress at 20°C (E0)	MPa 210000,0
Rate of change of compressive modulus of elasticity of gasket with compressive stress at 20°C (†)	-- 0,00
Load - pressure ratio corresponding to reference conditions Q/P (20°C)	-- 2,00
Creep factor for gasket at 20°C (gc)	-- 1,00
Numerical constant c1 (eq. 4a)	-- 0,0
Thermal conductivity (alphaG) at 20°C	W/mK 0,0
Reference inside gasket diameter (dG1)ref	mm 50,0
Reference outside diameter (dG2)ref	mm 90,0
Reference gasket width (bGt)ref	mm 40,0
Reference gasket thickness (eG)ref	mm 2,0
Reference pressure (Pref)	barg 40,0
Nitrogen gas leak rate	ml/min 1,0



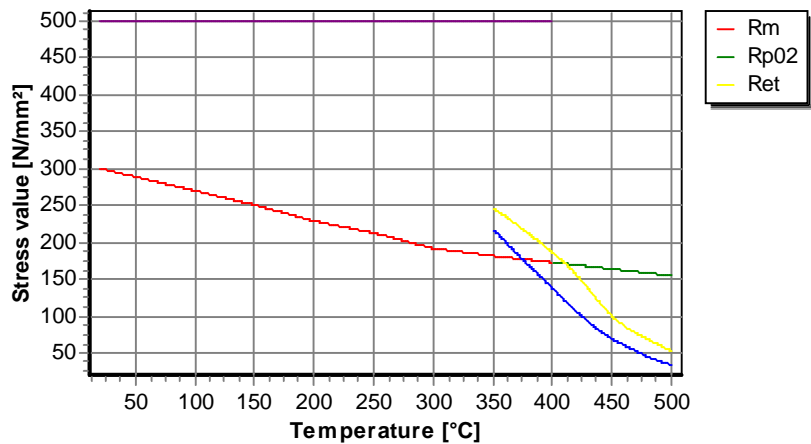


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Bolt fabrication code	--	EN/ISO 898
Bolt thread type	--	ISO M24
Number of bolts	pcs	8
Bolt nominal diameter	mm	24,00
Bolt outside diameter (dB0)	mm	24,00
Bolt effective diameter (dBe)	mm	21,20
Bolt shank diameter (dBs)	mm	22,10
Thread mean diameter (dB2)	mm	22,05
Thread pitch (pt)	mm	3,00
Bolt axial dimension (LB - figure 2)	mm	576,2
Bolt axial diemnsion (LS - figure 2)	mm	100,0
Nominal stress area for single bolt (As)	mm ²	353,0
Nominal stress area for all bolt (AB)	mm ²	2823,9
Plastic torsion modulus for single bolt (IB)	mm ³	2494,5
Flexibility modulus for all bolts (XB)	1/mm	0,207
Bolt material code	--	EN10269
Bolt material class	--	NA
Bolt material grade	--	C35E +N
Bolt material number	--	1.1181
Bolt material type	--	Other
Heat treatment	--	N
Minimum tensile strength at room temperature (Rm)	N/mm ²	500,0
Proof strength at room temperature (Rp02)	N/mm ²	300,0
Elongation after fracture (A)	%	20,0
Reduction in area after fracture (Z)	%	--
Impact energy (ISO-V) (KV)	J	27,0

Elements	Min	Max
C	0,3200	0,3900
Si	0,0000	0,4000
Mn	0,5000	0,8000
P	0,0000	0,0350
S	0,0000	0,0350
N	0,0000	0,0000
Cr	0,0000	0,4000
Cu	0,0000	0,0000
Mo	0,0000	0,1000
Nb	0,0000	0,0000
Ni	0,0000	0,4000
Ti	0,0000	0,0000
W	0,0000	0,0000

