WOLF	**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 Adsorber**

Tag No.: **W15001 / W15002**

Drawing No.: **11437 - 0**

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WOLF GmbH & Co. KG
Behälter- und Apparatebau
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Test Pressure Calculation
acc to AD 2000-Merkblatt HP30:2003-01

drawing no: 11437-0
name/ item: Molsieve Adsorber W15001 / W15002

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 =	250 °C
temperature for test condition	T'=	20 °C
operating mode horizontal = 1	vertical = 2 =	2
pressure test horizontal = 1	vertical = 2 =	1
length (height) of vessel	L / H =	4020 mm

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 yield strength Rp 0.2 [250°C,20mm]	K =	175 N/mm²
design strength value at T' yield strength Rp 0.2 [20°C,20mm]	K'=	255 N/mm²

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.

additional pressure from static liquid column pstat = 0.402 bar

intermediate results

no	name / item	material	*	thickness mm	factor K'/K	Fp	req test press bar
1	Mantel	P 265 GH	D	>16=<40	1.457	1.821	**11.330**

required **test pressure pT = 11.331** bar, for component with no. 1
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!

For Information
For the calculation of testing condition of the vessel the additional static column from medium (=Di) have to be considered.

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

drawing no: 11437-0
name/ item: Heads left and right

input data - dished end

<u>design data</u>

design pressure	p =	6 bar
design temperature	T =	250 °C

<u>material data, dished end</u>

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

design strength value yield strength Rp 0.2 [250°C,20mm]	K =	175 N/mm²
design strength value at room temperature yield strength Rp 0.2 [20°C,20mm]	K20 =	255 N/mm²
safety factor	S =	1.5
joint efficiency	v =	.85

<u>geometry data, dished end</u>

head type: 2- Korbbogen type

outer diameter	Da =	4040 mm
wall thickness	se =	20 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 =	17.79 mm
» act wall thickness is adequate!		res =	**+12 %**
with ß= 2.34 and (sreq-c)/Da=.0035 and manuf. tolerance/corrosion allowance		c1/c2 =	0.50/3.00 mm
allowances, head (act wall thickness)		c1/c2 =	0.50/3.00 mm
max. unreinforced opening crown		da max ca	640 mm
knuckle		da max ca	324 mm
influence of multiple openings / AD-B9 [8]	from	l <=	654.4 mm
max all working pressure – with decisive component: dished end		**pmax =**	**7.13 bar**
max all test pressure		**pTmax =**	**14.84 bar**

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

drawing no: 11437-0
name/ item: Shell Molsieve Adsorber W15001 / W15002

input data - shell

design data

design pressure	p =	6	bar
design temperature	T =	250	°C

material data, shell

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

design strength value	K =	175	N/mm²
yield strength Rp 0.2 [250°C,20mm]			
design strength value at room temperature	K20 =	255	N/mm²
yield strength Rp 0.2 [20°C,20mm]			
safety factor	S =	1.5	
joint efficiency	v =	.85	

geometry data, shell

outer diameter	Da =	4040	mm
actual wall thickness	se =	20	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 =	15.78	mm
» act wall thickness is adequate!	res =	**+27**	%
manufacturing tolerance / corrosion allowance	c1/c2 =	0.60/3.00	mm
allowances, shell (act wall thickness)	c1/c2 =	0.60/3.00	mm
max unreinforced opening	da max ca	299	mm
influence of multiple nozzles / AD-B9 [8] from	l <=	513.8	mm
max all working pressure	**pmax =**	**6.58**	**bar**
– with decisive component: opening no. 1			
max all test pressure	**pTmax =**	**13.69**	**bar**

input data - opening 1

opening - name/item: Manway N6, DN1000

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 =	175	N/mm²
yield strength Rp 0.2 [250°C,25mm]			
design strength value, nozzle at room temp.	K20 =	255	N/mm²
yield strength Rp 0.2 [20°C,25mm]			
joint efficiency, nozzle	v =	.85	

geometry data

outer diameter	da =	1000	mm
actual wall thickness	ss =	25	mm
manufacturing tolerance	c1 =	7- DIN EN	10029A
corrosion allowance	c2 =	3	mm
actual length of nozzle	ls =	200	mm
protruding length	ls'=	50	mm
distance nozzle outside diameter - discontinuity	x =	190	mm

results - opening 1

opening-name/item: Manway N6, DN1000

req wall thickness of nozzle acc to AD-B1	[2]	sserf =	6.42	mm
» act wall thickness is adequate!		res =	**+290**	%
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 =	106.4	N/mm²
allowable stress		K/S =	116.7	N/mm²
» actual opening is adequately reinforced!		res =	**+10**	%
with allowances, nozzle (act wall thickness)		c1/c2 =	0.80/3.00	mm
calculated wall thickness of nozzle		ss =	21.2	mm
calculated outer nozzle length	[6]	ls mit =	180.1	mm
inner nozzle length		ls'mit =	50.0	mm
calculated shell length	[3]	b mit =	190.0	mm
load-bearing cross sectional area		Aσ =	8341	mm²
pressure load area		Ap =	1475491	mm²

input data - opening 2

opening - name/item: Nozzle N1 / N2, DN 700

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 =	175	N/mm²
yield strength Rp 0.2 [250°C,20mm]			
design strength value, nozzle at room temp.	K20 =	255	N/mm²
yield strength Rp 0.2 [20°C,20mm]			
joint efficiency, nozzle	v =	.85	

geometry data

outer diameter	da =	711	mm
actual wall thickness	ss =	20	mm
manufacturing tolerance	c1 =	7- DIN EN 10029A	
corrosion allowance	c2 =	3	mm
actual length of nozzle	ls =	150	mm
protruding length	ls'=	50	mm
distance nozzle outside diameter - discontinuity	x =	0	mm

results - opening 2

opening-name/item: Nozzle N1 / N2, DN 700

req wall thickness of nozzle acc to AD-B1	[2]	sserf =	5.54	mm
» act wall thickness is adequate!		res =	**+261**	%
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 =	102.6	N/mm²
allowable stress		K/S =	116.7	N/mm²
» actual opening is adequately reinforced!		res =	**+14**	%
with allowances, nozzle (act wall thickness)		c1/c2 =	0.60/3.00	mm
calculated wall thickness of nozzle		ss =	16.4	mm
calculated outer nozzle length	[6]	ls mit =	133.4	mm
inner nozzle length		ls'mit =	50.0	mm
calculated shell length	[3]	b mit =	256.9	mm
load-bearing cross sectional area		Aσ =	7490	mm²
pressure load area		Ap =	1276945	mm²

input data - opening 3

opening - name/item: Nozzle N8, N9 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 =	175	N/mm²
yield strength Rp 0.2 [250°C,20mm]			

continuation material data

design strength value, nozzle at room temp.	K20 =	255	N/mm²
yield strength Rp 0.2 [20°C,20mm]			
joint efficiency, nozzle	v =	.85	

geometry data

outer diameter	da =	508	mm
actual wall thickness	ss =	20	mm
manufacturing tolerance	c1 =	7- DIN EN 10029A	
corrosion allowance	c2 =	3	mm
actual length of nozzle	ls =	150	mm
protruding length	ls'=	0	mm
distance nozzle outside diameter - discontinuity	x =	0	mm

results - opening 3

opening-name/item: Nozzle N8, N9 DN500

req wall thickness of nozzle acc to AD-B1	[2]	sserf =	4.93	mm
» act wall thickness is adequate!		res =	**+306**	**%**
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 =	100.3	N/mm²
allowable stress		K/S =	116.7	N/mm²
» actual opening is adequately reinforced!		res =	**+16**	**%**
with allowances, nozzle (act wall thickness)		c1/c2 =	0.60/3.00	mm
calculated wall thickness of nozzle		ss =	16.4	mm
calculated outer nozzle length	[6]	ls mit =	112.2	mm
inner nozzle length		ls'mit =	0.0	mm
calculated shell length	[3]	b mit =	256.9	mm
load-bearing cross sectional area		Aσ =	6322	mm²
pressure load area		Ap =	1054162	mm²

input data - opening 4

opening - name/item: Manway N5, 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 =	175	N/mm²
yield strength Rp 0.2 [250°C,20mm]			
design strength value, nozzle at room temp.	K20 =	255	N/mm²
yield strength Rp 0.2 [20°C,20mm]			
joint efficiency, nozzle	v =	.85	

geometry data

outer diameter	da =	508	mm
actual wall thickness	ss =	20	mm
manufacturing tolerance	c1 =	7- DIN EN 10029A	
corrosion allowance	c2 =	3	mm
actual length of nozzle	ls =	150	mm
protruding length	ls'=	0	mm
distance nozzle outside diameter - discontinuity	x =	0	mm

results - opening 4

opening-name/item: Manway N5, DN500

req wall thickness of nozzle acc to AD-B1	[2]	sserf =	4.93	mm
» act wall thickness is adequate!		res =	**+306**	%
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 =	100.3	N/mm^2
allowable stress		K/S =	116.7	N/mm^2
» actual opening is adequately reinforced!		res =	**+16**	%
with allowances, nozzle (act wall thickness)		c1/c2 =	0.60/3.00	mm
calculated wall thickness of nozzle		ss =	16.4	mm
calculated outer nozzle length	[6]	ls mit =	112.2	mm
inner nozzle length		ls'mit =	0.0	mm
calculated shell length	[3]	b mit =	256.9	mm
load-bearing cross sectional area		Aσ =	6322	mm^2
pressure load area		Ap =	1054162	mm^2

input data - opening 5

opening - name/item: Nozzle N4, N5 DN50

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	K =	165	N/mm^2
yield strength Rp 0.2 [250°C,5.6mm]			
design strength value, nozzle at room temp.	K20 =	235	N/mm^2
yield strength Rp 0.2 [20°C,5.6mm]			
joint efficiency, nozzle	v =	1	

geometry data

outer diameter	da =	60.3	mm
actual wall thickness	ss =	5.6	mm
manufacturing tolerance	c1 =	3- DIN 17175	
corrosion allowance	c2 =	3	mm
actual length of nozzle	ls =	100	mm
protruding length	ls'=	0	mm
distance nozzle outside diameter - discontinuity	x =	0	mm

results - opening 5

opening-name/item: Nozzle N4, N5 DN50

req wall thickness of nozzle acc to AD-B1	[2]	sserf =	3.52	mm
» act wall thickness is adequate!		res =	**+59**	%
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 =	81.2	N/mm^2
allowable stress		K/S =	116.7	N/mm^2
» actual opening is adequately reinforced!		res =	**+44**	%
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 =	13.6	mm
inner nozzle length		ls'mit =	0.0	mm
calculated shell length	[3]	b mit =	256.9	mm
load-bearing cross sectional area		Aσ =	4271	mm^2
pressure load area		Ap =	575936	mm^2

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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: 11437-0
name/ item: manway flange N6, DN1000

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'=	11.6	bar
design temperature	T =	50	°C

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

Geometry Data, Flange

outside diameter flange	da =	1130	mm
outside diameter hub	dr =	1000	mm
bolt-circle diameter	dt =	1080	mm
outer dia of tapered neck at trans to flange	d3 =	1024	mm
flange thickness	hF =	45	mm
total length of flange	ha =	70	mm
bolt hole diameter	dL =	27	mm
number of bolts or bolt holes	n =	40	Stck
act wall thickness of hub respectively tube	s1 =	12	mm
manufacturing tolerance of hub respect. tube	c1 =	0	mm
corrosion allowance of hub respect. tube	c2 =	3	mm

