	Wolf GmbH & Co.KG 57234 Wilnsdorf	Air Liquide Purchase-no.: 4500023998 Project: ASU Kosice No.9
	Kom.Nr. 37106	Dokument No. :

Document: **Design Calculation**

Description: **Molsieve Filter**

Tag No.: **F15031**

Drawing No.: **11441 - 0**

0	first issue	07.12.2004		Strake	TB		
Status	Ausgabe	Datum	geänd.Seiten	erstellt	Abtlg.	geprüft	genehmigt

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Test Pressure Calculation
acc to AD 2000-Merkblatt HP30:2003-01

drawing no: 11441-0
name/ item: Molsieve filter F15031

input data

Operating Data

maximum allowable pressure	p =	6	bar
relative density of the test fluid	GammaP =	1	dN/dm3
relative density of the working fluid	GammaF =	1	dN/dm3
design temperature	T =	120	°C
temperature for test condition	T'=	20	°C
operating mode horizontal = 1 vertical = 2	=	1	

test pressure calculation under consideration of
maximum ratio K'/K: 1
or preferably minimum ratio K'/K: 2 = 2

Material Data

name/item: Mantel
material: 0741-P 265 GH (1.0425) DIN EN 10028-2:1992 AD-W1:1998-02
design strenght value K = 215 N/mm²
yield strength Rp 0.2 [120°C,8mm]
design strength value at T' K'= 265 N/mm²
yield strength Rp 0.2 [20°C,8mm]

name/item: Böden
material: 0741-P 265 GH (1.0425) DIN EN 10028-2:1992 AD-W1:1998-02
design strenght value K = 215 N/mm²
yield strength Rp 0.2 [120°C,10mm]
design strength value at T' K'= 265 N/mm²
yield strength Rp 0.2 [20°C,10mm]

results

scope:
Only for a liquid pressure test according to AD 2000 Hp 30, section 4.
Attention!
The condition is that the pressure gauge is placed on the highest level of the vertical or horizontal vessel during testing procedure.

No pressure from from static liquid column was taken into account.

intermediate results

no	name / item	material	*	thickness mm	factor K'/K	Fp	req test press bar
1	Mantel	P 265 GH	D	=<16	1.233	1.541	9.244
2	Böden	P 265 GH	D	=<16	1.233	1.541	**9.244**

required **test pressure pT = 9.244** bar, for component with no. **2**
the lowest ratio of K'/K was taken into account

* D = data from DIMy database resp. F = individual input data

Fp= test pressure factor

Attention: it have to be checked whether all components of the pressure equipment will withstand this calculated test pressure!

Cylindrical Shells with Opening
under Internal Pressure
acc to AD 2000-Merkblatt B1/B9:2000-10

drawing no: 11441-0
name/ item: shell

input data - shell

design data

design pressure	p =	6 bar
design temperature	T =	120 °C

material data, shell

material: 0741-P 265 GH (1.0425) DIN EN 10028-2:1992 AD-W1:1998-02

design strength value	K =	215 N/mm²
yield strength Rp 0.2 [120°C,8mm]		
design strength value at room temperature	K20 =	265 N/mm²
yield strength Rp 0.2 [20°C,8mm]		
safety factor	S =	1.5
joint efficiency	v =	.85

geometry data, shell

outer diameter	Da =	1316 mm
actual wall thickness	se =	8 mm
manufacturing tolerance	c1 =	7- DIN EN 10029A
corrosion allowance	c2 =	3 mm

results - shell

results shown in percentages signify over-/underdimensioning
for dimensions: (act-req) / req, with other data: (allow-act) / act

req wall thickness without opening	[2]	sreq =	6.63 mm
» act wall thickness is adequate!		res =	**+21 %**
manufacturing tolerance / corrosion allowance		c1/c2 =	0.40/3.00 mm
allowances, shell (act wall thickness)		c1/c2 =	0.50/3.00 mm
max unreinforced opening		da max ca	98 mm
influence of multiple nozzles / AD-B9 [8] from		l <=	153.6 mm
max all working pressure		**pmax =**	**6.31 bar**
– with decisive component: opening no. 3			
max all test pressure		**pTmax =**	**11.03 bar**

input data - opening 1

opening - name/item: N3.1 (Mannloch DN500)

type of opening: 1- nozzle, set-through without reinf. pad

material data

nozzle: 0741-P 265 GH (1.0425) DIN EN 10028-2:1992 AD-W1:1998-02

design strength value, nozzle	K =	215 N/mm²
yield strength Rp 0.2 [120°C,12mm]		
design strength value, nozzle at room temp.	K20 =	265 N/mm²
yield strength Rp 0.2 [20°C,12mm]		
joint efficiency, nozzle	v =	.85

geometry data

outer diameter	da =	508 mm
actual wall thickness	ss =	12 mm
manufacturing tolerance	c1 =	7- DIN EN 10029A
corrosion allowance	c2 =	3 mm
actual length of nozzle	ls =	100 mm
protruding length	ls'=	0 mm
distance nozzle outside diameter - discontinuity	x =	216 mm

results - opening 1

opening-name/item: N3.1 (Mannloch DN500)

req wall thickness of nozzle acc to AD-B1	[2]	sserf =	4.65	mm
» act wall thickness is adequate!		res =	**+158**	%
with manufact. tolerance/corrosion allowance		c1/c2 =	0.40/3.00	mm
area comparison acc to AD-B9 with act wall thicknesses:				
actual stress	[2]	σv =	132.6	N/mm²
allowable stress		K/S =	143.3	N/mm²
» actual opening is adequately reinforced!		res =	**+8**	%
with allowances, nozzle (act wall thickness)		c1/c2 =	0.50/3.00	mm
calculated wall thickness of nozzle		ss =	8.5	mm
calculated outer nozzle length	[6]	ls mit =	81.4	mm
inner nozzle length		ls'mit =	0.0	mm
calculated shell length	[3]	b mit =	76.8	mm
load-bearing cross sectional area		Aσ =	1076	mm²
pressure load area		Ap =	237293	mm²

input data - opening 2

opening - name/item: N3.2 (Mannloch DN500)

type of opening: 1- nozzle, set-through without reinf. pad

material data

nozzle: 0741-P 265 GH (1.0425) DIN EN 10028-2:1992 AD-W1:1998-02

design strength value, nozzle	K =	215	N/mm²
yield strength Rp 0.2 [120°C,12mm]			
design strength value, nozzle at room temp.	K20 =	265	N/mm²
yield strength Rp 0.2 [20°C,12mm]			
joint efficiency, nozzle	v =	.85	

geometry data

outer diameter	da =	508	mm
actual wall thickness	ss =	12	mm
manufacturing tolerance	c1 =	7- DIN EN 10029A	
corrosion allowance	c2 =	3	mm
actual length of nozzle	ls =	100	mm
protruding length	ls'=	0	mm
distance nozzle outside diameter - discontinuity	x =	216	mm

results - opening 2

opening-name/item: N3.2 (Mannloch DN500)

req wall thickness of nozzle acc to AD-B1	[2]	sserf =	4.65	mm
» act wall thickness is adequate!		res =	**+158**	%
with manufact. tolerance/corrosion allowance		c1/c2 =	0.40/3.00	mm
area comparison acc to AD-B9 with act wall thicknesses:				
actual stress	[2]	σv =	132.6	N/mm²
allowable stress		K/S =	143.3	N/mm²
» actual opening is adequately reinforced!		res =	**+8**	%
with allowances, nozzle (act wall thickness)		c1/c2 =	0.50/3.00	mm
calculated wall thickness of nozzle		ss =	8.5	mm
calculated outer nozzle length	[6]	ls mit =	81.4	mm
inner nozzle length		ls'mit =	0.0	mm
calculated shell length	[3]	b mit =	76.8	mm
load-bearing cross sectional area		Aσ =	1076	mm²
pressure load area		Ap =	237293	mm²