Material strength properties





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Bolting up method		Wrench. Torque measuring
Bolting up model		General
Surface conditions		Smooth lubricated surface (0,10 to 0,15)
Friction coefficient under nut or bolt head (myn)	--	0,130
Friction coefficient on thread (myt)	--	0,000
Mean contact diameter under nut or bolt head (dn)	mm	20,80
Mean contact diameter on thread (dt)	mm	14,40
Scatter of initial bolt load of a single bolt (eps1+)	--	0,070
Scatter of initial bolt load of a single bolt (eps1-)	--	0,070
Systematic error due to inaccuracy of bolt tightening (Ks)	--	0,018
Scatter for the global load of all bolts (eps+)	--	0,036
Scatter for the global load of all bolts (eps-)	--	0,036
Nominal torque applied to tighten bolt (Mt,nom)	Nm	45725
Nominal twisting moment on bolt shanks (MtB,nom)	Nm	11925
Nominal bolt assembly force (FB0nom)	N	200000
Minimum bolt assembly force inclusive scatter (FB0min)	N	192788
Maximum bolt assembly force inclusive scatter (FB0max)	N	207212
Required bolt assembly force (FB0req)	N	145223
Max allowable assembly force (FB0all)	N	282391

**Project Catliq Demo****Component : Flange****ID No.****First flange**

Load point		0	1	2	3	4
Load description	--	Bolting Up	Operation	Test		
Load condition	--	Assembly	Operation	Test		
Internal pressure (Pi)	barg	1,0	325,0	550,0		
External pressure (Pe)	barg	0,0	0,0	0,0		
Temperature (T)	°C	20,0	400,0	20,0		
Additional external axial force (FA)	N	0,0	0,0	0,0		
Additional external moment (MA)	Nm	0,0	0,0	0,0		
Bolt temperature (TB)	°C	20,0	400,0	20,0		
Flange temperature (TF)	°C	20,0	400,0	20,0		
Temperature loose flange (TL)	°C	20,0	400,0	20,0		
Gasket temperature (TG)	°C	20,0	400,0	20,0		
Min. tensile strength at 20°C (RmS)	N/mm ²	760,0	760,0	760,0		
Min tensile strength at design temp (RetS)	N/mm ²	0,0	0,0	0,0		
0,2% yield stress at design temp. (Rp02S)	N/mm ²	380,0	260,0	380,0		
Safety factor for shell material (SS)	--	1,5	1,5	1,5		
Nominal stress for shell material (fS)	N/mm ²	253,3	173,3	253,3		
Min. tensile strength at 20°C (RmF)	N/mm ²	570,0	570,0	570,0		
Min tensile strength at design temp. (RetF) ...	N/mm ²	0,0	0,0	0,0		
0,2% yield stress at design temp. (Rp02F)	N/mm ²	445,0	253,0	445,0		
Safety factor for flange material (SF)	--	2,4	1,5	2,4		
Nominal stress for flange material (fF)	N/mm ²	253,3	173,3	253,3		
Min tensile strength at 20°C (RmB)	N/mm ²	500,0	500,0	500,0		
Min tensile strength at design temp. (RetB) ...	N/mm ²	0,0	0,0	0,0		
0,2% yield stress at design temp (Rp02B)	N/mm ²	300,0	173,0	300,0		
Safety factor for bolt material (SB)	--	3,0	3,0	2,0		
Nominal stress for bolt material (fB)	N/mm ²	100,0	57,7	150,0		
Axial compliance YG (eq. 46)	--	9,57E-06	1,14E-05	9,57E-06		
Axial compliance YQ (eq. 47)	--	1,76E-06	2,04E-06	1,76E-06		
Axial compliance YR (eq. 48)	--	1,76E-06	2,04E-06	1,76E-06		
Min gasket force FGmin (eq. 49/50)	N	78169	96203	78169		
Min gasket force FGd (eq. 51)	N	78188	145223	89038		
Bolt assembly force (FG0)	N	145209	145209	145209		
Req. assembly force (FG0req)	N	145223	145223	145223		
Nominal assembly force (FB0nom)	N	200000	200000	200000		
Minimum assembly force (FB0min)	N	192788	192788	192788		
Maximum assembly force (FB0max)	N	207212	207212	207212		
Bolt load ratio ØB (eq.71)	--	0,522	0,805	0,324		
Gasket load ratio ØG (eq.72)	--	0,353	0,303	0,190		
Flange load ratio ØF (eq.73)	--	0,000	0,000	0,000		
Blank flange load ratio ØF (eq.85)	--	--	--	--		
Blank flange load ratio Øx (eq.87)	--	--	--	--		
Loose flange load ratio ØL (eq.89)	--	--	--	--		
Allowable load ratio Ømax	--	0,950	0,950	0,950		
Minimum value of eF (eq. A.1)	mm	12,99	13,15	12,99		
Load point admissibility valid	--	OK	OK	OK		