Material Data, Flange

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

strength value, design yield strength Rp 0.2 [50°C,70mm]	K =	215	N/mm²
safety factor, design	S =	1.5	
strength value, test/bolting-up yield strength Rp 0.2 [20°C,70mm]	K =	215	N/mm²
safety factor, test/bolting-up	S =	1.05	
modulus of elasticity, design [50°C]	E =	210125	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 = 1- yes
retighten the bolts after setting of gasket = 0- No
code no. of medium: 1- design: gases and vapours; test: liquids

outside diameter, gasket	dDa =	1050	mm
inside diameter, gasket	dDi =	1000	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 yield strength Rp 0.2 [50°C,20mm]	K =	300	N/mm²
strength value, test/bolting-up yield strength Rp 0.2 [20°C,20mm]	K'=	300	N/mm²
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	95	**116%**	44	**224%**	84	**144%**	194
section B-B	N/mm²	155	**32%**	72	**99%**	137	**49%**	317
section C-C	N/mm²	29	**603%**	9	**999%**	17	**999%**	60
act. flange deflection	°	0.579		0.273		0.512		1.19
bolts								
req root diameter	dk mm	15.81	**62%**	13.41	**170%**	11.99	**181%**	20.11

geometry data

calc. wall thickness of hub respectively tube	s1 =	9.00 mm
with manufacturing tolerance	c1 =	0.00 mm
corosion allowance	c2 =	3.00 mm
moment arms		
- of hub load	aR =	44.50 mm
- of ring area load	aF =	38.25 mm
- of gasket load	aD =	27.50 mm
- of bolt load (for section C-C)	a1 =	28.00 mm
reduced bolt hole diameter	dL'=	13.50 mm
mean gasket diameter	dD =	1025.00 mm
effective width of gasket	bD =	25.00 mm
bolt pitch / dL	=	3.14

		bolt-up (0)	design (B)	testing (P)
gasket data				
medium		gases/vap.	gases/vap.	liquids
characteristic k1	mm	--	32.50	25.00
characteristic k0*KD	N/mm	577.35	--	--
loads	N			
hub load - int.press.	FI..	--	454427	878559
ring area load	FF..	--	40668	78626
gasket load - design	FD..	--	75351	112061
setting load	FDV	1859145	--	--
min req bolt load	FS..	1859145	570447	1069245
flange (DIN 2505)				
bending moments	Nmm			
section A-A,B-B		51126476	23849724	45184968
section C-C		51126476	15972502	29938864
section modulus	mm^3			
section A-A		539842	539479	538485
section B-B		330709	330350	329368
section C-C		1754246	1754246	1754246
act stresses	N/mm²			
section A-A		94.71	44.21	83.91
section B-B		154.60	72.20	137.19
section C-C		29.14	9.11	17.07
design stress	N/mm²	204.76	143.33	204.76
eff. stress reserve				
section A-A	%	**116**	**224**	**144**
section B-B	%	**32**	**99**	**49**
section C-C	%	**603**	**999**	**999**
act flange deflection	°	0.5792	0.2726	0.5119

			bolt-up (0)	design (B)	testing (P)
bolts					
req root diameter	dk	mm	15.81	13.41	11.99
auxiliary factor	Z		1.27	1.51	1.27
design allowance	c5	mm	0.00	3.00	0.00
stress reserve		%	**62**	**170**	**181**

max allow operating pressure pmax = **11.87 bar**
max allow test pressure pTmax = **17.23 bar**

results for bolting up condition (for information)

basic bolt load FS0 max = 3811495 N
acc. to stress value of 100% of strength value
of bolts (testing/ bolting-up)

actual stress section A-A = 194.2 N/mm²
actual stress section B-B = 316.9 N/mm²
actual stress section C-C = 59.7 N/mm²
actual flange deflection = 1.187 °
actual seating stress of gaske = 47.3 N/mm²

bolting torques acc. to VDI-Richtlinie 2230

req bolting torque (with μmax) MAmin = 182 Nm
with FVM =FS0 = 1859145 N / 40 bolts = 46479 N

act seating stress of gasket with MAmin = 23.1 N/mm²

max bolting torque (bolting-up/with μmin) MAmax = 241 Nm
with FVM = FS0maxT = 2462421 N / 40 bolts = 61561 N
FS0maxT = cause of usage factor of flange reduced force FS0max.

act seating stress of gasket with MAmax = 30.6 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: 11437-0
name/ item: cover manway flange N6, DN1000

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 =	250	°C

Material Data

plate: 0741-P 265 GH (1.0425) DIN EN 10028-2:1992 AD-W1:1998-02			
design strength value, plate	K =	175	N/mm²
yield strength Rp 0.2 [250°C,45mm]			
design strength value at room temperature	K20 =	245	N/mm²
yield strength Rp 0.2 [20°C,45mm]			
modulus of elasticity [250°C]	E =	195500	N/mm²
safety factor, plate	S =	1.5	

Geometry Data

actual wall thickness, plate	se =	45	mm
manufacturing tolerance	c1 =	7- DIN EN 10029A	
corrosion allowance	c2 =	3	mm
bolt circle diameter (plate width)	dt;f =	1080	mm
mean gasket diameter (plate width)	dD;f =	1025	mm
residual plate thickness	sR =	42	mm
gasket type: 4- asbestos - only for Information			
width of gasket	b =	25	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 =	38.14	mm
	res =	**+18**	**%**
manufacturing tolerance	c1 =	0.0	mm
corrosion allowance	c2 =	3.0	mm
manuf. toler., act. plate thickness, for Info only	c1 =	1.0	mm
design diameter (width)	D1;f =	1025.0	mm
design factor (fig 5)	C1 =	0.478	
with diameter ratio	dt/dD =	1.054	
with gasket characteristic	k1 =	32.500	mm
with value	delta =	1.152	
max allow operating pressure	pmax =	**8.57**	**bar**
max allow test pressure	pTmax =	**17.14**	**bar**

conditions for flat end design

req resid thickness	sRmin =	26.70	mm
	res =	**+57**	**%**

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: 11437-0
name/ item: manway flange N5, 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'=	11.6	bar
design temperature	T =	250	°C

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

Geometry Data, Flange

outside diameter flange	da =	615	mm
outside diameter hub	dr =	528	mm
bolt-circle diameter	dt =	570	mm
outer dia of tapered neck at trans to flange	d3 =	544	mm
flange thickness	hF =	30	mm
total length of flange	ha =	50	mm
bolt hole diameter	dL =	23	mm
number of bolts or bolt holes	n =	20	Stck
act wall thickness of hub respectively tube	s1 =	10	mm
manufacturing tolerance of hub respect. tube	c1 =	0	mm
corrosion allowance of hub respect. tube	c2 =	3	mm

Material Data, Flange

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

strength value, design	K =	175	N/mm²
yield strength Rp 0.2 [250°C,50mm]			
safety factor, design	S =	1.5	
strength value, test/bolting-up	K =	245	N/mm²
yield strength Rp 0.2 [20°C,50mm]			
safety factor, test/bolting-up	S =	1.05	
modulus of elasticity, design [250°C]	E =	195500	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 = 1- yes
retighten the bolts after setting of gasket = 0- No
code no. of medium: 1- design: gases and vapours; test: liquids

outside diameter, gasket	dDa =	544	mm
inside diameter, gasket	dDi =	508	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 =	215	N/mm²
yield strength Rp 0.2 [250°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 =	16.76	mm
effective diameter thread	d2 =	18.376	mm
outer diameter of bearing surface (bolting)	daS =	30	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	120	**95%**	26	**355%**	48	**388%**	196
section B-B	N/mm²	167	**39%**	36	**225%**	67	**249%**	274
section C-C	N/mm²	25	**828%**	5	**999%**	9	**999%**	41
act. flange deflection	°	0.548		0.127		0.218		0.90
bolts								
req root diameter	dk mm	14.75	**29%**	12.16	**126%**	8.88	**256%**	16.76

geometry data

calc. wall thickness of hub respectively tube	s1 =	7.00 mm
with manufacturing tolerance	c1 =	0.00 mm
corosion allowance	c2 =	3.00 mm
moment arms		
- of hub load	aR =	24.50 mm
- of ring area load	aF =	25.00 mm
- of gasket load	aD =	22.00 mm
- of bolt load (for section C-C)	a1 =	13.00 mm
reduced bolt hole diameter	dL'=	11.50 mm
mean gasket diameter	dD =	526.00 mm
effective width of gasket	bD =	18.00 mm
bolt pitch / dL	=	3.89

		bolt-up (0)	design (B)	testing (P)
gasket data				
medium		gases/vap.	gases/vap.	liquids
characteristic k1	mm	--	23.40	18.00
characteristic k0*KD	N/mm	489.90	--	--
loads	N			
hub load - int.press.	FI..	--	124499	240699
ring area load	FF..	--	5881	11370
gasket load - design	FD..	--	27841	41404
setting load	FDV	809546	--	--
min req bolt load	FS..	809546	158221	293473
flange (DIN 2505)				
bending moments	Nmm			
section A-A,B-B		17810002	3809764	7092274
section C-C		10524092	2056879	3815155
section modulus	mm^3			
section A-A		148617	148538	148467
section B-B		106337	106259	106189
section C-C		418460	418460	418460
act stresses	N/mm²			
section A-A		119.84	25.65	47.77
section B-B		167.49	35.85	66.79
section C-C		25.15	4.92	9.12
design stress	N/mm²	233.33	116.67	233.33
eff. stress reserve				
section A-A	%	**95**	**355**	**388**
section B-B	%	**39**	**225**	**249**
section C-C	%	**828**	**999**	**999**
act flange deflection	°	0.5485	0.1272	0.2184

			bolt-up (0)	design (B)	testing (P)
bolts					
req root diameter	dk	mm	14.75	12.16	8.88
auxiliary factor	Z		1.27	1.51	1.27
design allowance	c5	mm	0.00	3.00	0.00
stress reserve		%	**29**	**126**	**256**

max allow operating pressure pmax = **13.54 bar**
max allow test pressure pTmax = **39.90 bar**

<u>results for bolting up condition (for information)</u>

basic bolt load FS0 max = 1323699 N
acc. to stress value of 100% of strength value
of bolts (testing/ bolting-up)

actual stress section A-A	=	195.9 N/mm²
actual stress section B-B	=	273.9 N/mm²
actual stress section C-C	=	41.1 N/mm²
actual flange deflection	=	0.897 °
actual seating stress of gaske	=	44.5 N/mm²

<u>bolting torques acc. to VDI-Richtlinie 2230</u>

req bolting torque (with μmax) MAmin = 136 Nm
with FVM =FS0 = 809546 N / 20 bolts = 40477 N

act seating stress of gasket with MAmin = 27.2 N/mm²

max bolting torque (bolting-up/with μmin) MAmax = 179 Nm
with FVM = FS0maxT = 1069693 N / 20 bolts = 53485 N
FS0maxT = cause of torsional strain reduced force FS0max

act seating stress of gasket with MAmax = 36.0 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: 11437-0
name/ item: cover manway flange N5, DN500

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 =	250	°C

Material Data

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

design strength value, plate	K =	175	N/mm²
yield strength Rp 0.2 [250°C,45mm]			
design strength value at room temperature	K20 =	245	N/mm²
yield strength Rp 0.2 [20°C,45mm]			
modulus of elasticity [250°C]	E =	195500	N/mm²
safety factor, plate	S =	1.5	

Geometry Data

actual wall thickness, plate	se =	30	mm
manufacturing tolerance	c1 =	7- DIN EN 10029A	
corrosion allowance	c2 =	3	mm
bolt circle diameter (plate width)	dt;f =	570	mm
mean gasket diameter (plate width)	dD;f =	526	mm
residual plate thickness	sR =	27	mm
gasket type: 4- asbestos - only for Information			
width of gasket	b =	18	mm
code no. of medium: 1- gases and vapours			

Openings in Plates

opening: 0- none

results

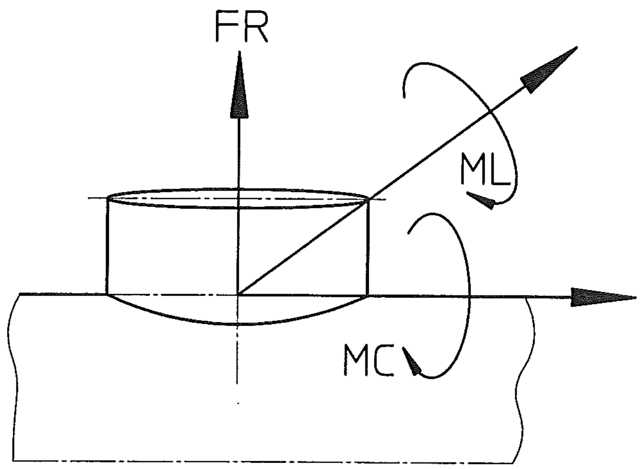
results shown in percentages signify over-/underdimensioning
for dimensions: (act-req) / req, with other data: (allow-act) / act

required plate thickness	sreq =	22.27	mm
	res =	**+35**	**%**
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 =	526.0	mm
design factor (fig 5)	C1 =	0.495	
with diameter ratio	dt/dD =	1.084	
with gasket characteristic	k1 =	23.400	mm
with value	delta =	1.214	
max allow operating pressure	pmax =	**12.54**	**bar**
max allow test pressure	pTmax =	**25.08**	**bar**