input data - opening 3

opening - name/item: N4,DN100

type of opening: 2- nozzle, set-on without reinf. pad

material data

nozzle: 0090-St 35.8 (1.0305) DIN 17175 AD-W4/W12

design strength value, nozzle	K =	207	N/mm²
yield strength Rp 0.2 [120°C,5.6mm]			

continuation material data

design strength value, nozzle at room temp. yield strength Rp 0.2 [20°C,5.6mm]	K20 =	235 N/mm²
joint efficiency, nozzle	v =	1

geometry data

outer diameter	da =	114.3 mm
actual wall thickness	ss =	5.6 mm
manufacturing tolerance	c1 =	3- DIN 17175
corrosion allowance	c2 =	3 mm
actual length of nozzle	ls =	50 mm
distance nozzle outside diameter - discontinuity	x =	0 mm

results - opening 3

opening-name/item: N4,DN100

req wall thickness of nozzle acc to AD-B1	[2]	sserf =	3.61 mm
» act wall thickness is adequate!		res =	**+55 %**
with manufact. tolerance/corrosion allowance		c1/c2 =	0.36/3.00 mm
area comparison acc to AD-B9 with act wall thicknesses:			
actual stress	[2]	σv =	136.3 N/mm²
allowable stress		K/S =	143.3 N/mm²
» actual opening is adequately reinforced!		res =	**+5 %**
with allowances, nozzle (act wall thickness)		c1/c2 =	0.56/3.00 mm
calculated wall thickness of nozzle		ss =	2.0 mm
calculated outer nozzle length	[6]	ls mit =	18.9 mm
inner nozzle length		ls'mit =	0.0 mm
calculated shell length	[3]	b mit =	76.8 mm
load-bearing cross sectional area		Aσ =	392 mm²
pressure load area		Ap =	88842 mm²

input data - opening 4

opening - name/item: N5.1u.N5.2, DN 50

type of opening: 1- nozzle, set-through without reinf. pad

material data

nozzle: 0090-St 35.8 (1.0305) DIN 17175 AD-W4/W12

design strength value, nozzle yield strength Rp 0.2 [120°C,3.6mm]	K =	207 N/mm²
design strength value, nozzle at room temp. yield strength Rp 0.2 [20°C,3.6mm]	K20 =	235 N/mm²
joint efficiency, nozzle	v =	1

geometry data

outer diameter	da =	60.3 mm
actual wall thickness	ss =	3.6 mm
manufacturing tolerance	c1 =	3- DIN 17175
corrosion allowance	c2 =	3 mm
actual length of nozzle	ls =	50 mm
protruding length	ls'=	0 mm
distance nozzle outside diameter - discontinuity	x =	0 mm

results - opening 4

opening-name/item: N5.1u.N5.2, DN 50

req wall thickness of nozzle acc to AD-B1	[2]	sserf =	3.48	mm
» act wall thickness is adequate!		res =	**+3**	%
with manufact. tolerance/corrosion allowance		c1/c2 =	0.35/3.00	mm
area comparison acc to AD-B9 with act wall thicknesses:				
actual stress	[2]	σv =	121.4	N/mm²
allowable stress		K/S =	143.3	N/mm²
» actual opening is adequately reinforced!		res =	**+18**	%
with allowances, nozzle (act wall thickness)		c1/c2 =	0.36/3.00	mm
calculated wall thickness of nozzle		ss =	0.2	mm
calculated outer nozzle length	[6]	ls mit =	4.7	mm
inner nozzle length		ls'mit =	0.0	mm
calculated shell length	[3]	b mit =	76.8	mm
load-bearing cross sectional area		Aσ =	348	mm²
pressure load area		Ap =	70183	mm²

input data - double-nozzle calculation

area comparision between openings according to AD-B9

first opening- pos./item (no.): 1
second opening- pos./item (no.): 2
distance of opening center lines - circumferential: 0- no distance
distance of opening center lines - longitudinal tl = 2000 mm

results - double-nozzle calculation

opening 1 and 2 (N3.1 (Mannloch DN500 and N3.2 (Mannloch DN500)

actual stress	[2]	σv =	99.3	N/mm²
» influenced nozzles are adequately reinforced!		res =	**+44**	%
with load-bearing cross sectional area		Aσ =	8175	mm²
pressure load area		Ap =	1349201	mm²

input data - double-nozzle calculation

area comparision between openings according to AD-B9

first opening- pos./item (no.): 1
second opening- pos./item (no.): 3
distance of opening center lines - circumferential: 2- degree
angle circumferential direction tu = 90 °
distance of opening center lines - longitudinal tl = 0 mm

results - double-nozzle calculation

opening 1 and 3 (N3.1 (Mannloch DN500 and N4,DN100)

actual stress	[2]	σv =	53.0	N/mm²
» influenced nozzles are adequately reinforced!		res =	**+171**	%
with load-bearing cross sectional area		Aσ =	3984	mm²
pressure load area		Ap =	349829	mm²

Formed Heads with Opening
under internal and external pressure
acc to AD 2000-Merkblatt B3/B9:2000-10

drawing no: 11441-0
name/ item: Head (left, right)

input data - dished end

design data

design pressure	p =	6 bar
design temperature	T =	120 °C

material data, dished end

material: 0741-P 265 GH (1.0425) DIN EN 10028-2:1992 AD-W1:1998-02

design strength value yield strength Rp 0.2 [120°C,10mm]	K =	215 N/mm²
design strength value at room temperature yield strength Rp 0.2 [20°C,10mm]	K20 =	265 N/mm²
safety factor	S =	1.5
joint efficiency	v =	.85

geometry data, dished end

head type: 2- Korbbogen type

outer diameter	Da =	1320 mm
wall thickness	se =	10 mm
manufacturing tolerance	c1 =	6- DIN 28011-13
corrosion allowance	c2 =	3 mm

results - dished end

results shown in percentages signify over-/underdimensioning
for dimensions: (act-req) / req, with other data: (allow-act) / act

req wall thickness without opening [15]	sreq =	7.24 mm
» act wall thickness is adequate!	res =	**+38 %**
with ß= 2.42 and (sreq-c)/Da=.0030		
and manuf. tolerance/corrosion allowance	c1/c2 =	0.30/3.00 mm
allowances, head (act wall thickness)	c1/c2 =	0.30/3.00 mm
max. unreinforced opening crown	da max ca	490 mm
knuckle	da max ca	278 mm
influence of multiple openings / AD-B9 [8] from	l <=	238.7 mm
max all working pressure	**pmax =**	**9.10 bar**
– with decisive component: opening no. 1		
max all test pressure	**pTmax =**	**16.02 bar**

input data - opening 1

opening name/item: N1,N2 (DN700)

type of opening: 3- nozzle, set-through with reinf. pad

material data

nozzle: 0741-P 265 GH (1.0425) DIN EN 10028-2:1992 AD-W1:1998-02

design strength value, nozzle yield strength Rp 0.2 [120°C,10mm]	K =	215 N/mm²
design strength value, nozzle at room temp. yield strength Rp 0.2 [20°C,10mm]	K20 =	265 N/mm²
joint efficiency, nozzle	v =	.85
consideration of v for area comparison	=	1- yes

