Design of Process Equipment

Vessels

Lecture

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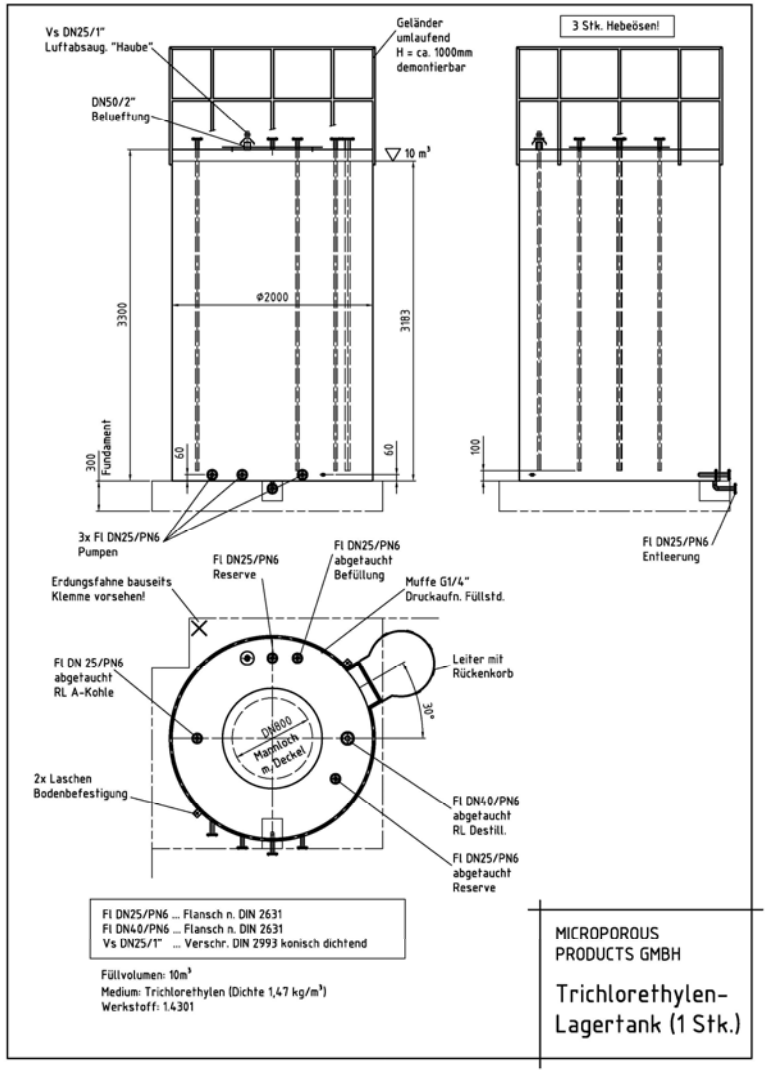
Process Equipment Design: Vessel

Introduction:

- SHAPE (cylinder, square/rectangular/ container
- MATERIAL / steel, plastic, glass, FRP .../ + surface treatment
- CONNECTIONS / flange, clamp, etc.)
- EXTRA (e.g. special design (jacketed), reinforcement, interior construction, service platform, etc.)