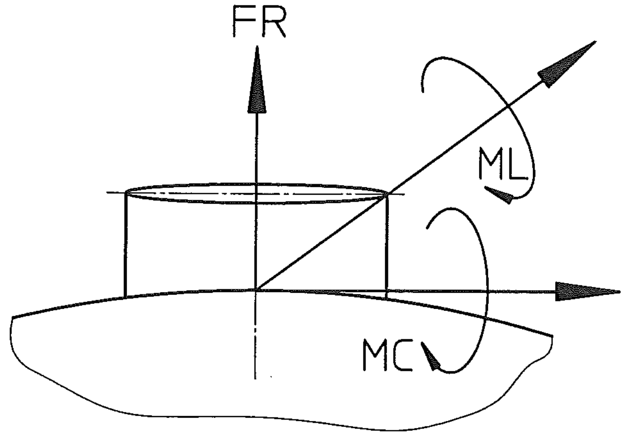
conditions for flat end design

req resid thickness	sRmin =	15.59	mm
	res =	**+73**	**%**

Stutzen-Zusatzlasten Additional Nozzle loads				
Stutzen Nr.	DN	FR [N]	ML [Nm]	MC [Nm]
N1,N2	700	31500	27400	22500
N3,N4	50	1125	900	800



Mantel



Boden

Cylindrical shell

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

drawing no: 11437-0
name/ item: flange N1, DN700

input data

Type Declaration

superposition of int. pressure: 2- AD-S4/KTA 3211

Design Data

design pressure	p =	1	bar
design temperature	T =	250	°C

Additional Loads

lever arm of loading point Please note INFC F1!	a =	0	mm
radial force (in direction of vessel - positive)	P =	-31500	N
shearing force - circumferential direction	Vc =	0	N
shearing force - longitudinal direction	Vl =	0	N
moment - circumferential direction	Mc =	22500	Nm
moment - longitudinal direction	Ml =	27400	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 =	175	N/mm²
yield strength Rp 0.2 [250°C,20mm]			
safety factor	S =	1.5	
shear stress theory= 1 / deformation energy theory= 2	=	2	

Geometry Data Cylindrical Shell

outer diameter	DA =	4040	mm
wall thickness	T =	20	mm
manufacturing tolerance	c1 =	7- DIN EN 10029A	
corrosion allowance	c2 =	3	mm

Geometry Data Nozzle

code-no: 1- nozzle, round

outer diameter	da =	711	mm
wall thickness	t =	25	mm
manufacturing tolerance	c1 =	7- DIN EN 10029A	
corrosion allowance	c2 =	3	mm

attention

errors WRC 107:
----
dm/Dm*√(Dm/T)= 2.685 out of scope
diagramrange for WRC App.3.3.4: dm/Dm*√(Dm/T) < 2

errors KTA 3211:

Dm/T = 245.34 out of scope.
range for KTA: 30 ≤ Dm/T ≤ 200

calculation may be unconservative.

results FOR INFORMATION ONLY

actual shell thickness	T= sH= Te-c1-c2 =	16.40	mm
tollerance cylindrical shell	c1/c2 =	0.60/3.00	mm
actual shell thickness	t= sA= te-c1-c2 =	21.20	mm
tollerance nozzle	c1/c2 =	0.80/3.00	mm

-21-

geometrical values

WRC: Gamma = 122.671   ß = 0.155
KTA: t/T = 1.292   dm/√(Dm*T) = 2.685

factors resulting WRC-diagrams

	A-B		C-D	
Nϕ - P	14.933	(4C)	7.848	(3C)
Mϕ - P	0.024	(2C-1)	0.052	(1C)
Nϕ - Mc			4.513	(3A)
Mϕ - Mc			0.065	(1A)
Nϕ - Ml	10.534	(3B)		
Mϕ - Ml	0.017	(1B-1)		
Nx - P	7.848	(3C)	14.933	(4C)
Mx - P	0.052	(1C-1)	0.024	(2C)
Nx - Mc			10.437	(4A)
Mx - Mc			0.029	(2A)
Nx - Ml	4.553	(4B)		
Mx - Ml	0.022	(2B-1)		

factors resulting KTA-Diagrams

	A-B				C-D			
	ϕ-up	ϕ-lo	x-up	x-lo	ϕ-up	ϕ-lo	x-up	x-lo
Pl	2.76	2.76	0.32	0.32	0.03	0.03	0.36	0.36
PlQ	2.45	2.93	0.63	0.01	0.52	-0.50	0.64	0.05

N / M = bending- / membran stress component   () = diagram
Mc / Ml = circumferential / longitudinal moment   P = radial load
ϕ / x = circumferential / logitudinal component up/lo = upper/lower
Pl / PlQ = membr. / membr.+bend. stress acc. to internal Pressure

single stresses

σ N/mm²	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Nϕ - P	14.3	14.3	14.3	14.3	7.5	7.5	7.5	7.5
Mϕ - P	17.1	-17.1	17.1	-17.1	36.4	-36.4	36.4	-36.4
Nϕ - Mc					-9.9	-9.9	9.9	9.9
Mϕ - Mc					-105.1	105.1	105.1	-105.1
Nϕ - Ml	-28.1	-28.1	28.1	28.1				
Mϕ - Ml	-34.0	34.0	34.0	-34.0				
total - ϕ	-30.8	3.1	93.5	-8.8	-71.1	66.3	158.9	-124.1
Nx - P	7.5	7.5	7.5	7.5	14.3	14.3	14.3	14.3
Mx - P	36.4	-36.4	36.4	-36.4	17.1	-17.1	17.1	-17.1
Nx - Mc					-22.9	-22.9	22.9	22.9
Mx - Mc					-47.2	47.2	47.2	-47.2
Nx - Ml	-12.2	-12.2	12.2	12.2				
Mx - Ml	-43.4	43.4	43.4	-43.4				
total - x	-11.7	2.4	99.4	-60.1	-38.7	21.4	101.4	-27.2
τ - Mt	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
τ - Fc	0.0	0.0	0.0	0.0				
τ - Fl					0.0	0.0	0.0	0.0
total - τ	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Au= Location A upper,   Al= Location A lower,   Bu= Loc B upper, etc.
N = membran stress,   M= bending stress,   τ=Tau= shear stress
P = radial force,   Mc/Ml= moment of load,   Vc/Vl= shear force
Mt= torsional moment,   ϕ= circumf. direction   x= longit. direction

combines stress according to AD-Merkblatt S4

GEH: distortion energy theory

m stress	N/mm²	A		B		C		D	
WRC-φ	σmφ	-13.9		42.4		-2.4		17.4	
WRC-x	σmx	-4.7		19.6		-8.6		37.1	
WRC-τ	σmτ	0.0		0.0		0.0		0.0	
KTA-φ	σmPφ	33.9		33.9		0.4		0.4	
KTA-x	σmPx	4.0		4.0		4.4		4.4	
total-φ	σmTφ	20.0		76.3		-2.0		17.8	
total-x	σmTx	-0.7		23.6		-4.2		41.5	
comb.str.	σmC	20.4	**758%**	67.6	**159%**	3.7	**999%**	36.1	**385%**
allowable	1.5*f	175.0		175.0		175.0		175.0	

m+b stress	N/mm²	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
WRC-φ	σmbφ	-30.8	3.1	93.5	-8.8	-71.1	66.3	158.9	-124.1
WRC-x	σmbx	-11.7	2.4	99.4	-60.1	-38.7	21.4	101.4	-27.2
WRC-τ	σmbτ	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
KTA-φ	σmbPφ	30.0	36.0	30.0	36.0	6.4	-6.1	6.4	-6.1
KTA-x	σmbPx	7.8	0.1	7.8	0.1	7.9	0.6	7.9	0.6
total-φ	σmbTφ	-0.8	39.1	123.6	27.2	-64.8	60.2	165.2	-130.2
total-x	σmbTx	-3.9	2.5	107.2	-60.0	-30.8	22.0	109.3	-26.6
comb.str.	σmbC	3.6	37.9	116.3	77.3	56.1	52.8	145.6	119.2
		999%	**825%**	**201%**	**353%**	**524%**	**563%**	**140%**	**194%**
allowed	3*f	350.0		350.0		350.0		350.0	

m= membrane stress b= bending stress C= combined stress
φ= circumf. direction x= tangential direction T= total stress

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

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

drawing no: 11437-0
name/ item: flange N1, DN700

input data

Type Declaration
superposition of int. pressure: 2- AD-S4/KTA 3211

Design Data

design pressure	p =	6	bar
design temperature	T =	50	°C

Additional Loads

lever arm of loading point Please note INFO F1!	a =	0	mm
radial force (in direction of vessel - positive)	P =	-31500	N
shearing force - circumferential direction	Vc =	0	N
shearing force - longitudinal direction	Vl =	0	N
moment - circumferential direction	Mc =	22500	Nm
moment - longitudinal direction	Ml =	27400	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 =	255	N/mm²
yield strength Rp 0.2 [50°C,20mm]			
safety factor	S =	1.5	
shear stress theory= 1 / deformation energy theory= 2	=	2	

Geometry Data Cylindrical Shell

outer diameter	DA =	4040	mm
wall thickness	T =	20	mm
manufacturing tolerance	c1 =	7- DIN EN 10029A	
corrosion allowance	c2 =	3	mm

Geometry Data Nozzle
code-no: 1- nozzle, round

outer diameter	da =	711	mm
wall thickness	t =	25	mm
manufacturing tolerance	c1 =	7- DIN EN 10029A	
corrosion allowance	c2 =	3	mm

attention

errors WRC 107:
----
dm/Dm*√(Dm/T)= 2.685 out of scope
diagramrange for WRC App.3.3.4: dm/Dm*√(Dm/T) < 2

errors KTA 3211:

Dm/T = 245.34 out of scope.
range for KTA: 30 ≤ Dm/T ≤ 200

calculation may be unconservative.

results FOR INFORMATION ONLY

actual shell thickness	T= sH= Te-c1-c2 =	16.40	mm
tollerance cylindrical shell	c1/c2 =	0.60/3.00	mm
actual shell thickness	t= sA= te-c1-c2 =	21.20	mm
tollerance nozzle	c1/c2 =	0.80/3.00	mm

<u>geometrical values</u>

WRC: Gamma = 122.671 ß = 0.155
KTA: t/T = 1.292 dm/√(Dm*T) = 2.685

	factors resulting WRC-diagrams A-B		C-D	
Nφ - P	14.933	(4C)	7.848	(3C)
Mφ - P	0.024	(2C-1)	0.052	(1C)
Nφ - Mc			4.513	(3A)
Mφ - Mc			0.065	(1A)
Nφ - Ml	10.534	(3B)		
Mφ - Ml	0.017	(1B-1)		
Nx - P	7.848	(3C)	14.933	(4C)
Mx - P	0.052	(1C-1)	0.024	(2C)
Nx - Mc			10.437	(4A)
Mx - Mc			0.029	(2A)
Nx - Ml	4.553	(4B)		
Mx - Ml	0.022	(2B-1)		

	factors resulting KTA-Diagrams A-B				C-D			
	φ-up	φ-lo	x-up	x-lo	φ-up	φ-lo	x-up	x-lo
Pl	2.76	2.76	0.32	0.32	0.03	0.03	0.36	0.36
PlQ	2.45	2.93	0.63	0.01	0.52	-0.50	0.64	0.05

N / M = bending- / membran stress component () = diagram
Mc / Ml = circumferential / longitudinal moment P = radial load
φ / x = circumferential / logitudinal component up/lo = upper/lower
Pl / PlQ = membr. / membr.+bend. stress acc. to internal Pressure