pad: 0741-P 265 GH (1.0425) DIN EN 10028-2:1992 AD-W1:1998-02

design strength value, pad yield strength Rp 0.2 [120°C,10mm]	K =	215 N/mm²
design strength value, pad at room temp. yield strength Rp 0.2 [20°C,10mm]	K20 =	265 N/mm²

geometry data

outer diameter	da =	711	mm
actual wall thickness	ss =	8	mm
manufacturing tolerance	c1 =	7- DIN EN 10029A	
corrosion allowance	c2 =	1	mm
actual length of nozzle	ls =	100	mm
protruding length	ls'=	0	mm
distance outside diameter - discontinuity	x =	0	mm
distance vessel longit. axis - opening, mean axis	t =	0	mm
inclination of nozzle: 2- axial, parallel to mean axis of shell			
width of pad reinforcement	b =	50	mm
thickness of a pad reinforcement	h =	8	mm

results - opening 1

opening-name/item: N1,N2 (DN700)

req wall thickness of nozzle acc AD-B1	[2]	sserf =	3.15	mm
» act wall thickness is adequate!		res =	**+154**	%
with manuf. tolerance/corrosion allowance		c1/c2 =	0.40/1.00	mm
area comparison acc AD-B9 with actual wall thicknesses:				
resulting stress	[2]	σv =	94.5	N/mm²
allowable stress		K/S =	143.3	N/mm²
» opening is adequately reinforced!		res =	**+52**	%
with stressed shell-length	[3]	bmit =	142.3	mm
calculated wall thickness of nozzle		ss =	6.5	mm
with allowances, nozzle (act wall thicknesses)		c1/c2 =	0.50/1.00	mm
calculated outer nozzle length	[6]	ls =	67.7	mm
inner nozzle length		ls'=	0.0	mm
calc. reinforcement thickness	[4]	hv =	2.8	mm
angle of slope, nozzle		psi =	90.0	grd
load-bearing cross sectional area		Aσ =	1773	mm²
pressure load area		Ap =	278362	mm²

Integral Type Flanges

under Internal Pressure and Additional Forces
acc to AD 2000-B7:2000-10 B8:2000-10 DINV 2505:1986-01

drawing no: 11441-0
name/ item: Manway flange (DN500)

input data

Type Declaration

flange type: 1- welding neck flange (inside gasket)
bolt type: 3- bolts, S=1.8 / S'=1.26 / phi=1.0 (AD-B7)
calculation of bolting torque = 1- yes

Design Data

design pressure	p =	6	bar
test pressure	p'=	9.24	bar
design temperature	T =	120	°C

code no. of external loads: 1- without external loads

Geometry Data, Flange

outside diameter flange	da =	670	mm
outside diameter hub	dr =	508	mm
bolt-circle diameter	dt =	620	mm
outer dia of tapered neck at trans to flange	d3 =	542	mm
flange thickness	hF =	28	mm
total length of flange	ha =	63	mm
bolt hole diameter	dL =	26	mm
number of bolts or bolt holes	n =	20	Stck
act wall thickness of hub respectively tube	s1 =	7.1	mm
manufacturing tolerance of hub respect. tube	c1 =	7- DIN EN 10029A	
corrosion allowance of hub respect. tube	c2 =	3	mm

Material Data, Flange

material: 0133-C 22.8 (1.0460) VdTÜV 350/3:2001-09

strength value, design	K =	220	N/mm²
yield strength Rp 0.2 [120°C,88mm]			
safety factor, design	S =	1.5	
strength value, test/bolting-up	K =	230	N/mm²
yield strength Rp 0.2 [20°C,88mm]			
safety factor, test/bolting-up	S =	1.05	
modulus of elasticity, design [120°C]	E =	205400	N/mm²
modulus of elasticity, bolting-up [20°C]	E =	212000	N/mm²

Gasket Data

gasket type: 4- asbestos - only for Information
calculation without reduction of setting load = 0- no
retighten the bolts after setting of gasket = 1- Yes
code no. of medium: 1- design: gases and vapours; test: liquids

outside diameter, gasket	dDa =	595	mm
inside diameter, gasket	dDi =	520	mm
thickness of gasket	hD =	3	mm

Bolt Data

material: 0171-5.6 DIN 267 Teil 13:1993-08 AD-W7:1999-12

strength value, design	K =	270	N/mm²
yield strength Rp 0.2 [120°C,20mm]			
strength value, test/bolting-up	K'=	300	N/mm²
yield strength Rp 0.2 [20°C,20mm]			
root diameter of screw thread	dk =	20.11	mm
effective diameter thread	d2 =	22.051	mm
outer diameter of bearing surface (bolting)	daS =	36	mm
thread angle, bolts	α =	60	°
thread pitch, bolts	P =	3	mm
min coefficient of friction, thread	μG_min =	.12	
min coefficient of friction, bearing surface	μA_min =	.12	

continuation Bolt Data

max coefficient of friction, thread	µG_max =	.12
max coefficient of friction, bearing surface	µA_max =	.12

results

summary of results

flange		bolting-up		design		testing		FS0 max
act. stresses and reserve								
section A-A	N/mm²	77	**183%**	38	**285%**	56	**291%**	226
section B-B	N/mm²	124	**77%**	61	**141%**	90	**144%**	361
section C-C	N/mm²	52	**325%**	20	**617%**	29	**646%**	150
act. flange deflection	°	0.292		0.148		0.211		0.85
bolts								
req root diameter	dk mm	13.26	**130%**	12.37	**233%**	8.96	**404%**	20.11

geometry data

calc. wall thickness of hub respectively tube	s1 =	3.70	mm
with manufacturing tolerance	c1 =	0.40	mm
corosion allowance	c2 =	3.00	mm
moment arms			
- of hub load	aR =	57.85	mm
- of ring area load	aF =	45.47	mm
- of gasket load	aD =	31.25	mm
- of bolt load (for section C-C)	a1 =	39.00	mm
reduced bolt hole diameter	dL'=	13.00	mm
mean gasket diameter	dD =	557.50	mm
effective width of gasket	bD =	37.50	mm
bolt pitch / dL	=	3.75	

		bolt-up (0)	design (B)	testing (P)
gasket data				
medium		gases/vap.	gases/vap.	liquids
characteristic k1	mm	--	48.75	37.50
characteristic k0*KD	N/mm	707.11	--	--
loads	N			
hub load - int.press.	FI..	--	118093	181863
ring area load	FF..	--	28371	43692
gasket load - design	FD..	--	61475	72825
setting load	FDV	1238454	--	--
red. setting load	FDV'	653665	--	--
min req bolt load	FS..	653665	207940	298379
flange (DIN 2505)				
bending moments	Nmm			
section A-A,B-B		20427030	10042956	14783420
section C-C		20427030	8109641	11636796
section modulus	mm^3			
section A-A		263735	263688	263633
section B-B		164850	164805	164752
section C-C		396544	396544	396544
act stresses	N/mm²			
section A-A		77.45	38.09	56.08
section B-B		123.91	60.94	89.73
section C-C		51.51	20.45	29.35
design stress	N/mm²	219.05	146.67	219.05
eff. stress reserve				
section A-A	%	**183**	**285**	**291**
section B-B	%	**77**	**141**	**144**
section C-C	%	**325**	**617**	**646**
act flange deflection	°	0.2917	0.1480	0.2111

			bolt-up (0)	design (B)	testing (P)
bolts					
req root diameter	dk	mm	13.26	12.37	8.96
auxiliary factor	Z		1.27	1.51	1.27
design allowance	c5	mm	0.00	3.00	0.00
stress reserve		%	**130**	**233**	**404**

max allow operating pressure pmax = **14.42 bar**
max allow test pressure pTmax = **22.49 bar**

results for bolting up condition (for information)

basic bolt load FS0 max = 1905747 N
acc. to stress value of 100% of strength value
of bolts (testing/ bolting-up)

actual stress section A-A = 225.8 N/mm²
actual stress section B-B = 361.3 N/mm²
actual stress section C-C = 150.2 N/mm²
actual flange deflection = 0.850 °
actual seating stress of gaske = 29.0 N/mm²

bolting torques acc. to VDI-Richtlinie 2230

req bolting torque (with µmax) MAmin = 127 Nm
with FVM =FS0 = 653665 N / 20 bolts = 32683 N

act seating stress of gasket with MAmin = 10.0 N/mm²

max bolting torque (bolting-up/with µmin) MAmax = 224 Nm
with FVM = FS0maxT = 1155523 N / 20 bolts = 57776 N
FS0maxT = cause of usage factor of flange reduced force FS0max.