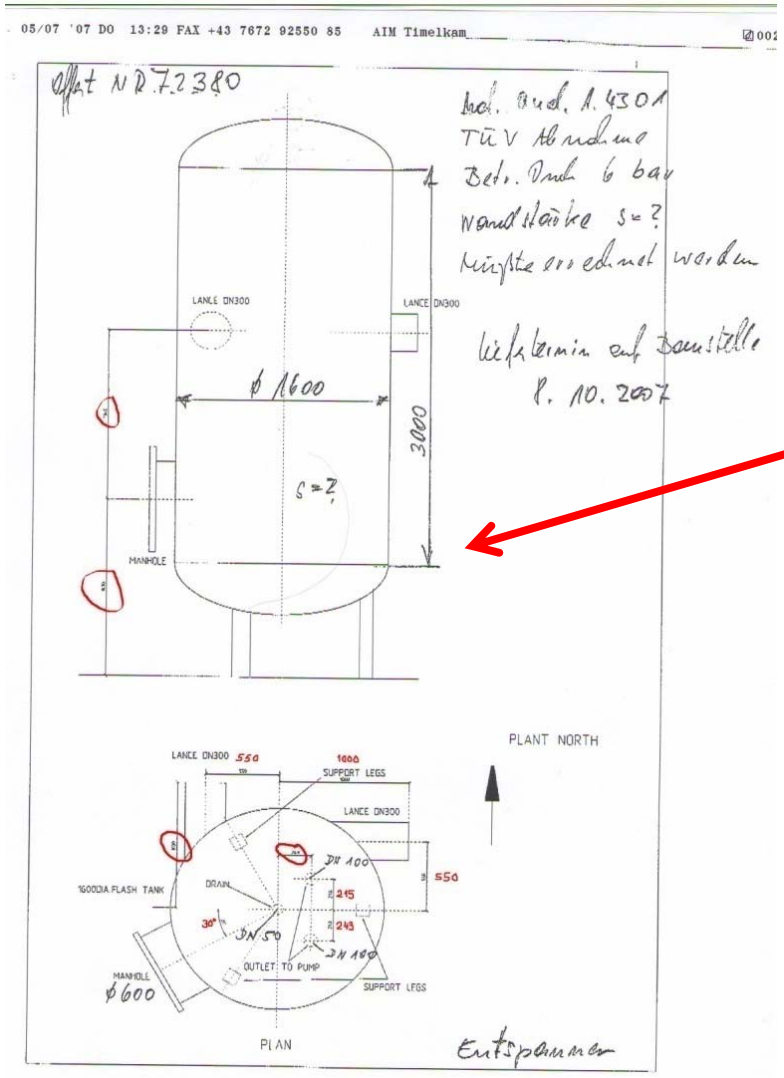
Process Equipment Design: Vessel



Assignment:

- Text information about project
- Dimensional sketch
- Volume
- Main dimensions D/L
- Position and placement of nozzles
- Material design
- Equipment / flanges, sockets, anchoring, insulation, etc.)
- Control and Regulation

Process Equipment Design: Vessel



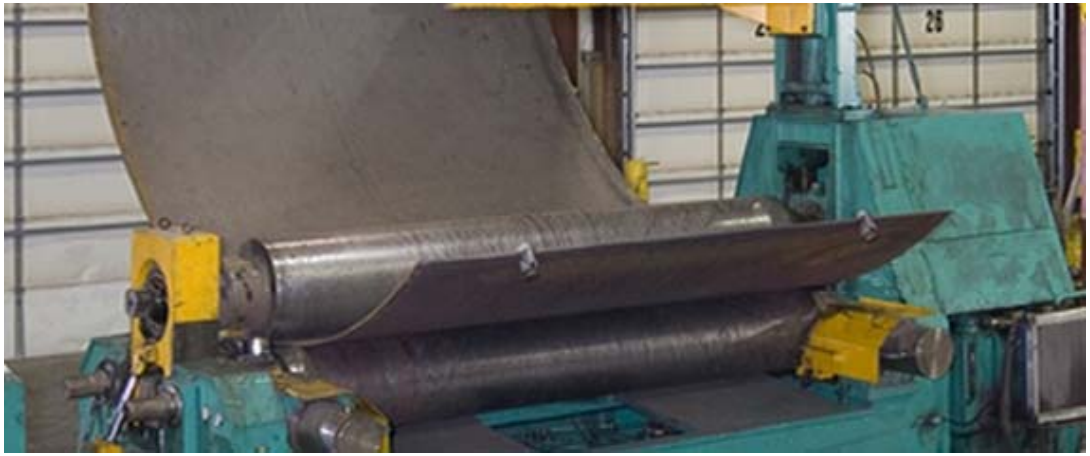
Process calculation:

- Check dimensions
- Correction of dimensions
- Optimization.