<u>single stresses</u>

σ N/mm²	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Nφ - P	14.3	14.3	14.3	14.3	7.5	7.5	7.5	7.5
Mφ - P	17.1	-17.1	17.1	-17.1	36.4	-36.4	36.4	-36.4
Nφ - Mc					-9.9	-9.9	9.9	9.9
Mφ - Mc					-105.1	105.1	105.1	-105.1
Nφ - Ml	-28.1	-28.1	28.1	28.1				
Mφ - Ml	-34.0	34.0	34.0	-34.0				
total - φ	-30.8	3.1	93.5	-8.8	-71.1	66.3	158.9	-124.1
Nx - P	7.5	7.5	7.5	7.5	14.3	14.3	14.3	14.3
Mx - P	36.4	-36.4	36.4	-36.4	17.1	-17.1	17.1	-17.1
Nx - Mc					-22.9	-22.9	22.9	22.9
Mx - Mc					-47.2	47.2	47.2	-47.2
Nx - Ml	-12.2	-12.2	12.2	12.2				
Mx - Ml	-43.4	43.4	43.4	-43.4				
total - x	-11.7	2.4	99.4	-60.1	-38.7	21.4	101.4	-27.2
τ - Mt	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
τ - Fc	0.0	0.0	0.0	0.0				
τ - Fl					0.0	0.0	0.0	0.0
total - τ	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Au= Location A upper, Al= Location A lower, Bu= Loc B upper, etc.
N = membran stress, M= bending stress, τ=Tau= shear stress
P = radial force, Mc/Ml= moment of load, Vc/Vl= shear force
Mt= torsional moment, φ= circumf. direction x= longit. direction

combines stress according to AD-Merkblatt S4
GEH: distortion energy theory

m stress	N/mm²	A		B		C		D	
WRC-ϕ	$\sigma m\phi$	-13.9		42.4		-2.4		17.4	
WRC-x	σmx	-4.7		19.6		-8.6		37.1	
WRC-τ	$\sigma m\tau$	0.0		0.0		0.0		0.0	
KTA-ϕ	$\sigma mP\phi$	203.4		203.4		2.2		2.2	
KTA-x	σmPx	23.8		23.8		26.4		26.4	
total-ϕ	$\sigma mT\phi$	189.6		245.8		-0.2		19.6	
total-x	σmTx	19.1		43.4		17.7		63.5	
comb.str.	σmC	180.8	**41%**	227.2	**12%**	17.8	**999%**	56.3	**353%**
allowable	1.5*f	255.0		255.0		255.0		255.0	

m+b stress	N/mm²	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
WRC-ϕ	$\sigma mb\phi$	-30.8	3.1	93.5	-8.8	-71.1	66.3	158.9	-124.1
WRC-x	σmbx	-11.7	2.4	99.4	-60.1	-38.7	21.4	101.4	-27.2
WRC-τ	$\sigma mb\tau$	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
KTA-ϕ	$\sigma mbP\phi$	180.2	216.0	180.2	216.0	38.3	-36.8	38.3	-36.8
KTA-x	$\sigma mbPx$	46.7	0.8	46.7	0.8	47.4	3.3	47.4	3.3
total-ϕ	$\sigma mbT\phi$	149.4	219.1	273.7	207.2	-32.8	29.5	197.2	-160.9
total-x	$\sigma mbTx$	35.0	3.2	146.2	-59.4	8.8	24.8	148.9	-23.8
comb.str.	σmbC	135.3	217.5	237.2	242.4	38.0	27.4	178.0	150.4
		277%	**134%**	**115%**	**110%**	**999%**	**999%**	**186%**	**239%**
allowed	3*f	510.0		510.0		510.0		510.0	

m= membrane stress b= bending stress C= combined stress
ϕ= circumf. direction x= tangential direction T= total stress

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

Cylindrical shell

subject to internal pressure and add. loads
WRC 107:1979-03, AD S3/6 sec. 5.3, AD S4:2000-10

drawing no: 1
name/ item: Nozzle N3,N4, DN50

input data

Type Declaration
superposition of int. pressure: 3- AD S3/6 sec. 5.3

Design Data

utilisation factor	rho =	.6
design temperature	T =	250 °C

Additional Loads

lever arm of loading point Please note INFO F1!	a =	0 mm
radial force (in direction of vessel - positive)	P =	-1125 N
shearing force - circumferential direction	Vc =	0 N
shearing force - longitudinal direction	Vl =	0 N
moment - circumferential direction	Mc =	900 Nm
moment - longitudinal direction	Ml =	800 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 =	175 N/mm²
yield strength Rp 0.2 [250°C,20mm]		
safety factor	S =	1.5

Geometry Data Cylindrical Shell

outer diameter	DA =	4040 mm
wall thickness	T =	15 mm
manufacturing tolerance	c1 =	7- DIN EN 10029A
corrosion allowance	c2 =	3 mm

Geometry Data Nozzle
code-no: 1- nozzle, round

outer diameter	da =	60.3 mm
wall thickness	t =	8.8 mm
manufacturing tolerance	c1 =	0 mm
corrosion allowance	c2 =	3 mm

attention

errors WRC 107:

ß = 0.013 is out of scope
pange for WRC Fig 1A-4C page 38-53: 0.03 ≤ ß ≤ 0.22
values taken for ß = .03

results FOR INFORMATION ONLY

actual shell thickness	T= sH= Te-c1-c2 =	11.40 mm
tollerance cylindrical shell	c1/c2 =	0.60/3.00 mm
actual shell thickness	t= sA= te-c1-c2 =	5.80 mm
tollerance nozzle	c1/c2 =	0.00/3.00 mm

geometrical values WRC: Gamma = 176.693 ß = 0.030

	factors resulting WRC-diagrams A-B		C-D	
Nϕ - P	31.898	(4C)	31.545	(3C)
Mϕ - P	0.138	(2C-1)	0.182	(1C)
Nϕ - Mc			2.962	(3A)
Mϕ - Mc			0.100	(1A)
Nϕ - Ml	12.309	(3B)		
Mϕ - Ml	0.058	(1B-1)		
Nx - P	31.545	(3C)	31.898	(4C)
Mx - P	0.182	(1C-1)	0.138	(2C)
Nx - Mc			4.121	(4A)
Mx - Mc			0.059	(2A)
Nx - Ml	3.094	(4B)		
Mx - Ml	0.089	(2B-1)		

N / M = bending- / membran stress component
Mc / Ml = circumferential / longitudinal moment
ϕ / x = circumferential / logitudinal component

() = diagram
P = radial load

single stresses

σ N/mm²	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Nϕ - P	1.6	1.6	1.6	1.6	1.5	1.5	1.5	1.5
Mϕ - P	7.2	-7.2	7.2	-7.2	9.5	-9.5	9.5	-9.5
Nϕ - Mc					-1.9	-1.9	1.9	1.9
Mϕ - Mc					-68.8	68.8	68.8	-68.8
Nϕ - Ml	-7.1	-7.1	7.1	7.1				
Mϕ - Ml	-35.7	35.7	35.7	-35.7				
total - ϕ	-34.1	23.0	51.5	-34.2	-59.7	58.9	81.7	-74.7
Nx - P	1.5	1.5	1.5	1.5	1.6	1.6	1.6	1.6
Mx - P	9.5	-9.5	9.5	-9.5	7.2	-7.2	7.2	-7.2
Nx - Mc					-2.7	-2.7	2.7	2.7
Mx - Mc					-40.9	40.9	40.9	-40.9
Nx - Ml	-1.8	-1.8	1.8	1.8				
Mx - Ml	-54.3	54.3	54.3	-54.3				
total - x	-45.1	44.6	67.1	-60.4	-34.8	32.6	52.3	-43.8
τ - Mt	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
τ - Fc	0.0	0.0	0.0	0.0				
τ - Fl					0.0	0.0	0.0	0.0
total - τ	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Au= Location A upper, Al= Location A lower, Bu= Loc B upper, etc.
N = membran stress, M= bending stress, τ=Tau= shear stress
P = radial force, Mc/Ml= moment of load, Vc/Vl= shear force
Mt= torsional moment, ϕ= circumf. direction x= longit. direction

combines stress according to AD-Merkblatt S4
SSH: shear stress theory
hypothetical strength Kquer = K·(1-rho) = 70.0 N/mm²

m stress N/mm²		A		B		C		D	
WRC-ϕ	$\sigma m\phi$	-5.5		8.7		-0.4		3.5	
WRC-x	σmx	-0.2		3.3		-1.1		4.2	
WRC-τ	$\sigma m\tau$	0.0		0.0		0.0		0.0	
comb.str.	σmC	5.5	**999%**	8.7	**708%**	1.1	**999%**	4.2	**999%**

allowable membran stress σmVzul = 1.5·Kquer/S = 70.0

m+b stress N/mm²		Au	Al	Bu	Bl	Cu	Cl	Du	Dl
WRC-ϕ	$\sigma mb\phi$	-34.1	23.0	51.5	-34.2	-59.7	58.9	81.7	-74.7
WRC-x	σmbx	-45.1	44.6	67.1	-60.4	-34.8	32.6	52.3	-43.8
WRC-τ	$\sigma mb\tau$	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
comb.str.	σmbC	45.1	44.6	67.1	60.4	59.7	58.9	81.7	74.7
		211%	**214%**	**109%**	**132%**	**135%**	**138%**	**71%**	**87%**

allowable membran+bending stress σmbVzul = 3·Kquer/S = 140.0

m= membrane stress b= bending stress C= combined stress
ϕ= circumf. direction x= tangential direction T= total stress

reference: - Welding Research Council Bulletin No.107, edition 3.79
- AD-S3/6 section 5.3
- stress rating according to AD-Merkblatt S4

According to AD-S3/6 sec. 5.3 this calculation is only valid for predominatly static loads, stiffness limits acc. BS 5500. are kept and the reinforcement of opening does not take place exclusively in the nozzle.

Cylindrical shell
subject to internal pressure and add. loads
WRC 107:1979-03, AD S3/6 sec. 5.3, AD S4:2000-10

drawing no: 1
name/ item: Nozzle N3,N4, DN50

input data

Type Declaration

superposition of int. pressure: 3- AD S3/6 sec. 5.3

Design Data

utilisation factor	rho =	.6
design temperature	T =	50 °C

Additional Loads

lever arm of loading point Please note INFO F1!	a =	0 mm
radial force (in direction of vessel - positive)	P =	-1125 N
shearing force - circumferential direction	Vc =	0 N
shearing force - longitudinal direction	Vl =	0 N
moment - circumferential direction	Mc =	900 Nm
moment - longitudinal direction	Ml =	800 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 =	255 N/mm²
yield strength Rp 0.2 [50°C,20mm]		
safety factor	S =	1.5

Geometry Data Cylindrical Shell

outer diameter	DA =	4040 mm
wall thickness	T =	15 mm
manufacturing tolerance	c1 =	7- DIN EN 10029A
corrosion allowance	c2 =	3 mm

Geometry Data Nozzle

code-no: 1- nozzle, round

outer diameter	da =	60.3 mm
wall thickness	t =	8.8 mm
manufacturing tolerance	c1 =	0 mm
corrosion allowance	c2 =	3 mm

attention

errors WRC 107:

ß = 0.013 is out of scope
pange for WRC Fig 1A-4C page 38-53: 0.03 ≤ ß ≤ 0.22
values taken for ß = .03

results FOR INFORMATION ONLY

actual shell thickness	T= sH= Te-c1-c2 =	11.40 mm
tollerance cylindrical shell	c1/c2 =	0.60/3.00 mm
actual shell thickness	t= sA= te-c1-c2 =	5.80 mm
tollerance nozzle	c1/c2 =	0.00/3.00 mm

geometrical values WRC: Gamma = 176.693 ß = 0.030

factors resulting WRC-diagrams

	A-B		C-D	
Nφ - P	31.898	(4C)	31.545	(3C)
Mφ - P	0.138	(2C-1)	0.182	(1C)
Nφ - Mc			2.962	(3A)
Mφ - Mc			0.100	(1A)
Nφ - Ml	12.309	(3B)		
Mφ - Ml	0.058	(1B-1)		
Nx - P	31.545	(3C)	31.898	(4C)
Mx - P	0.182	(1C-1)	0.138	(2C)
Nx - Mc			4.121	(4A)
Mx - Mc			0.059	(2A)
Nx - Ml	3.094	(4B)		
Mx - Ml	0.089	(2B-1)		