act seating stress of gasket with MAmax = 17.6 N/mm²

$$MA = FVM * (d2/2 * \tan(phi + rho') + \mu A * rA)$$
$$phi = \arctan(P / (d2 * \pi))$$
$$rho' = \arctan(\mu G / \cos(\alpha / 2))$$
$$rA = (dL + daS) / 4$$

the seating stress of gasket was not checked with MAmax !

Unstayed and Stayed Flat Ends and Plates
acc to AD 2000-Merkblatt B5:2004-05

drawing no: 11441-0
name/ item: Blind flange DN 500

input data

Type Declaration

shape of plate		= 1- circular
bound cond: 13- supplementary marginal moment (chapt 6.3)		
calculation of deflection of plate without opening		= 0- no

Design Data/ Type of Plate

design pressure	p =	6 bar
design temperature	T =	120 °C

Material Data

plate: 0741-P 265 GH (1.0425) DIN EN 10028-2:1992 AD-W1:1998-02		
design strength value, plate	K =	215 N/mm²
yield strength Rp 0.2 [120°C,28mm]		
design strength value at room temperature	K20 =	255 N/mm²
yield strength Rp 0.2 [20°C,28mm]		
modulus of elasticity [120°C]	E =	205400 N/mm²
safety factor, plate	S =	1.5

Geometry Data

actual wall thickness, plate	se =	28 mm
manufacturing tolerance	c1 =	7- DIN EN 10029A
corrosion allowance	c2 =	3 mm
bolt circle diameter (plate width)	dt;f =	620 mm
mean gasket diameter (plate width)	dD;f =	557.5 mm
residual plate thickness	sR =	24 mm
gasket type: 4- asbestos - only for Information		
width of gasket	b =	37.5 mm
code no. of medium: 1- gases and vapours		

Openings in Plates

opening: 0- none

results

results shown in percentages signify over-/underdimensioning
for dimensions: (act-req) / req, with other data: (allow-act) / act

required plate thickness	sreq =	22.50 mm
	res =	**+24 %**
manufacturing tolerance	c1 =	0.6 mm
corrosion allowance	c2 =	3.0 mm
manuf. toler., act. plate thickness, for Info only	c1 =	0.8 mm
design diameter (width)	D1;f =	557.5 mm
design factor (fig 5)	C1 =	0.524
with diameter ratio	dt/dD =	1.112
with gasket characteristic	k1 =	48.750 mm
with value	delta =	1.420
max allow operating pressure	pmax =	**10.49 bar**
max allow test pressure	pTmax =	**17.78 bar**
conditions for flat end design		
req resid thickness	sRmin =	15.75 mm
	res =	**+52 %**

Horizontal Cylindrical Shells on Saddles
acc to AD 2000-Merkblatt S3/2:2001-09

drawing no: 11441
name/ item: Molsieve Filter, saddle, operation condition

input data

Type Declaration

types of support: 1- Type A - two saddles, symmetrical
saddle type with stiffener = 0- no
reinforcing plate existent = 0- no
forms of saddle support: 4- form B II - vertical with reinforcing ribs

Design Data

design pressure	p =	6	bar
design temperature	T =	120	°C
total weight force	G =	23000	N

load case acc to AD-S3/0 sect 4.2: 1- load case BF1
internal pressure, temperature, dead/ external/ live/ wind/ snow load

Material Data, Shell

material: 0741-P 265 GH (1.0425) DIN EN 10028-2:1992 AD-W1:1998-02

design strength value	K =	215	N/mm²
yield strength Rp 0.2 [120°C,8mm]			
safety factor	S =	1.5	
load case aux value for bending stress, formula 2	K2 =	1.2	
modulus of elasticity [120°C]	E =	205400	N/mm²
joint efficiency	vB =	.85	

Material Data, Saddle Support

material: 0741-P 265 GH (1.0425) DIN EN 10028-2:1992 AD-W1:1998-02

design strength value	Ks =	215	N/mm²
yield strength Rp 0.2 [120°C,12mm]			
safety factor	Ss =	1.5	
allow design stress acc to AD-S3/0, table 1	fv =	143.33	N/mm²
modulus of elasticity [120°C]	Es =	205400	N/mm²

Geometry Data, Shell

outer diameter	Da =	1316	mm
wall thickness cylinder	se =	8	mm
manufacturing tolerance	c1 =	7- DIN EN 10029A	
corrosion allowance	c2 =	3	mm
length of cylinder (incl. cylindrical skirt)	L =	3000	mm
mean depth of dished end	h2 =	340	mm
weakening factor	Nue =	.85	
largest unsupported length	l_DASt =	1940	mm

Geometry Data, Saddle

angle of saddle support, figure 2a and table 2	δ1 =	90	°
angle of support plate, figure 2a	δ2 =	100	°
distance of saddle supports	l1 =	1940	mm
width of saddle support	b1 =	160	mm
wall thickness of saddle web plate	es =	12	mm
effective plate width of web plate, fig 6	be =	350	mm
wall thickness of support plate, sec A-A, fig 8	e2 =	8	mm
length of web plate, fig 6	l2 =	1000	mm
dist. saddle to center of gravity of dished end	a3 =	870	mm