Strength calculation:

- p/T
- other loads
- special requirements (snow, wind, seismic analysis)
- Is it a pressure vessel according to EN 13 445?

Process Equipment Design: Vessel



Process calculation:

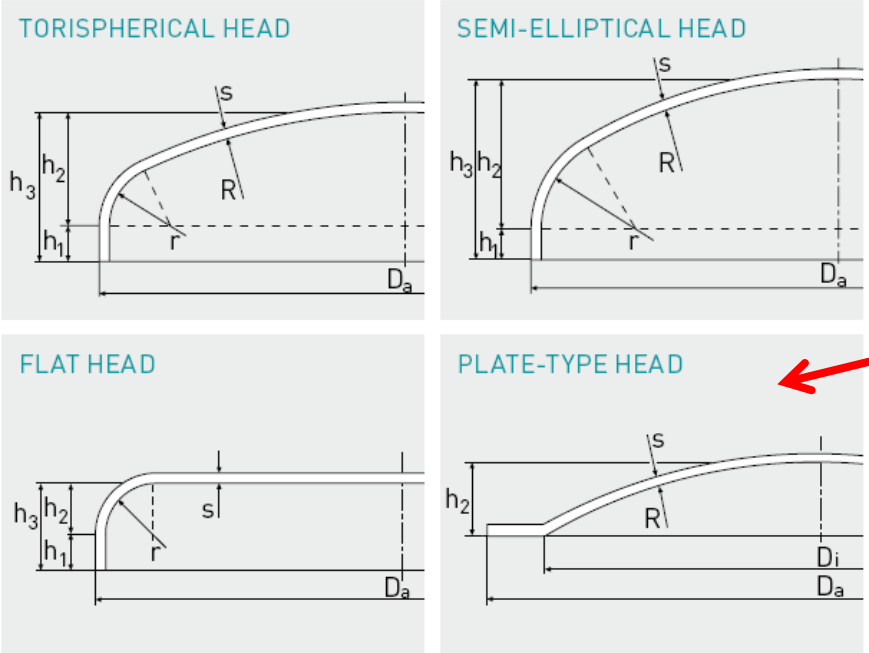
Change in dimensions

Reducing the number of welds

Adjustment to acceptable transport dimensions

Minimum number of loops

Process Equipment Design: Vessel

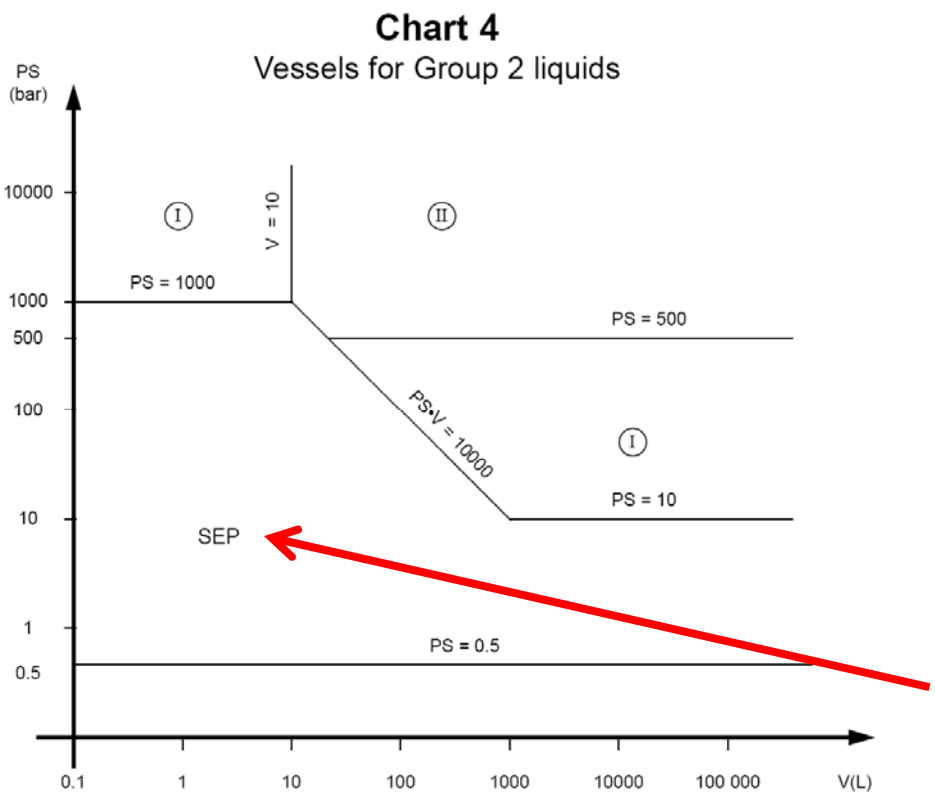


$d_a^{2)}$ mm	r_1 mm	r_2 mm	Wölbungshöhe h_2 bei s = 3–5 mm	6–11 mm	12–20 mm	Rundschnitt ø bei h_1 = 20–25 mm³) s = 3–4 mm	s = 5–7 mm	Raum-inhalt ohne h_1 Ltr.	Gewicht bei s = 1 kg