N / M = bending- / membran stress component () = diagram
Mc / Ml = circumferential / longitudinal moment P = radial load
φ / x = circumferential / logitudinal component

<u>single stresses</u>

σ N/mm²	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Nφ - P	1.6	1.6	1.6	1.6	1.5	1.5	1.5	1.5
Mφ - P	7.2	-7.2	7.2	-7.2	9.5	-9.5	9.5	-9.5
Nφ - Mc					-1.9	-1.9	1.9	1.9
Mφ - Mc					-68.8	68.8	68.8	-68.8
Nφ - Ml	-7.1	-7.1	7.1	7.1				
Mφ - Ml	-35.7	35.7	35.7	-35.7				
total - φ	-34.1	23.0	51.5	-34.2	-59.7	58.9	81.7	-74.7
Nx - P	1.5	1.5	1.5	1.5	1.6	1.6	1.6	1.6
Mx - P	9.5	-9.5	9.5	-9.5	7.2	-7.2	7.2	-7.2
Nx - Mc					-2.7	-2.7	2.7	2.7
Mx - Mc					-40.9	40.9	40.9	-40.9
Nx - Ml	-1.8	-1.8	1.8	1.8				
Mx - Ml	-54.3	54.3	54.3	-54.3				
total - x	-45.1	44.6	67.1	-60.4	-34.8	32.6	52.3	-43.8
τ - Mt	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
τ - Fc	0.0	0.0	0.0	0.0				
τ - Fl					0.0	0.0	0.0	0.0
total - τ	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Au= Location A upper, Al= Location A lower, Bu= Loc B upper, etc.
N = membran stress, M= bending stress, τ=Tau= shear stress
P = radial force, Mc/Ml= moment of load, Vc/Vl= shear force
Mt= torsional moment, φ= circumf. direction x= longit. direction

combines stress according to AD-Merkblatt S4
SSH: shear stress theory
hypothentical strength Kquer = K·(1-rho) = 102.0 N/mm²

m stress	N/mm²	A		B		C		D	
WRC-ϕ	σmϕ	-5.5		8.7		-0.4		3.5	
WRC-x	σmx	-0.2		3.3		-1.1		4.2	
WRC-τ	σmτ	0.0		0.0		0.0		0.0	
comb.str.	σmC	5.5	**999%**	8.7	**999%**	1.1	**999%**	4.2	**999%**

allowable membran stress σmVzul = 1.5·Kquer/S = 102.0

m+b stress	N/mm²	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
WRC-ϕ	σmbϕ	-34.1	23.0	51.5	-34.2	-59.7	58.9	81.7	-74.7
WRC-x	σmbx	-45.1	44.6	67.1	-60.4	-34.8	32.6	52.3	-43.8
WRC-τ	σmbτ	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
comb.str.	σmbC	45.1	44.6	67.1	60.4	59.7	58.9	81.7	74.7
		353%	**358%**	**204%**	**238%**	**242%**	**246%**	**150%**	**173%**

allowable membran+bending stress σmbVzul = 3·Kquer/S = 204.0

m= membrane stress b= bending stress C= combined stress
ϕ= circumf. direction x= tangential direction T= total stress

reference: - Welding Research Council Bulletin No.107, edition 3.79
- AD-S3/6 section 5.3
- stress rating according to AD-Merkblatt S4

According to AD-S3/6 sec. 5.3 this calculation is only valid for predominatly static loads, stiffness limits acc. BS 5500. are kept and the reinforcement of opening does not take place exclusively in the nozzle.

Static Calculation

saddle of Molsieve Adsorber W15001 / W15002

In consideration of wind-, snow,earthquake- and nozzle loads

Description :	**Molsieve Adsorber**
Item Nr.:	**W15001 / W15002**
accompanying drawing:	**11437-0**
Client	**Kosice No.9**
	Slovakia
calculate:	**Strake**
approved:	Str.
date:	**25.11.2004**
issue:	**0**
date of revision	

1. General

Operation data:	acc. drawing No.: 11437 - 0
Windloads:	acc. DIN 1055
Snowloads:	acc. DIN 1055
earthquake:	acc.Assessment of Seismic Hazard of Construction Edifice 730036

2. reference of calculation

- drawing No.: 11437-0
- acc. DIN 1055
- AD-S3/2
- WRC 107

3. Materials and allowable stresses

zul. Betriebstemperatur: 250 °C

Vessel and reinforcing pad

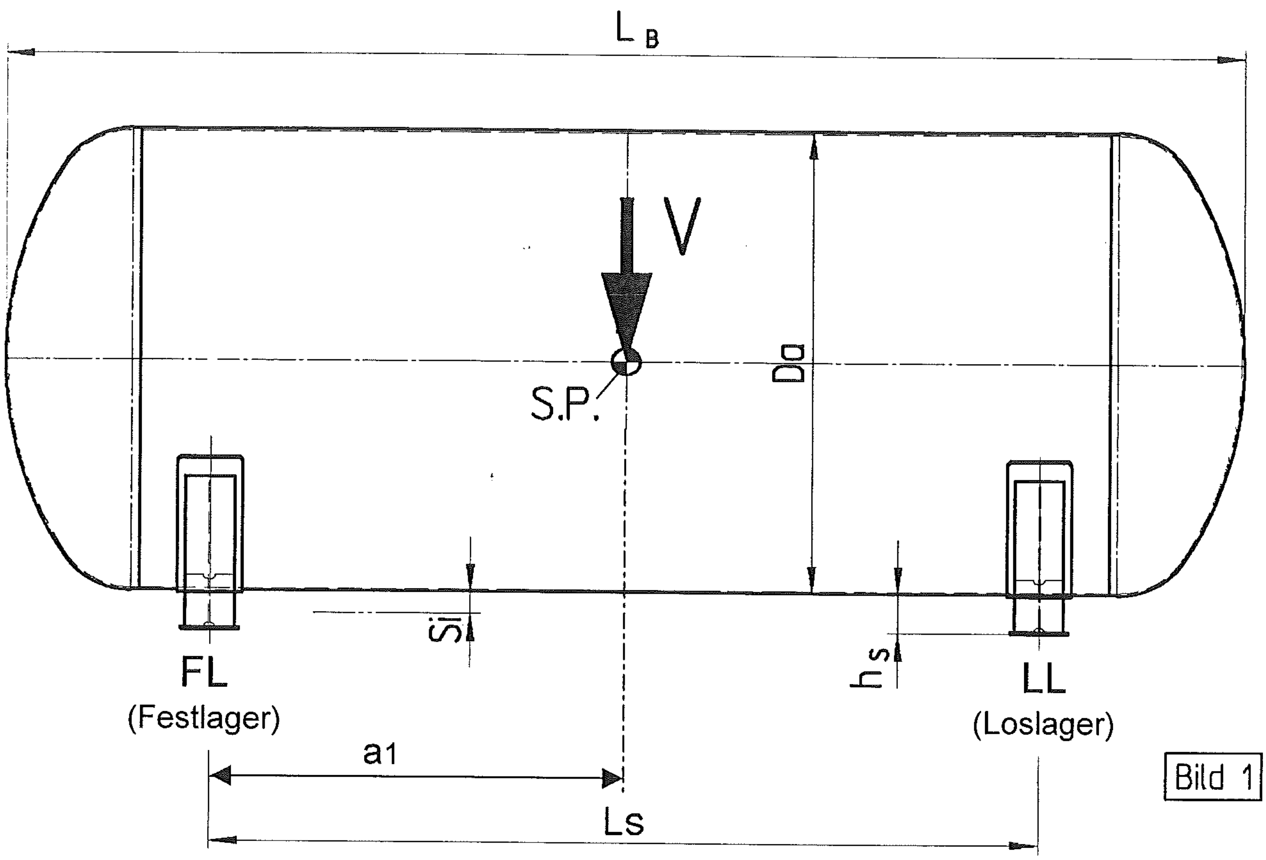
Material:	**P265 GH**				
design strenght value at	250 °C		=	**175**	N/mm²
allowable stress	1,5	- safety factor	σ=	**116,6**	N/mm²

saddle (without reinforcing pad)

material:	**P265GH**				
design strenght value at	250 °C		=	**175**	N/mm²
allowable stress	**1,5**	- safety factor	σ=	**116,6**	N/mm²

anchorbolts **M 24** ; n= **4** bolts per saddle

Material	**4.6**				
design strenght value at	**20** °C		=	**240**	N/mm²
allowable tensile stress	**2,2**	- safety factor	σ=	**109,1**	N/mm²
allowable Shear stress	**2,2**	- safety factor	σ=	**87,3**	N/mm²
	2,2	- safety factor	σ_{LD}=	**127,3**	N/mm²
rel. bolt cross sectional area	**380,5** mm²				



4. <u>Vessel dimension</u>

Erection weight	V_M = 285000 N
total operation weight (with water filling)	V_B = 1317500 N
vessel diameter	Da= 4040 mm
Insulation thickness	Si= 300 mm
length of vessel	L_B= 8327 mm
saddle height	h_s= 430 mm
distance between saddles	Ls= 5100 mm
distance in longitudinal direction to fixed saddle	a_1 = 3000 mm
number of saddles	n_s = 2