results

results shown in percentages signify over-/underdimensioning
for dimensions: (act-req) / req, with other data: (allow-act) / act

```
  actual wall thickness                     se - c1 - c2 =   e =       4.50 mm
    with c1 =  0.50    and    c2 =  3.00
  inner diameter of shell                    Da - 2 * e =   D =     1307.0 mm
  distance saddle - end of cyl. part           (L-l1)/2 =  a1 =      530.0 mm

4.2 actual stress resultants
  spec. transverse force  G / ( L + 4/3 * h2 ) =        q =       6.66 N/mm
  support moment                     q * D² / 16 =     M0 =        711 Nm

4.2.1 reaction support forces
  saddle no. 1 ; 2                                Omega1 =     1.0000
  reaction support force        Omega1 * G / n =     F1 =      11500 N

4.2.2 moments and transverse shear forces
  support moment              q * a3² / 2 - M0 =   M1 = M2 =     1809 Nm
  trans. force    (L-2*a1) / (L+4/3*h2) * F1 =   Q1 = Q2 =       6460 N
  mid-span M0 + F1 * (L/2-a1) - q/2 * (L/2+2/3*h2)² = M =        1938 Nm

4.3 verification at mid-span between supports
4.3.1 vessels subject or not subject to internal pressure
  acc. to section 8 (diagrams):                      K14 =     1.4969
       p * D              4 * ABS(M) * K14
  _____________  +  ________________________   <=   f=K/S
  40 * e * Nue        π * D² * e * Nue
                                  51.82        <=     143.3                  177 %

  verification of stability acc to DASt 013
    4 * ABS(M) / (π * (D + e)² * e) =                  σ_x43 =       0.3 N/mm²
    σ_x,u      >=    σ_x43 * τ_DASt               with τ_DASt =     1.50
          152 >=                0                                     9999 %

5 verification of cylinder load-carrying capacity in the saddle region
5.2.1.1 proof of strength (no reinf plate, no stiffening ring)
  aux values
    angle of saddle support                              δ1B =      1.571 rad
    2.83 * a1 / D * SQRT(e/D) =                            τ =     0.0673
    0.91 * b1 / SQRT(D*e) =                                ß =     1.8985
                                                          K2 see input part
    max( 2.718282^(-ß) * sin(ß) / ß;  0.25 )      =      K3 =      0.250
    1 - 2.718282^(-ß) * cos(ß) / ß                =      K4 =      0.552
    1.15 - 0.1432 * δ1B / sin(0.5 * δ1)           =      K5 =      1.308
    max(1.7 - 2.1 * δ1B / π;  0) / sin(0.5*δ1)    =      K6 =      0.919
    1.45 - 0.43 * δ1B / sin(0.5 * δ1)             =      K7 =      1.095
    min(1.0;  0.8 * SQRT(τ) + 6 * τ / δ1B )       =      K8 =      0.389
    1 - 0.65 / (1+(6*τ)²) * SQRT(π / (3 * δ1B)) =        K9 =      0.544
    1 / (1 + 0.6* (D/e)^(1/3) * b1 / D * δ1B)    =      K10 =      0.567

    ABS(4 * M1 / (π * D² * e))                    =    σ_mx =       0.30 N/mm²

    Theta-values at location 2
      -0.23 * K6 * K8 / (K5 * K3) =              Theta1, 2 =   -0.25170
      -σ_mx * K2 / (S * f) =                     Theta21,2 =   -0.00167
      (p*D/(40*e) - σ_mx) * K2 / (S*f) =         Theta22,2 =    0.24149
      For Theta2-values lesser than 0 the absolute value of Theta2 has
      been used and the sign of Theta1 has been inverted.
    applied: Theta21,2                                K1,2 =     1.3302
```

Theta-values at location **3**
-0.53 * K4 / (K7*K9*K10*sin(0.5*δ1)) = Theta1 ,3 = -1.22567
(const) Theta21,3 = 0
p * D / (20 * e) * K2 / (S * f) = Theta22,3 = 0.48633
applied: Theta21,3 K1,3 = 0.6236

allowable bending stress (5.1)
with allowable stress K / S = f = 143.33 N/mm²
K1,2 * f * S / K2 = σ_gr,2 = 238.32 N/mm²
K1,3 * f * S / K2 = σ_gr,3 = 111.73 N/mm²

0.7*σ_gr,2 * SQRT(D*e)*e / (K3 * K5) = allF2 = 176033 N
0.9*σ_gr,3 * SQRT(D*e)*e / (K7*K9*K10)= allF3 = 102785 N
saddle 1 ; 2 F1 <= min(allF2; allF3) **794 %**

5.2.1.2 proof of stability acc to DASt 013
mean radius of shell (Da - e) / 2 = r = 655.75 mm
yield stress K = σ_F = 215.0 N/mm²
safety factor dependent on load case τ_DASt = 1.50

longitudinal stresses for non-benched cylinders of intermed length
0.605 * E * e / r = σ_x,Ki = 852.8 N/mm²
0.52 / SQRT(1 + r / (100 * e)) = α_x = 0.33
α_x * σ_x,Ki = σ_x,e = 282.9 N/mm²
σ_F * [1 + 0.434 * (0.2 - SQRT(σ_F/σ_x,e))] = σ_x,u = 152.3 N/mm²

shear stresses for non-benched cylinders
0.74 * E * (e/r)^5/4 * (r/l_DASt/2)^0.5 = σ_T,Ki = 123.4 N/mm²
Linear course of transverse force was assumed!
(const) = α_T = 0.65
α_T * σ_T,Ki = σ_T,e = 80.2 N/mm²
with σ_T,e <= 0.4*σ_F / SQRT(3) σ_T,e = σ_T,u = 72.9 N/mm²

saddle no. 1 ; 2
lowest point of the cross section
F1 * π / 4 * SQRT (D / e) * K6 * K8 = Fe = 55094.5 N
4 * ABS(M1) / (π*(D+e)^2*e) + Fe/(π*(D+e)*e)= σ_x = 3.3 N/mm²
σ_x,u >= σ_x * τ_DASt **3006 %**
side point of the cross section
2 * Q1 / [π * (D + e) * e] = σ_T = 0.7 N/mm²
σ_T,u >= σ_T * τ_DASt **6872 %**

6 verification of the load-carrying capacity of the saddle
6.1 allowable forces on the saddle (acc to 6.1.1 - 6.1.3)
min(allF4; allF5; allF6) = allFi = 281081 N
saddle 1 ; 2 F1 <= allFi **2344 %**
6.1.1 stability of web plate
not required for saddle support form A II and B II
6.1.2 bending of saddle support
not required for saddle support form B I and B II resp. stiffener
6.1.3 bending of web plate
1.4 * fs * D * e2² * sin(0.5 * δ2) / b1 = allF6_1 = 80363 N
2 * fs * b1 * e2 * sin(0.5 * δ2) = allF6_2 = 281081 N
max(allF6_1 ; allF6_2) = allF6 = 281081 N

Horizontal Cylindrical Shells on Saddles
acc to AD 2000-Merkblatt S3/2:2001-09

drawing no: 11441
name/ item: Molsieve Filter, saddle, testing condition

input data

Type Declaration

types of support: 1- Type A - two saddles, symmetrical
saddle type with stiffener = 0- no
reinforcing plate existent = 0- no
forms of saddle support: 4- form B II - vertical with reinforcing ribs

Design Data

design pressure	p =	9.244	bar
design temperature	T =	20	°C
total weight force	G =	71000	N

load case acc to AD-S3/0 sect 4.2: 1- load case BF1
internal pressure, temperature, dead/ external/ live/ wind/ snow load

Material Data, Shell

material: 0741-P 265 GH (1.0425) DIN EN 10028-2:1992 AD-W1:1998-02

design strength value	K =	265	N/mm²
yield strength Rp 0.2 [20°C,8mm]			
safety factor	S =	1.2	
load case aux value for bending stress, formula 2	K2 =	1.2	
modulus of elasticity [20°C]	E =	212000	N/mm²
joint efficiency	vB =	.85	

Material Data, Saddle Support

material: 0741-P 265 GH (1.0425) DIN EN 10028-2:1992 AD-W1:1998-02

design strength value	Ks =	265	N/mm²
yield strength Rp 0.2 [20°C,12mm]			
safety factor	Ss =	1.5	
allow design stress acc to AD-S3/0, table 1	fv =	176.66	N/mm²
modulus of elasticity [20°C]	Es =	212000	N/mm²

Geometry Data, Shell

outer diameter	Da =	1316	mm
wall thickness cylinder	se =	8	mm
manufacturing tolerance	c1 =	7- DIN EN 10029A	
corrosion allowance	c2 =	3	mm
length of cylinder (incl. cylindrical skirt)	L =	3000	mm
mean depth of dished end	h2 =	340	mm
weakening factor	Nue =	.85	
largest unsupported length	l_DASt =	1940	mm