500	500	50	95	93	90	610	610	12,5	2,3
600	600	60	114	112	109	720	720	21,6	3,7
700	700	70	134	132	129	830	830	34	4,2
800	800	80	153	151	148	940	940	51	5,4
900	900	90	172	170	167	1055	1055	73	6,9
1000	1000	100	192	190	187	1170	1170	100	8,4
1100	1100	110	211	209	206	1290	1290	133	10,3

Process calculation

- Change in dimensions
- Adjustment due to realistically produced torispherical /spherical/ elliptical bottoms
- For example DIN 28 011 torispherical heads. (approx. up to 7000 mm)
- Normalized dimension

Process Equipment Design: Vessel



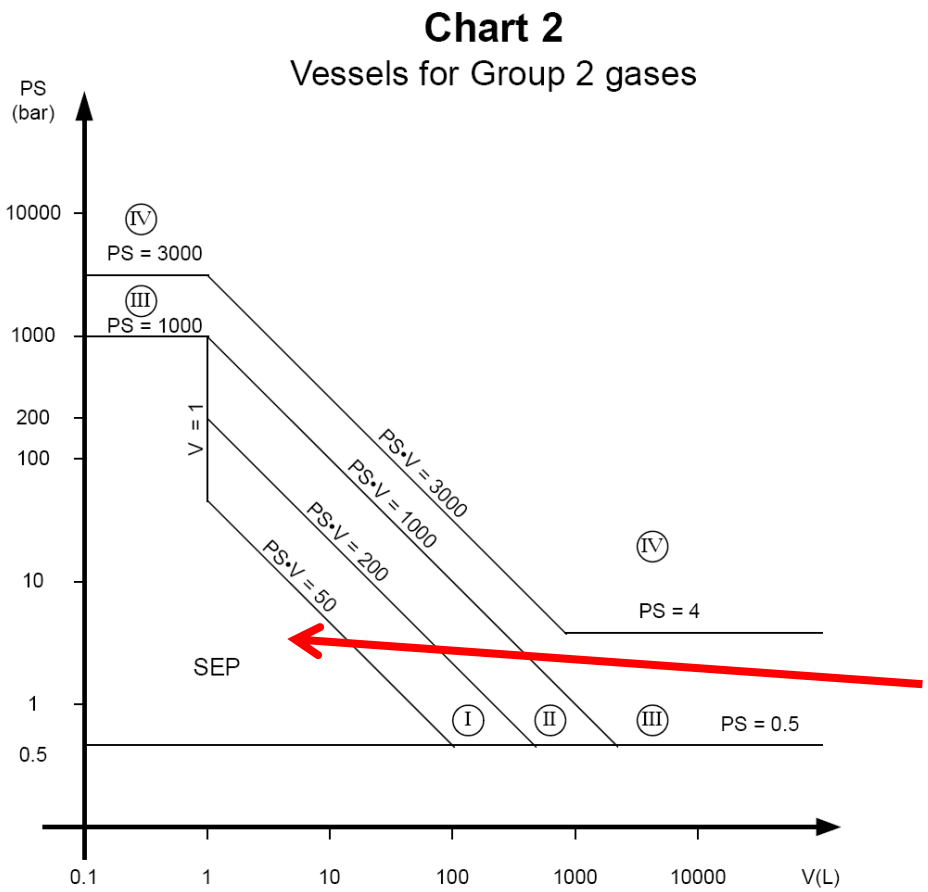
Strength calculation
Categorization 13 445-7