**Project Catliq Demo****Component : Flange****ID No.****Second flange**

Load point		0	1	2	3	4
Load description	--	Bolting Up	Operation	Test		
Load condition	--	Assembly	Operation	Test		
Internal pressure (Pi)	barg	1,0	325,0	550,0		
External pressure (Pe)	barg	0,0	0,0	0,0		
Temperature (T)	°C	20,0	400,0	20,0		
Additional external axial force (FA)	N	0,0	0,0	0,0		
Additional external moment (MA)	Nm	0,0	0,0	0,0		
Bolt temperature (TB)	°C	20,0	400,0	20,0		
Flange temperature (TF)	°C	20,0	400,0	20,0		
Temperature loose flange (TL)	°C	20,0	400,0	20,0		
Gasket temperature (TG)	°C	20,0	400,0	20,0		
Min. tensile strength at 20°C (RmS)	N/mm ²	760,0	760,0	760,0		
Min tensile strength at design temp (RetS)	N/mm ²	0,0	0,0	0,0		
0,2% yield stress at design temp. (Rp02S)	N/mm ²	380,0	260,0	380,0		
Safety factor for shell material (SS)	--	1,5	1,5	1,5		
Nominal stress for shell material (fS)	N/mm ²	253,3	173,3	253,3		
Min. tensile strength at 20°C (RmF)	N/mm ²	570,0	570,0	570,0		
Min tensile strength at design temp. (RetF) ...	N/mm ²	0,0	0,0	0,0		
0,2% yield stress at design temp. (Rp02F)	N/mm ²	445,0	253,0	445,0		
Safety factor for flange material (SF)	--	2,4	1,5	2,4		
Nominal stress for flange material (fF)	N/mm ²	253,3	173,3	253,3		
Min tensile strength at 20°C (RmB)	N/mm ²	500,0	500,0	500,0		
Min tensile strength at design temp. (RetB) ...	N/mm ²	0,0	0,0	0,0		
0,2% yield stress at design temp (Rp02B)	N/mm ²	300,0	173,0	300,0		
Safety factor for bolt material (SB)	--	3,0	3,0	2,0		
Nominal stress for bolt material (fB)	N/mm ²	100,0	57,7	150,0		
Axial compliance YG (eq. 46)	--	9,57E-06	1,14E-05	9,57E-06		
Axial compliance YQ (eq. 47)	--	1,76E-06	2,04E-06	1,76E-06		
Axial compliance YR (eq. 48)	--	1,76E-06	2,04E-06	1,76E-06		
Min gasket force FGmin (eq. 49/50)	N	78169	96203	78169		
Min gasket force FGd (eq. 51)	N	78188	145223	89038		
Bolt assembly force (FG0)	N	145209	145209	145209		
Req. assembly force (FG0req)	N	145223	145223	145223		
Nominal assembly force (FB0nom)	N	200000	200000	200000		
Minimum assembly force (FB0min)	N	192788	192788	192788		
Maximum assembly force (FB0max)	N	207212	207212	207212		
Bolt load ratio ØB (eq.71)	--	0,522	0,805	0,324		
Gasket load ratio ØG (eq.72)	--	0,353	0,303	0,190		
Flange load ratio ØF (eq.73)	--	0,000	0,000	0,000		
Blank flange load ratio ØF (eq.85)	--	--	--	--		
Blank flange load ratio Øx (eq.87)	--	--	--	--		
Loose flange load ratio ØL (eq.89)	--	--	--	--		
Allowable load ratio Ømax	--	0,950	0,950	0,950		
Minimum value of eF (eq. A.1)	mm	12,99	13,15	12,99		
Load point admissibility valid	--	OK	OK	OK		