Geometry Data, Saddle

angle of saddle support, figure 2a and table 2	δ1 =	90	°
angle of support plate, figure 2a	δ2 =	100	°
distance of saddle supports	l1 =	1940	mm
width of saddle support	b1 =	160	mm
wall thickness of saddle web plate	es =	12	mm
effective plate width of web plate, fig 6	be =	350	mm
wall thickness of support plate, sec A-A, fig 8	e2 =	8	mm
length of web plate, fig 6	l2 =	1000	mm
dist. saddle to center of gravity of dished end	a3 =	870	mm

results

results shown in percentages signify over-/underdimensioning
for dimensions: (act-req) / req, with other data: (allow-act) / act

```
actual wall thickness                          se - c1 - c2 =   e =      4.50 mm
  with c1 =  0.50   and   c2 =  3.00
inner diameter of shell                          Da - 2 * e =   D =    1307.0 mm
distance saddle - end of cyl. part                (L-l1)/2 =  a1 =     530.0 mm
```

4.2 actual stress resultants

```
spec. transverse force  G / ( L + 4/3 * h2 ) =        q =     20.56 N/mm
support moment                      q * D² / 16 =     M0 =      2195 Nm
```

4.2.1 reaction support forces

```
saddle no. 1 ; 2                                 Omega1 =    1.0000
reaction support force        Omega1 * G / n =       F1 =     35500 N
```

4.2.2 moments and transverse shear forces

```
support moment              q * a3² / 2 - M0 =  M1 = M2 =      5586 Nm
trans. force    (L-2*a1) / (L+4/3*h2) * F1 =   Q1 = Q2 =     19943 N
mid-span M0 + F1 * (L/2-a1) - q/2 * (L/2+2/3*h2)² = M =      5982 Nm
```

4.3 verification at mid-span between supports

4.3.1 vessels subject or not subject to internal pressure

```
acc. to section 8 (diagrams):                          K14 =    1.4969
```

$$\frac{p * D}{40 * e * Nue} + \frac{4 * ABS(M) * K14}{\pi * D^2 * e * Nue} \leq f=K/S$$

```
                              80.71    <=     220.8                  174 %
```

```
verification of stability acc to DASt 013
  4 * ABS(M) / (π * (D + e)² * e) =               σ_x43 =        1.0 N/mm²
  σ_x,u     >=    σ_x43 * τ_DASt          with τ_DASt =       1.50
       178 >=                1                                  9999 %
```

5 verification of cylinder load-carrying capacity in the saddle region

5.2.1.1 proof of strength (no reinf plate, no stiffening ring)

```
aux values
  angle of saddle support                            δ1B =      1.571 rad
  2.83 * a1 / D * SQRT(e/D) =                          τ =     0.0673
  0.91 * b1 / SQRT(D*e) =                              ß =     1.8985
                                                      K2 see input part
  max( 2.718282^(-ß) * sin(ß) / ß;  0.25 )      =     K3 =      0.250
  1 - 2.718282^(-ß) * cos(ß) / ß                =     K4 =      0.552
  1.15 - 0.1432 * δ1B / sin(0.5 * δ1)           =     K5 =      1.308
  max(1.7 - 2.1 * δ1B / π;  0) / sin(0.5*δ1)    =     K6 =      0.919
  1.45 - 0.43 * δ1B / sin(0.5 * δ1)             =     K7 =      1.095
  min(1.0;  0.8 * SQRT(τ) + 6 * τ / δ1B )       =     K8 =      0.389
  1 - 0.65 / (1+(6*τ)²) * SQRT(π / (3 * δ1B))   =     K9 =      0.544
  1 / (1 + 0.6* (D/e)^(1/3) * b1 / D * δ1B)     =    K10 =      0.567

  ABS(4 * M1 / (π * D² * e))                    =  σ_mx =       0.93 N/mm²

  Theta-values at location 2
    -0.23 * K6 * K8 / (K5 * K3) =              Theta1, 2 =  -0.25170
    -σ_mx * K2 / (S * f) =                     Theta21,2 =  -0.00419
    (p*D/(40*e) - σ_mx) * K2 / (S*f) =         Theta22,2 =   0.29976
    For Theta2-values lesser than 0 the absolute value of Theta2 has
    been used and the sign of Theta1 has been inverted.
  applied: Theta21,2                                K1,2 =    1.3281
```

Theta-values at location **3**
-0.53 * K4 / (K7*K9*K10*sin(0.5*δ1)) = Theta1 ,3 = -1.22567
(const) Theta21,3 = 0
p * D / (20 * e) * K2 / (S * f) = Theta22,3 = 0.60789
applied: Theta21,3 K1,3 = 0.6236

allowable bending stress (5.1)
with allowable stress K / S = f = 220.83 N/mm²
K1,2 * f * S / K2 = σ_gr,2 = 293.30 N/mm²
K1,3 * f * S / K2 = σ_gr,3 = 137.72 N/mm²

0.7*σ_gr,2 * SQRT(D*e)*e / (K3 * K5) = allF2 = 216639 N
0.9*σ_gr,3 * SQRT(D*e)*e / (K7*K9*K10)= allF3 = 126689 N
saddle 1 ; 2 F1 <= min(allF2; allF3) **257 %**

5.2.1.2 proof of stability acc to DASt 013
mean radius of shell (Da - e) / 2 = r = 655.75 mm
yield stress K = σ_F = 265.0 N/mm²
safety factor dependent on load case τ_DASt = 1.50

longitudinal stresses for non-benched cylinders of intermed length
0.605 * E * e / r = σ_x,Ki = 880.2 N/mm²
0.52 / SQRT(1 + r / (100 * e)) = α_x = 0.33
α_x * σ_x,Ki = σ_x,e = 292.0 N/mm²
σ_F * [1 + 0.434 * (0.2 - SQRT(σ_F/σ_x,e))] = σ_x,u = 178.4 N/mm²

shear stresses for non-benched cylinders
0.74 * E * (e/r)^5/4 * (r/l_DASt/2)^0.5 = σ_T,Ki = 127.4 N/mm²
Linear course of transverse force was assumed!
(const) = α_T = 0.65
α_T * σ_T,Ki = σ_T,e = 82.8 N/mm²
with σ_T,e <= 0.4*σ_F / SQRT(3) σ_T,e = σ_T,u = 80.0 N/mm²

saddle no. 1 ; 2
lowest point of the cross section
F1 * π / 4 * SQRT (D / e) * K6 * K8 = Fe = 170074.4 N
4 * ABS(M1) / (π*(D+e)^2*e) + Fe/(π*(D+e)*e)= σ_x = 10.1 N/mm²
σ_x,u >= σ_x * τ_DASt **1079 %**
side point of the cross section
2 * Q1 / [π * (D + e) * e] = σ_T = 2.2 N/mm²
σ_T,u >= σ_T * τ_DASt **2380 %**

6 verification of the load-carrying capacity of the saddle
6.1 allowable forces on the saddle (acc to 6.1.1 - 6.1.3)
min(allF4; allF5; allF6) = allFi = 346443 N
saddle 1 ; 2 F1 <= allFi **876 %**
6.1.1 stability of web plate
not required for saddle support form A II and B II
6.1.2 bending of saddle support
not required for saddle support form B I and B II resp. stiffener
6.1.3 bending of web plate
1.4 * fs * D * e2² * sin(0.5 * δ2) / b1 = allF6_1 = 99050 N
2 * fs * b1 * e2 * sin(0.5 * δ2) = allF6_2 = 346443 N
max(allF6_1 ; allF6_2) = allF6 = 346443 N