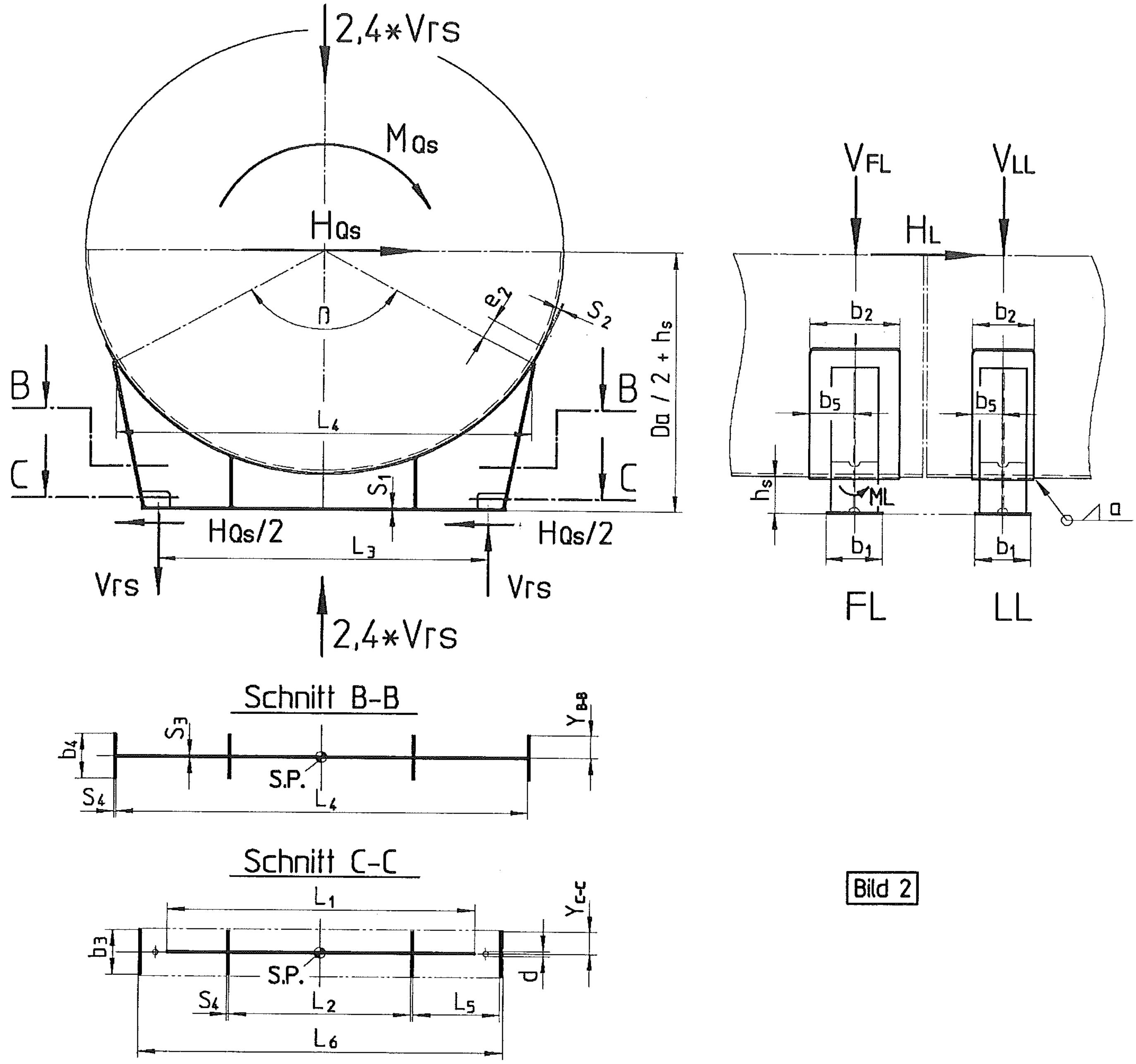


Bild 2

5. saddle dimensions

L_1 =	2700	mm	$b_{1\,FL}$ =	450	mm	$b_{1\,LL}$ =	450	mm	S_1 =	18	mm
L_2 =	1600	mm	$b_{2\,FL}$ =	500	mm	$b_{2\,LL}$ =	500	mm	S_2 =	18	mm
L_3 =	2900	mm	$b_{3\,FL}$ =	420	mm	$b_{3\,LL}$ =	420	mm	S_3 =	18	mm
L_4 =	3560	mm	$b_{4\,FL}$ =	420	mm	$b_{4\,LL}$ =	420	mm	S_4 =	18	mm
L_5 =	754	mm	$b_{5\,FL}$ =	250	mm	$b_{5\,LL}$ =	250	mm	a =	10	mm
L_6 =	3180	mm	$e_{2\,FL}$ =	350	mm	$e_{2\,LL}$ =	350	mm	d =	35	mm
ß =	120	°									

$A_{B\text{-}B}$ =	93014 mm²	*)	$Y_{B\text{-}B}$ =	210	mm	*) Du
$A_{C\text{-}C}$ =	63072 mm²	*)	$Y_{C\text{-}C}$ =	210	mm	*) Du
$W_{B\text{-}B}$ =	2124871 mm³	*) Zcu				
$W_{C\text{-}C}$ =	1064565 mm³	*) Zcu				

*) (data from ME10) Schnitt A-A = Schnitt B-B

7. calculation of vertical loads for testing condition

- vertical load sliding point V_{LL}= **625000** N — Wert aus der DIMY Berechnung / data from dimy calculation / AD2000-S3/2. See page: bis
- vertical load fixed point V_{FL}= **625000** N — Wert aus der DIMY Berechnung / data from Dimy calculation / AD2000-S3/2. (conservatively)

8. saddle loads resulting from wind - longitudinal direction testing condition

- **ZONE:** acc DIN1055
- const. Pressure at h < 8 m — $q_0 = 0{,}70$ kN/m²
- Form factor / Formbeiwert — $C_f = 1{,}2$
- horizontal load : $HL = q_0 \cdot cf \cdot ((Da+2 \cdot Si)^2 \cdot \pi/4 + L_4 \cdot hs) =$ **15489,7** N
- horizontalload sliding point HL_{LL}= 0 N
- horizontal load **Fix point** HL_{FL}= HL = **15489,7** N
- longitud.moment slid. point ML_{LL}= 0 N
- longitud.moment fix. point ML_{FL}= $HL \cdot hs$ = **6.660.567** *Nmm*

calculation of saddles for section B-B,
This calculation shows the stability of the shell and the saddle with vertical loads for testing condition. (results conservativelely)

Load in anchorbolt / Schubbelastung Ankerschrauben - Längsrichtung/longitudinal

$$\tau_{ASL} = \frac{H_{LFL}}{n \cdot A_{sp}} = \underline{10{,}18} \text{ N/mm}^2 < \tau \text{ zul.} \quad (758\ \% \text{ -Reserve})$$

$$\sigma_{LD} = \frac{H_{LFL}}{n \cdot 24 \cdot S_1} = \underline{8{,}96} \text{ N/mm}^2 < \sigma \text{ zul.} \quad (1320\ \% \text{ -Reserve})$$

9. saddle loads from Wind - Querrichtung im Montagezustand

- **ZONE:** **acc DIN1055**
- const. Pressure at height h=10 m $q_o =$ **0,70** kN/m²
- Form factor / Formbeiwert $Cf =$ **1,2**
- Horizontalload: $H_Q = q_0 \bullet cf \bullet (L_B \cdot (Da+2 \bullet Si) + ns \bullet b3 \bullet h_s) =$ **32758,7** N
- Horizontal load per Saddle $H_{Qs} = H_Q / 2 =$ **16379,4** N
- Moment per Saddle $M_{Qs} = H_{Qs} \bullet (Da / 2 + h_s) =$ **40.129.436** *Nmm*
- ***Vertikallast*** V_{rs} as result of M_{QS} (see Bild 2) :

$$V_{rs} = \frac{M_{Qs}}{L_3} = \underline{13837,7} \text{ N}$$

calculation of Saddles for section B-B,
This calculation shows the stability of the shell and saddle with
vertical loads for operating conditions. (results conservatively)

Zugbelastung je Ankerschraube im Sattel - Querrichtung

$$F_{LLZUG} = 0,5 \bullet n \bullet (V_{rs} - V_{LL} / 2) = \underline{-597325} \text{ N}$$

Ein Nachweis der Ankerschrauben und der Grundplatte im Bereich der Ankerschrauben auf Zugbelastung erübrigt sich, da die Zugkraft negativ ist.

$$F_{FLZUG} = 0,5 \bullet n \bullet (V_{rs} - V_{FL} / 2) = \underline{-597325} \text{ N}$$

Ein Nachweis der Ankerschrauben und der Grundplatte im Bereich der Ankerschrauben auf Zugbelastung erübrigt sich, da die Zugkraft negativ ist.

10. Operating Condition
calculation of total vertical load
from dead load of the vessel and additional Nozzle loads

dead load of the vessel:

V_B = **1317500** N

additionsl Nozzle loads (Definition - WRC 107, Revision 03.79, see accomp. drawing) :

P_{St} = 65250 N

VL_{St} = 0 N

VC_{St} = 0 N

ML_{St} = 56600 Nm

MC_{St} = 46600 Nm

resulting vertical loads :

$$V_1 \text{ (aus } VL_{St}) = \frac{VL_{St} * (Da + hs)}{Ls / 2} = 0 \text{ N}$$

$$V_2 \text{ (aus } VC_{St}) = \frac{VC_{St} * (Da + hs)}{L3} = 0 \text{ N}$$

$$V_3 \text{ (aus } ML_{St}) = \frac{ML_{St}}{Ls/2} = 22196 \text{ N}$$

$$V_4 \text{ (aus } MC_{St}) = \frac{MC_{St}}{L3} = 16069 \text{ N}$$

Result / Ergebnis :

$G = V_B + V_1 + V_2 + V_3 + V_4 =$ **1355765** N (Werte für Berechnung nach AD2000-S3/2)

(P)**	- Vertikalload slid. Point	V_{LL}=	**677890**	N	Wert aus der DIMY Berechnung AD2000-S3/2. Siehe Seiten:	1 bis 4
(P)**	- Vertikalload **Fix. Point**	V_{FL}=	**677890**	N	Wert aus der DIMY Berechnung AD2000-S3/2. Siehe Seiten: (Betrachtung konservativ)	1 bis 4

( )** - Werte für Berechnung nach WRC 107.
siehe Seite: und 0

Sattellasten aus Wind und zul. Stutzenzusatzlasten - Längsrichtung im Betriebszustand

- ZONE: acc DIN1055
- const. Pressure at height h= 10 m $qo = 0{,}70$ kN/m²
- Formfactor / Formbeiwert $Cf = 1{,}2$
- Horizontalload: $HL = q_0 \cdot cf \cdot ((Da+2 \cdot Si)^2 \cdot \pi/4 + L_4 \cdot hs) =$ **15489,7** N
- Horizontalload slid. Point $HL_{LL} =$ 0 N
- Horizontalload fix. Point $HL_{FL} = HL + VL_{St} =$ **15489,7** N (VI)**
- long. Moment slid. Point $ML_{LL} =$ 0 N
- long. Moment fix. Point $ML_{FL} = HL_{FL} \cdot hs + ML_{St} =$ **63.260.567** *Nmm* (MI)**

fixed point Section B-B:

$$\sigma_{B-B} = \frac{V_{FL}}{A_{B-B}} + \frac{ML_{FL}}{W_{B-B}} = 7{,}3 + 29{,}8 = \underline{37{,}06} \text{ N/mm}^2 < \sigma \text{ zul.} \; (215\ \% \text{ -Reserve})$$

$$Fz_{naht} = \frac{ML_{FL}}{b_{2FL}} = 126521{,}1 \text{ N}$$

$$\sigma_{naht} = \frac{Fz_{naht}}{a \cdot ((Da+S_2) \cdot \pi \cdot ß / 360° + 2 \cdot e_{2FL})} = \underline{2{,}56} \text{ N/mm}^2 < \sigma \text{ zul.} \; (3549\ \% \text{ -Reserve})$$

plate

$$Me_{UBl} = Fz_{naht} \cdot b_5 = 31630284 \text{ Nmm}$$

$$W_{Ubl} = \frac{((Da+S_2) \cdot \pi \cdot ß / 360° + 2 \cdot e_{2FL}) \cdot S_2^{\,2}}{6} = 267274 \text{ mm}^3$$

$$\sigma_{Ubl} = \frac{Me_{UBl}}{W_{Ubl}} = \underline{118{,}34} \text{ N/mm}^2 > \sigma \text{ zul.} \; (-1\ \% \text{ -Reserve})$$

***Schubbelastung Ankerschrauben - Längsrichtung** (nur im Festlager)*

$$\tau_{ASL} = \frac{H_{LFL}}{n \cdot A_{sp}} = \underline{10{,}18} \text{ N/mm}^2 < \tau \text{ zul.} \; (758\ \% \text{ -Reserve})$$

$$\sigma_{LD} = \frac{H_{LFL}}{n \cdot 24 \cdot S_1} = \underline{8{,}96} \text{ N/mm}^2 < \sigma \text{ zul.} \; (1320\ \% \text{ -Reserve})$$

Nachweis des Mantels unter den Schnittlasten im Sattel:

Der Nachweis erfolgt für das Los- und Festlager, (Bei gleicher Ausführung des LL und FL wird nur der Festlager berechnet.)
Zur Berechnung mit WRC 107 wird eine Belastungsfläche
für Loslager von 2*c1= **3360** mm ; 2*c2= **500** mm unterstellt, siehe Seiten: **1** bis **6**
für Festlager von 2*c1= **3360** mm ; 2*c2= **500** mm unterstellt, siehe Seiten: **1** bis **6**
obwohl die Fläche von 2*c1= **4931** mm ; 2*c2= **500** mm vorhanden ist.
Dieses geschiet um im Bereich der ß-Werte entsprechend WRC 107 zu bleiben.

( )** - Werte für Berechnung nach WRC 107.

12. saddle loads from Wind and add. nozzle loads - transverse to longitudinal axis, operatio

- **ZONE:** **acc DIN1055**
- const. Pressure at height h= 10 m $q_0 =$ **0,70** kN/m²
- Form factor /Formfaktor $C_f =$ **1,2**
- Horizontalload: $H_Q = q_0 \cdot c_f \cdot (L_B \cdot (D_a + 2 \cdot S_i) + n_s \cdot b_3 \cdot h_s) =$ **32758,7** N
- ıorizontalload per Saddl‹ $H_{Qs} = (H_Q + V_{CSt}) / 2 =$ **16379,4** N
- Moment per saddle $M_{Qs} = H_{Qs} \cdot (D_a / 2 + h_s) + M_{CSt} =$ **86.729.436** *Nmm*
- ***verticalload*** V_{rs} (see Picture 2)

$$V_{rs} = \frac{M_{Qs}}{L_3} = \underline{29906{,}7} \text{ N}$$

- ***Total load saddles*** (for F_{LLGES}-slid. point und F_{FLGES}-fix point)
  (if dimensions at fix and sliding point equal only data for fix point calculated.)

$F_{LLGES} = 2{,}4 \cdot V_{rs} + V_{LL} =$ **749666,1** N < **zul Fi** (siehe Berechnung AD2000-S3/2 Seite: 4 (P)**

$F_{FLGES} = 2{,}4 \cdot V_{rs} + V_{FL} =$ **749666,1** N < **zul Fi** (siehe Berechnung AD2000-S3/2 Seite: 4 (P)**

$$\sigma_{LLc\text{-}c} = \frac{F_{LLGES}}{A_{c\text{-}c}} = \underline{11{,}89} \text{ N/mm}^2 < \sigma_{zul.} \quad (881 \text{ \% -Reserve})$$ < >

$$\sigma_{FLc\text{-}c} = \frac{F_{FLGES}}{A_{c\text{-}c}} = \underline{11{,}89} \text{ N/mm}^2 < \sigma_{zul.} \quad (881 \text{ \% -Reserve})$$ < >

Nachweis des Mantels unter den Schnittlasten im Sattel / verifying of shell as result of loads to saddle :

Der Nachweis erfolgt für das Los- und Festlager, (Bei gleicher Ausführung des LL und FL wird nur der Festlager berechnet.)
Zur Berechnung mit WRC 107 wird eine Belastungsfläche
für Loslager von 2*c1= **3360** mm ; 2*c2= **500** mm unterstellt, siehe Seiten: **1** bis **6**
für Festlager von 2*c1= **3360** mm ; 2*c2= **500** mm unterstellt, siehe Seiten: **1** bis **6**
obwohl die Fläche von 2*c1= **4931** mm ; 2*c2= **500** mm vorhanden ist.
Dieses geschiet um im Bereich der ß-Werte entsprechend WRC 107 zu bleiben.
( )** - Werte für Berechnung nach WRC 107. siehe Seite: und

load per anchorbolt / Zugbelastung je Ankerschraube - Querrichtung

$F_{LLZUG} = 0{,}5 \cdot n \cdot (V_{rs} - V_{LL} / 2) =$ **-618077** N

$F_{FLZUG} = 0{,}5 \cdot n \cdot (V_{rs} - V_{FL} / 2) =$ **-618077** N

Ein Nachweis der Ankerschrauben und der Grundplatte im Bereich der Ankerschrauben auf Zugbelastung erübrigt sich, da die Zugkraft negativ ist.

Verifying of anchor bolts and ground plate not necessary, bacause the resulting anchor load is negative.

additional Nozzle loads

description: **Molsieve Adsorber**

Item No.: **W15001 / W15002**

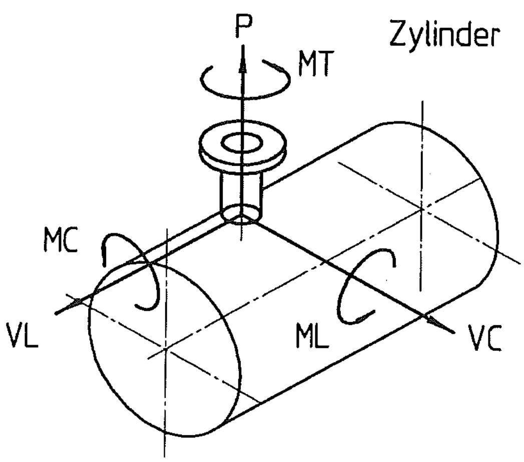
drawing No.: **11437-0**

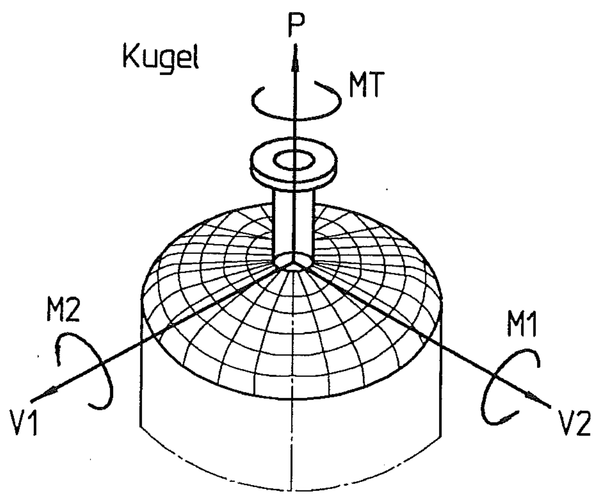
addtional Nozzle loads ***vessel shell (cylinder)***

description	no.	Nozzle	P	VC	VL	MC	ML	MT
			N	N	N	Nm	Nm	Nm
N01	1	DN700	31500	0	0	22500	27400	0
N02	1	DN700	31500.	0	0	22500	27400	0
N03	1	DN50	1125	0	0	800	900	0
N04	1	DN50	1125	0	0	800	900	0

additional Nozzle loads ***heads***

description	no	nozzle	P	V1	V2	M1	M2	MT
			N	N	N	Nm	Nm	Nm





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

drawing no: 11437-0, Molsieb,Probezust.-Wind Querrichtung, Bafürderis devoll
name/ item: Lasteinleitung in den Mantel u. Nachweis d. Sattelbleches

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: 2- form A II - inclined with reinforcing ribs

Design Data

design pressure	p =	6 bar
design temperature	T =	20 °C
total weight force	G =	1355765 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 =	255 N/mm²
yield strength Rp 0.2 [20°C,20mm]		
safety factor	S =	1.5
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 =	255 N/mm²
yield strength Rp 0.2 [20°C,20mm]		
safety factor	Ss =	1.5
allow design stress acc to AD-S3/0, table 1	fv =	170 N/mm²
modulus of elasticity [20°C]	Es =	212000 N/mm²

Geometry Data, Shell

outer diameter	Da =	4040 mm
wall thickness cylinder	se =	20 mm
manufacturing tolerance	c1 =	7- DIN EN 10029A
corrosion allowance	c2 =	3 mm
length of cylinder (incl. cylindrical skirt)	L =	6300 mm
mean depth of dished end	h2 =	1035 mm
weakening factor	Nue =	.85
largest unsupported length	l_DASt =	6300 mm

Geometry Data, Saddle

angle of saddle support, figure 2a and table 2	δ1 =	120 °
angle of support plate, figure 2a	δ2 =	140 °
distance of saddle supports	l1 =	5100 mm
width of saddle support	b1 =	500 mm
thickness of bottom flange plate	t5 =	18 mm
width of bottom flange plate	b =	450 mm
wall thickness of saddle web plate	es =	18 mm
effective plate width of web plate, fig 6	be =	1139.6 mm
wall thickness of support plate, sec A-A, fig 8	e2 =	18 mm
height of web plate, sec A-A, fig 8	hA =	860.5 mm
length of web plate, fig 6	l2 =	3164.4 mm
dist. saddle to center of gravity of dished end	a3 =	1435.5 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 = 16.40 mm
with c1 = 0.60 and c2 = 3.00
inner diameter of shell Da - 2 * e = D = 4007.2 mm
distance saddle - end of cyl. part (L-l1)/2 = a1 = 600.0 mm

4.2 actual stress resultants
spec. transverse force G / (L + 4/3 * h2) = q = 176.53 N/mm
support moment q * D² / 16 = M0 = 177168 Nm

4.2.1 reaction support forces
saddle no. 1 ; 2 Omega1 = 1.0000
reaction support force Omega1 * G / n = F1 = 677883 N

4.2.2 moments and transverse shear forces
support moment q * a3² / 2 - M0 = M1 = M2 = 4718 Nm
trans. force (L-2*a1) / (L+4/3*h2) * F1 = Q1 = Q2 = 450156 N
mid-span M0 + F1 * (L/2-a1) - q/2 * (L/2+2/3*h2)² = M = 604234 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 = 1.5437

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

48.42 <= 170.0 **251 %**

verification of stability acc to DASt 013
4 * ABS(M) / (π * (D + e)² * e) = σ_x43 = 2.9 N/mm²
σ_x,u >= σ_x43 * τ_DASt with τ_DASt = 1.50
185 >= 4 **4146 %**

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 = 2.094 rad
2.83 * a1 / D * SQRT(e/D) = τ = 0.0271
0.91 * b1 / SQRT(D*e) = ß = 1.7749
K2 see input part
max(2.718282^(-ß) * sin(ß) / ß; 0.25) = K3 = 0.250
1 - 2.718282^(-ß) * cos(ß) / ß = K4 = 0.583
1.15 - 0.1432 * δ1B / sin(0.5 * δ1) = K5 = 0.982
max(1.7 - 2.1 * δ1B / π; 0) / sin(0.5*δ1) = K6 = 0.346
1.45 - 0.43 * δ1B / sin(0.5 * δ1) = K7 = 0.634
min(1.0; 0.8 * SQRT(τ) + 6 * τ / δ1B) = K8 = 0.141
1 - 0.65 / (1+(6*τ)²) * SQRT(π / (3 * δ1B)) = K9 = 0.552
1 / (1 + 0.6* (D/e)^(1/3) * b1 / D * δ1B) = K10 = 0.505

ABS(4 * M1 / (π * D² * e)) = σ_mx = 0.02 N/mm²

Theta-values at location **2**
-0.23 * K6 * K8 / (K5 * K3) = Theta1, 2 = -0.04563
-σ_mx * K2 / (S * f) = Theta21,2 = -0.00011
(p*D/(40*e) - σ_mx) * K2 / (S*f) = Theta22,2 = 0.17237
For Theta2-values lesser than 0 the absolute value of Theta2 has been used and the sign of Theta1 has been inverted.
applied: Theta2**2**,2 K1,2 = 1.4836

Theta-values at location **3**
-0.53 * K4 / (K7*K9*K10*sin(0.5*δ1)) = Theta1 ,3 = -2.01596
(const) Theta21,3 = 0
p * D / (20 * e) * K2 / (S * f) = Theta22,3 = 0.34495
applied: Theta21,3 K1,3 = 0.4208

allowable bending stress (5.1)
with allowable stress K / S = f = 170.00 N/mm^2
K1,2 * f * S / K2 = σ_gr,2 = 315.26 N/mm^2
K1,3 * f * S / K2 = σ_gr,3 = 89.41 N/mm^2

0.7*σ_gr,2 * SQRT(D*e)*e / (K3 * K5) = allF2 = 3780768 N
0.9*σ_gr,3 * SQRT(D*e)*e / (K7*K9*K10)= allF3 = 1912302 N
saddle 1 ; 2 F1 <= min(allF2; allF3) **182 %**

5.2.1.2 proof of stability acc to DASt 013
mean radius of shell (Da - e) / 2 = r = 2011.80 mm
yield stress K = σ_F = 255.0 N/mm^2
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 = 1045.6 N/mm^2
0.52 / SQRT(1 + r / (100 * e)) = α_x = 0.35
α_x * σ_x,Ki = σ_x,e = 364.4 N/mm^2
σ_F * [1 + 0.434 * (0.2 - SQRT(σ_F/σ_x,e))] = σ_x,u = 184.5 N/mm^2

shear stresses for non-benched cylinders
0.74 * E * (e/r)^5/4 * (r/l_DASt/2)^0.5 = σ_T,Ki = 153.5 N/mm^2
Linear course of transverse force was assumed!
(const) = α_T = 0.65
α_T * σ_T,Ki = σ_T,e = 99.8 N/mm^2
with σ_T,e <= 0.4*σ_F / SQRT(3) σ_T,e = σ_T,u = 88.8 N/mm^2
saddle no. 1 ; 2
lowest point of the cross section
F1 * π / 4 * SQRT (D / e) * K6 * K8 = Fe = 405191.4 N
4 * ABS(M1) / (π*(D+e)^2*e) + Fe/(π*(D+e)*e)= σ_x = 2.0 N/mm^2
σ_x,u >= σ_x * τ_DASt **6123 %**
side point of the cross section
2 * Q1 / [π * (D + e) * e] = σ_T = 4.3 N/mm^2
σ_T,u >= σ_T * τ_DASt **1264 %**