Spherical shell
subject to internal pressure and add. loads
WRC 107:1979-03, KTA 3211.2, AD S4:2000-10

drawing no: 11441-0
name/ item: Nozzle N1, N2 (DN700)

input data

Type Declaration
superposition of int. pressure: 2- KTA 3211

Design data			
design pressure	p =	6	bar
design temperature	T =	120	°C
Additional Loads			
lever arm of loading point	a =	0	mm
radial force (in direction of vessel - positive)	P =	-31500	N
shearing force in direction 1-1	V1 =	0	N
shearing force in direction 2-2	V2 =	0	N
moment in direction 1-1	M1 =	35454	Nm
moment in direction 2-2	M2 =	0	Nm
torsional moment	Mt =	0	Nm
Material Data			
material: 0741-P 265 GH (1.0425) DIN EN 10028-2:1992 AD-W1:1998-02			
design strength value	K =	215	N/mm²
yield strength Rp 0.2 [120°C,20mm]			
safety factor	S =	1.5	
shear stress theory= 1 / deformation energy theory= 2	=	1	
Geometry Data Spherical Shell			
outer diameter of spherical shell	DA =	2080	mm
actuall wall thickness	Te =	20	mm * incl. reinforcing pad
manufacturing tolerance	c1 =	6- DIN 28011-13	
corrosion allowance	c2 =	3	mm
Geometry Data Nozzle			
code-no: 1- nozzle, round			
nozzle outer diameter	da =	711	mm
nozzle wall thickness	t =	12	mm
manufacturing tolerance	c1 =	7- DIN EN 10029A	
corrosion allowance	c2 =	3	mm

actual thickness of spherical shell T= sH= Te-c1-c2 = 16.50 mm
tolerance spherical shell c1/c2 = 0.50/3.00 mm
actual thickness of nozzle t= sA= te-c1-c2 = 8.50 mm
tolerance nozzle c1/c2 = 0.50/3.00 mm

geometrical values WRC

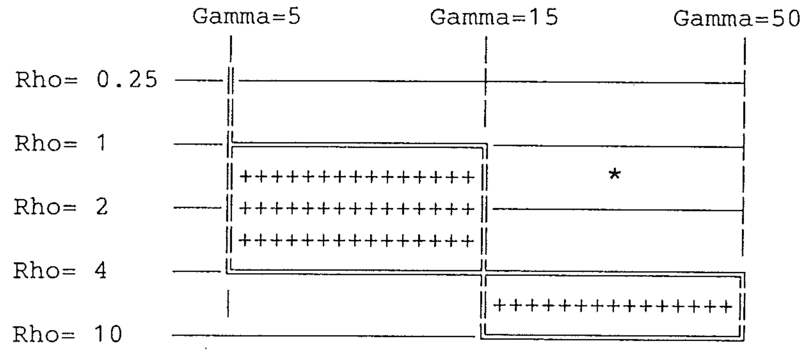
for rho= 1.94; gamma=41.32; u=2.200

Nx*T/P:0.0096 | Mx/P:0.0051 | Nx*T*√(RmT)/M:0.0080 | Mx*√(RmT)/M:0.0045
Ny*T/P:0.0921 | My/P:0.0060 | Ny*T*√(RmT)/M:0.0734 | My*√(RmT)/M:0.0063

This values has been interpolated from the diagrams
SP-1 to SP-10 and SM-1 to SM-10 using the folowing values
for gamma = 15 and rho = 1 and 2
and gamma = 50 and rho = 4

N= normal force, M= moment, x= meridional-, y= tangential-component

explanation to scope of Diagrams of WRC 107



+: in WRC specified values *: vallue needed for calculation

geometrical values KTA

da/√((DA-T)*T) = 3.81 (DA-T)/T = 125.06 t/T = 0.52

	stress value a	local membran stress
membran component	5.11	95.84
membran + bending comp.	9.02	169.21

single stresses

σ N/mm²	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Nx - P	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Mx - P	3.6	-3.6	3.6	-3.6	3.6	-3.6	3.6	-3.6
Nx - M1					-8.0	-8.0	8.0	8.0
Mx - M1					-27.1	27.1	27.1	-27.1
Nx - M2	0.0	0.0	0.0	0.0				
Mx - M2	0.0	0.0	0.0	0.0				
total - x	4.7	-2.4	4.7	-2.4	-30.4	16.7	39.7	-21.6
Ny - P	10.7	10.7	10.7	10.7	10.7	10.7	10.7	10.7
My - P	4.2	-4.2	4.2	-4.2	4.2	-4.2	4.2	-4.2
Ny - M1					-73.3	-73.3	73.3	73.3
My - M1					-37.6	37.6	37.6	-37.6
Ny - M2	0.0	0.0	0.0	0.0				
My - M2	0.0	0.0	0.0	0.0				
total - y	14.8	6.5	14.8	6.5	-96.1	-29.1	125.7	42.1

continuation single stresses

σ N/mm²	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
τ - V1					0.0	0.0	0.0	0.0
τ - V2	0.0	0.0	0.0	0.0				
τ - Mt	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
total - Tau	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Au=position A upper, Al= position A lower, Bl= position B upper
N= membran components, M = bending components, τ=tau= shear stress
P= radial force, M11/M22= overtuning moment, V1/V2= shear load
Mt=torsional moment, x = meridian dir. (1-1) y= tangential (2-2)

combines stress according to AD-Merkblatt S4

SSH: shear stress theory

m stresses N/mm²		A	B	C	D
WRC-x	σmx	1.1	1.1	-6.8	9.1
WRC-y	σmy	10.7	10.7	-62.6	83.9
WRC-τ	σmτ	0.0	0.0	0.0	0.0
KTA	σmP	95.8	95.8	95.8	95.8
total-x	σmTx	97.0	97.0	89.0	104.9
total-y	σmTy	106.5	106.5	33.2	179.8
comb.str.	σmC	106.5 **102%**	106.5 **102%**	89.0 **142%**	179.8 **20%**
allowed	1.5*f	215.0	215.0	215.0	215.0

m+b stresses N/mm²		Au	Al	Bu	Bl	Cu	Cl	Du	Dl
WRC-x	σmbx	4.7	-2.4	4.7	-2.4	-30.4	16.7	39.7	-21.6
WRC-y	σmby	14.8	6.5	14.8	6.5	-96.1	-29.1	125.7	42.1
WRC-τ	σmbτ	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
KTA	σmbP	169.2		169.2		169.2		169.2	
total-x	σmbTx	173.9	166.8	173.9	166.8	138.9	185.9	208.9	147.6
total-y	σmbTy	184.0	175.7	184.0	175.7	73.1	140.1	294.9	211.3
comb.str.	σmbC	184.0	175.7	184.0	175.7	138.9	185.9	294.9	211.3
		134%	**145%**	**134%**	**145%**	**210%**	**131%**	**46%**	**103%**
allowed	3*f	430.0		430.0		430.0		430.0	

m= membrane stress b= bending stress C= combined stress
x= meridian direc. y= tangential direction T= total stress

reference: - Welding Research Council Bulletin No.107, edition 3.79
- stress rating according to AD-Merkblatt S4
- KTA 3211.2

Following formulas are used to calculate the stresses:

- calculation with int. pressure loading acc. to KTA
  $\sigma mTx = \sigma mx + \sigma mP$ $\sigma mbTx = \sigma mbx + \sigma mbP$
  $\sigma mTy = \sigma my + \sigma mP$ $\sigma mbTy = \sigma mby + \sigma mbP$