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 = 2875460 N
saddle 1 ; 2 F1 <= allFi **324 %**
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
section modulus in section A-A W_A = 9233010 mm^3
partially included angle in section A-A Psi = 37.1 °
4 * fs * W_A * sin(0.5*δ1) / (D*(1-cos(Psi)) = allF5 = 6687402 N
6.1.3 bending of web plate
1.4 * fs * D * $e2^2$ * sin(0.5 * δ2) / b1 = allF6_1 = 580736 N
2 * fs * b1 * e2 * sin(0.5 * δ2) = allF6_2 = 2875460 N
max(allF6_1 ; allF6_2) = allF6 = 2875460 N

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

drawing no: 11437-0, Molsieb,Probezust.-Wind Querrichtung , Probedruck
name/ item: Lasteinleitung in den Mantel u. Nachweis d. Sattelbleches

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: 2- form A II - inclined with reinforcing ribs

Design Data

design pressure	p =	11.6	bar
design temperature	T =	20	°C
total weight force	G =	1250000	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 =	255	N/mm²
yield strength Rp 0.2 [20°C,20mm]			
safety factor	S =	1.5	
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 =	255	N/mm²
yield strength Rp 0.2 [20°C,20mm]			
safety factor	Ss =	1.5	
allow design stress acc to AD-S3/0, table 1	fv =	170	N/mm²
modulus of elasticity [20°C]	Es =	212000	N/mm²

Geometry Data, Shell

outer diameter	Da =	4040	mm
wall thickness cylinder	se =	20	mm
manufacturing tolerance	c1 =	7- DIN EN 10029A	
corrosion allowance	c2 =	3	mm
length of cylinder (incl. cylindrical skirt)	L =	6300	mm
mean depth of dished end	h2 =	1035	mm
weakening factor	Nue =	.85	
largest unsupported length	l_DASt =	6300	mm

Geometry Data, Saddle

angle of saddle support, figure 2a and table 2	δ1 =	120	°
angle of support plate, figure 2a	δ2 =	140	°
distance of saddle supports	l1 =	5100	mm
width of saddle support	b1 =	500	mm
thickness of bottom flange plate	t5 =	18	mm
width of bottom flange plate	b =	450	mm
wall thickness of saddle web plate	es =	18	mm
effective plate width of web plate, fig 6	be =	1139.6	mm
wall thickness of support plate, sec A-A, fig 8	e2 =	18	mm
height of web plate, sec A-A, fig 8	hA =	860.5	mm
length of web plate, fig 6	l2 =	3164.4	mm
dist. saddle to center of gravity of dished end	a3 =	1435.5	mm

results

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

actual wall thickness with c1 = 0.60 and c2 = 3.00	se - c1 - c2 =	e =	16.40 mm
inner diameter of shell	Da - 2 * e =	D =	4007.2 mm
distance saddle - end of cyl. part	(L-l1)/2 =	a1 =	600.0 mm

4.2 actual stress resultants

spec. transverse force	G / (L + 4/3 * h2) =	q =	162.76 N/mm
support moment	$q * D^2 / 16$ =	M0 =	163347 Nm

4.2.1 reaction support forces

saddle no. 1 ; 2		Omega1 =	1.0000
reaction support force	Omega1 * G / n =	F1 =	625000 N

4.2.2 moments and transverse shear forces

support moment	$q * a3^2 / 2 - M0$ =	M1 = M2 =	4350 Nm
trans. force	(L-2*a1) / (L+4/3*h2) * F1 =	Q1 = Q2 =	415039 N
mid-span	$M0 + F1 * (L/2-a1) - q/2 * (L/2+2/3*h2)^2$ =	M =	557097 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 = 1.5437

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

88.26 <= 170.0 **93 %**

verification of stability acc to DASt 013

$4 * ABS(M) / (\pi * (D + e)^2 * e)$ = σ_x43 = 2.7 N/mm^2

σ_x,u >= σ_x43 * τ_DASt with τ_DASt = 1.50

185 >= 4 **4505 %**

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 =	2.094 rad
2.83 * a1 / D * SQRT(e/D) =	τ =	0.0271
0.91 * b1 / SQRT(D*e) =	ß =	1.7749
	K2 see input part	
max(2.718282^(-ß) * sin(ß) / ß; 0.25) =	K3 =	0.250
1 - 2.718282^(-ß) * cos(ß) / ß =	K4 =	0.583
1.15 - 0.1432 * δ1B / sin(0.5 * δ1) =	K5 =	0.982
max(1.7 - 2.1 * δ1B / π; 0) / sin(0.5*δ1) =	K6 =	0.346
1.45 - 0.43 * δ1B / sin(0.5 * δ1) =	K7 =	0.634
min(1.0; 0.8 * SQRT(τ) + 6 * τ / δ1B) =	K8 =	0.141
1 - 0.65 / (1+(6*τ)²) * SQRT(π / (3 * δ1B)) =	K9 =	0.552
1 / (1 + 0.6* (D/e)^(1/3) * b1 / D * δ1B) =	K10 =	0.505
ABS(4 * M1 / (π * D² * e)) =	σ_mx =	0.02 N/mm²

Theta-values at location **2**

-0.23 * K6 * K8 / (K5 * K3) =	Theta1, 2 =	-0.04563
-σ_mx * K2 / (S * f) =	Theta21,2 =	-0.00010
(p*D/(40*e) - σ_mx) * K2 / (S*f) =	Theta22,2 =	0.33336

For Theta2-values lesser than 0 the absolute value of Theta2 has been used and the sign of Theta1 has been inverted.

applied: Theta2**2**,2 K1,2 = 1.3907

Theta-values at location **3**
-0.53 * K4 / (K7*K9*K10*sin(0.5*δ1)) = Theta1 ,3 = -2.01596
(const) Theta21,3 = 0
p * D / (20 * e) * K2 / (S * f) = Theta22,3 = 0.66691
applied: Theta21,3 K1,3 = 0.4208

allowable bending stress (5.1)
with allowable stress K / S = f = 170.00 N/mm^2
K1,2 * f * S / K2 = σ_gr,2 = 295.53 N/mm^2
K1,3 * f * S / K2 = σ_gr,3 = 89.41 N/mm^2

0.7*σ_gr,2 * SQRT(D*e)*e / (K3 * K5) = allF2 = 3544176 N
0.9*σ_gr,3 * SQRT(D*e)*e / (K7*K9*K10)= allF3 = 1912302 N
saddle 1 ; 2 F1 <= min(allF2; allF3) **206 %**

5.2.1.2 proof of stability acc to DASt 013
mean radius of shell (Da - e) / 2 = r = 2011.80 mm
yield stress K = σ_F = 255.0 N/mm^2
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 = 1045.6 N/mm^2
0.52 / SQRT(1 + r / (100 * e)) = α_x = 0.35
α_x * σ_x,Ki = σ_x,e = 364.4 N/mm^2
σ_F * [1 + 0.434 * (0.2 - SQRT(σ_F/σ_x,e))] = σ_x,u = 184.5 N/mm^2

shear stresses for non-benched cylinders
0.74 * E * (e/r)^5/4 * (r/l_DASt/2)^0.5 = σ_T,Ki = 153.5 N/mm^2
Linear course of transverse force was assumed!
(const) = α_T = 0.65
α_T * σ_T,Ki = σ_T,e = 99.8 N/mm^2
with σ_T,e <= 0.4*σ_F / SQRT(3) σ_T,e = σ_T,u = 88.8 N/mm^2
saddle no. 1 ; 2
lowest point of the cross section
F1 * π / 4 * SQRT (D / e) * K6 * K8 = Fe = 373581.9 N
4 * ABS(M1) / (π*(D+e)^2*e) + Fe/(π*(D+e)*e)= σ_x = 1.8 N/mm^2
σ_x,u >= σ_x * τ_DASt **6649 %**
side point of the cross section
2 * Q1 / [π * (D + e) * e] = σ_T = 4.0 N/mm^2
σ_T,u >= σ_T * τ_DASt **1379 %**

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 = 2875460 N
saddle 1 ; 2 F1 <= allFi **360 %**
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
section modulus in section A-A W_A = 9233010 mm^3
partially included angle in section A-A Psi = 37.1 °
4 * fs * W_A * sin(0.5*δ1) / (D*(1-cos(Psi)) = allF5 = 6687402 N
6.1.3 bending of web plate
1.4 * fs * D * e2^2 * sin(0.5 * δ2) / b1 = allF6_1 = 580736 N
2 * fs * b1 * e2 * sin(0.5 * δ2) = allF6_2 = 2875460 N
max(allF6_1 ; allF6_2) = allF6 = 2875460 N

12. Load table Foundation loads
(following loads are taken into account: deadload of vessel, snow- and wind loads and additional Nozzle loads)

Description **Molsieve Adsorber**

Item No.: **W15001 / W15002**

Drawing No.: **11437-0**

maximal foundation loads per saddle:

fixed saddle	vertical load V / kN	horizontal load ax. HL/kN	horizontal load tr. HQ/kN	Moment axial ML / kN/m	Moment transverse MQ / kN/m
operating	677,89	15,5	16,4	63,3	86,7
testing	625,00	15,5	16,4	6,7	40,1

sliding saddle	vertical load V / kN	horizontal load transverse HQ / kN	Moment transverse MQ / kN/m
operating	677,89	16,4	86,7
testing	625,00	16,4	40,1

Number of anchorbolts per saddle **4**

dimension: M **24** bolt crosssectional area = **20,1** mm

material: **4.6**

WOLF GmbH & Co. KG
Behälter- und Apparatebau
57234 Wilnsdorf

Ebene Böden und Platten
nach AD 2000-Merkblatt B5:2004-05

Zeichnungsnr: 11420-0
Bez./ Pos-Nr: W-1300A, W1301A Rohrplatte

Eingabedaten

Bauteilbeschreibung

Plattenform	=	1- rund
Einspanntyp: 13- zusätzliches Randmoment (Abschnitt 6.3)		
Berechnung der Durchbiegung für Platte ohne Ausschnitt	=	0- Nein

Betriebsdaten

Berechnungsüberdruck	p =	30	bar
Berechnungstemperatur	T =	300	°C

Werkstoffdaten

Platte: 0751-P 355 NH (1.0565) DIN EN 10028-3 VdTÜV 354/1 AD-W1			
Festigkeitskennwert, Platte	K =	177	N/mm²
Streckgrenze Rp 0.2 [300°C,135mm]			
Festigkeitskennwert bei RT	K20 =	295	N/mm²
Streckgrenze Rp 0.2 [20°C,135mm]			
Elastizitätsmodul, Platte [300°C]	E =	192000	N/mm²
Sicherheitsbeiwert, Platte	S =	1.5	

Geometriedaten

vorh Plattendicke	se =	135	mm
Herstellungstoleranz	c1 =	0	mm
Abnutzungszuschlag	c2 =	2	mm
Teilkreisdurchmesser (Plattenbreite)	dt;f =	1205	mm
mittlerer Dichtungsdurchmesser (Plattenbreite)	dD;f =	1118	mm
Restwanddicke	sR =	122	mm
Dichtungstyp: 26- Freie Eing.,(Metall-) Weichstoff			
Dichtungskennwert	k1 =	28	mm

Platten-Ausschnitt

Ausschnitt: 0- keiner

Ergebnisse

Prozentangaben im Ergebnis bedeuten Über-/Unterdimensionierungen:
bei Abmessungen: (vorh-erf)/erf, bei sonst Angaben: (zul-vorh)/vorh

erforderliche Plattendicke	serf =	89.14	mm
	Res =	**+51**	**%**
Herstellungstoleranz	c1 =	0.0	mm
Abnutzungszuschlag	c2 =	2.0	mm
Herstellungstol. für ausgef. Wandd. nur zur Info	c1 =	0.0	mm
Berechnungsdurchmesser (-breite)	D1;f =	1118.0	mm
Berechnungsbeiwert (Bild 5)	C1 =	0.489	
mit Verhältnis	dt/dD =	1.078	
mit Dichtungsbeiwert	k1 =	28.000	mm
mit Wert	delta =	1.120	

max zul Betriebsüberdruck	pmax =	**69.88**	**bar**
max zul Prüfüberdruck	pTmax =	**166.38**	**bar**

Randbedingung für Einspannung

erforderliche Restwanddicke	sRmin =	62.40	mm
	Res =	**+96**	**%**

52