- calculation of combined stress according to SS- theory
  σmC: max from $\frac{1}{2} * [(\sigma mx+\sigma my) \pm SQR((\sigma mx-\sigma my)^2 + 4*\tau^2)]$
  and $SQR((\sigma mx-\sigma my)^2 + 4*\tau^2)$
  σmbC: max from $\frac{1}{2} * [(\sigma mbx+\sigma mby) \pm SQR((\sigma mbx-\sigma mby)^2 + 4*\tau^2)]$
  and $SQR((\sigma mbx-\sigma mby)^2 + 4*\tau^2)$

- abbreviations:
  σm : membrane stress (WRC 107)
  σmP: int.press.stress (membr.)
  σmT: total membran stress
  σmC: combined membran stress
  τ : shearing stress (WRC 107)
  σmb : membrane+ bending stress WRC
  σmbP: int.press.stress(m.+bending)
  σmbT: total membran+bending stress
  σmbC: combined m. + bending stress

Calculation of lug **for** **Molsieve Filter**
acc. to drawing no. **11441** **Com.:** **37.016**

The calculation was prepared following DIN 28086

Loads:

Number of lugs $n=$ **2**

The empty weigth of one Molsieve Filter is about 2200 N

$S_1=$	**15**	mm
$R_1=$	**71**	mm
$d=$	**38**	mm
$h_1=$	**60**	mm
$b=$	**52**	mm
$2c=$	**90**	mm
$F_1=$	**8800**	N

Impact factor: 1,6

$Fe = 2200 * 0{,}5 * 1{,}6 = 1760$ N

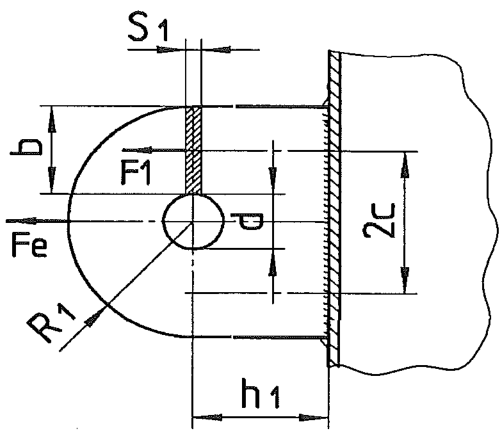
1. Calculation of tailing eye:

Moments and stresses:

$$Mb = \frac{Fe * 2c}{8} = 19800{,}00 \text{ Nmm}$$

$$W_{(actual)} = \frac{S_1 * b^2}{6} = 6760{,}00 \text{ mm}^3$$

$$A_{(act)} = S_1 * b = 780{,}00 \text{ mm}^2$$



Bending stress

$$\delta_{(b)} = \frac{Mb}{W_{(actual)}} = 2{,}93 \text{ N/mm}^2$$

Tension

$$\delta_{(z)} = \frac{F1}{A_{(actual)}} = 11{,}28 \text{ N/mm}^2$$

Total stress

$$\delta_{(tot)} = \delta_{(b)} + \delta_{(z)} = 14{,}21 \text{ N/mm}^2$$

Allowable stress value acc. to ASME Sect.IIA SA-516 Gr.60

S (90% of Yield Strength)= **198,57** N/mm²

$\delta_{(tot)}=$ **14,21** N/mm² < **S** (allow.)= **198,57** N/mm² (+ 1297,3 %)

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2. Calculation of welding seams:

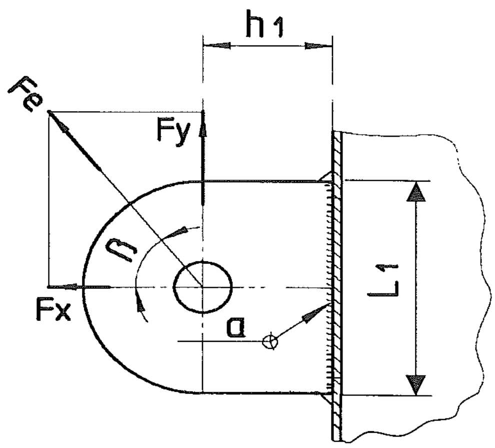
h_1=	**60**	mm
L_1=	**110**	mm
a=	**5**	mm

Total cross area of fillet welds:

$A_{(S)} = 2 * L_1 * a = 1100{,}00$ mm²

Total moment of resistance:

$$W_{(S)} = \frac{2 * a * L_1^{2}}{6} = 20166{,}67 \text{ mm}^3$$



The angle of maximum strain is β=ca. 45 °

cos β= 0,71

sin β= 0,71

$F_x = F_e * \cos\beta = 1244{,}51$ N

$F_y = F_e * \sin\beta = 1244{,}51$ N

Bending stress:

$$\delta_{(b)} = \frac{M_b}{W_{(S)}} = \frac{F_y * h1}{W_{(S)}} = 3{,}70 \text{ N/mm}^2$$

Tension:

$$\delta_{(z)} = \frac{F_x}{A_{(S)}} = 1{,}13 \text{ N/mm}^2$$

Gesamt Spannung:

$$\delta_{(tot)} = \delta_{(b)} + \delta_{(z)} = 4{,}83 \text{ N/mm}^2$$

Total stress:

$$\tau = \frac{F_y}{A_{(S)}} = \mathbf{1{,}13} \text{ N/mm}^2$$

Relative stress:

$$\delta_{(v)} = \sqrt{\delta_{(tot)}^{2} + \tau^{2}} = 4{,}96 \text{ N/mm}^2$$

Allowable stress value for welding seams with a joint efficiency E of 0,55

$S_w = E * S_{(allow.)} =$ **109,21** N/mm²

$\delta_{(v)} =$ **4,96** N/mm² < $S_{(allow.)} =$ **109,21** N/mm² (+ 2099,8 %)

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Unstayed and Stayed Flat Ends and Plates
acc to AD 2000-Merkblatt B5:2004-05

drawing no: 11441-0
name/ item: Cover Nozzle N1/N2 only for pressure test

input data

Type Declaration

shape of plate		= 1- circular
bound cond: 8- welded onto, both-side-welded (table 1, f)		

Design Data/ Type of Plate

design pressure	p =	9.24 bar
design temperature	T =	20 °C

Material Data

plate: 0703-S 235 JR G2 (1.0038) DIN EN 10025:1994-03 AD-W1:1998-02		
design strength value, plate	K =	225 N/mm²
yield strength Rp 0.2 [20°C,25mm]		
design strength value at room temperature	K20 =	225 N/mm²
yield strength Rp 0.2 [20°C,25mm]		
modulus of elasticity [20°C]	E =	212000 N/mm²
safety factor, plate	S =	1.05

Geometry Data

actual wall thickness, plate	se =	25 mm
manufacturing tolerance	c1 =	7- DIN EN 10029A
corrosion allowance	c2 =	1 mm
outer diameter of shell (plate width)	Da;fa =	711 mm
actual wall thickness, shell	s1 =	10 mm

Openings in Plates

opening: 0- none

results

results shown in percentages signify over-/underdimensioning
for dimensions: (act-req) / req, with other data: (allow-act) / act

required plate thickness	sreq =	19.75 mm
	res =	**+27 %**
manufacturing tolerance	c1 =	0.6 mm
corrosion allowance	c2 =	1.0 mm
manuf. toler., act. plate thickness, for Info only	c1 =	0.8 mm
design diameter (width)	D1;f =	691.0 mm
design factor serf =< 3*	C =	0.400
max allow operating pressure	pmax =	**16.16 bar**

only killed steels may be utilised. When plate material is employed, over an area of at least 3*s1 in the weld zone there must be no evidence of material discontinuities in the plate.