Material group - 1 / 2
Medium g or l
p.V (product of working pressure /bar/ and working volume /lit/)

Is it a pressure vessel?

SEP – sound engineering practice

Process Equipment Design: Vessel



Strength calculation
Categorization 13 445-7

Material group - 1 / 2
Medium g or l
p.V (product of working pressure /bar/ and working volume /lit/)

Is it a pressure vessel?

SEP – sound engineering practice

Process Equipment Design: Vessel

The conformity assessment modules available for the different categories of equipment are detailed below, along with a brief description in the key (fuller details are provided in Annex E). Manufacturers may choose the module(s) which best suit them, e.g. a manufacturer of Category II equipment may choose A1, D1 or E1.

Category I	Category II	Category III	Category IV
Module	**Modules**	**Modules**	**Modules**
A	A1	B1 + D	B + D
	D1	B1 + F	B + F
	E1	B + E	G
		B + C1	H1
		H	

Module	Design	Production
A	Technical documentation	Internal production control
A1	Technical documentation	Internal production control with monitoring of the final assessment
B	Type examination	
B1	Design examination	
C1		Monitoring of final assessment
D		Quality assurance for production, final inspection and test
D1	Technical documentation	Quality assurance for production, final inspection and test
E		Quality assurance for final inspection and test
E1	Technical documentation	Quality assurance for final inspection and test
F		Product verification
G	Unit verification	Unit verification
H	Quality assurance for design,	manufacture, final inspection and test
H1	Quality assurance for design, with design examination and	manufacture, final inspection and test monitoring of final assessment

Strength calculation
Categorization 13 445-7

Material group - 1 / 2
Medium g or l
p.V (product of working pressure /bar/ and working volume /lit/)

Is it a pressure vessel?

SEP – sound engineering practice

Process Equipment Design: Vessel

7.4.2 Valcovité plášte

Požadovaná hrúbka sa musí vypočítať z jednej z nasledujúcich dvoch rovníc:

$$e = \frac{P \cdot D_i}{2f \cdot z - P} \qquad (7.4\text{-}1)$$

alebo

$$e = \frac{P \cdot D_e}{2f \cdot z + P} \qquad (7.4\text{-}2)$$

Pre danú geometriu:

$$P_{max} = \frac{2f \cdot z \cdot e_a}{D_m} \qquad (7.4\text{-}3)$$

7.5.3 Tórisférické dná

7.5.3.1 Podmienky použiteľnosti

Nasledujúce požiadavky platia pre dná, pre ktoré sú splnené všetky nasledujúce podmienky:

$r \leq 0{,}2\ D_i$

$r \geq 0{,}06\ D_i$

$r \geq 2e$

$e \leq 0{,}08\ D_e$

$e_a \geq 0{,}001\ D_e$

$R \leq D_e$

7.5.3.2 Navrhovanie

Požadovaná hrúbka *e musí byť najväčšia* z e_s, e_y a e_b, kde:

$$e_s = \frac{P \cdot R}{2f \cdot z - 0{,}5P} \qquad (7.5\text{-}1)$$

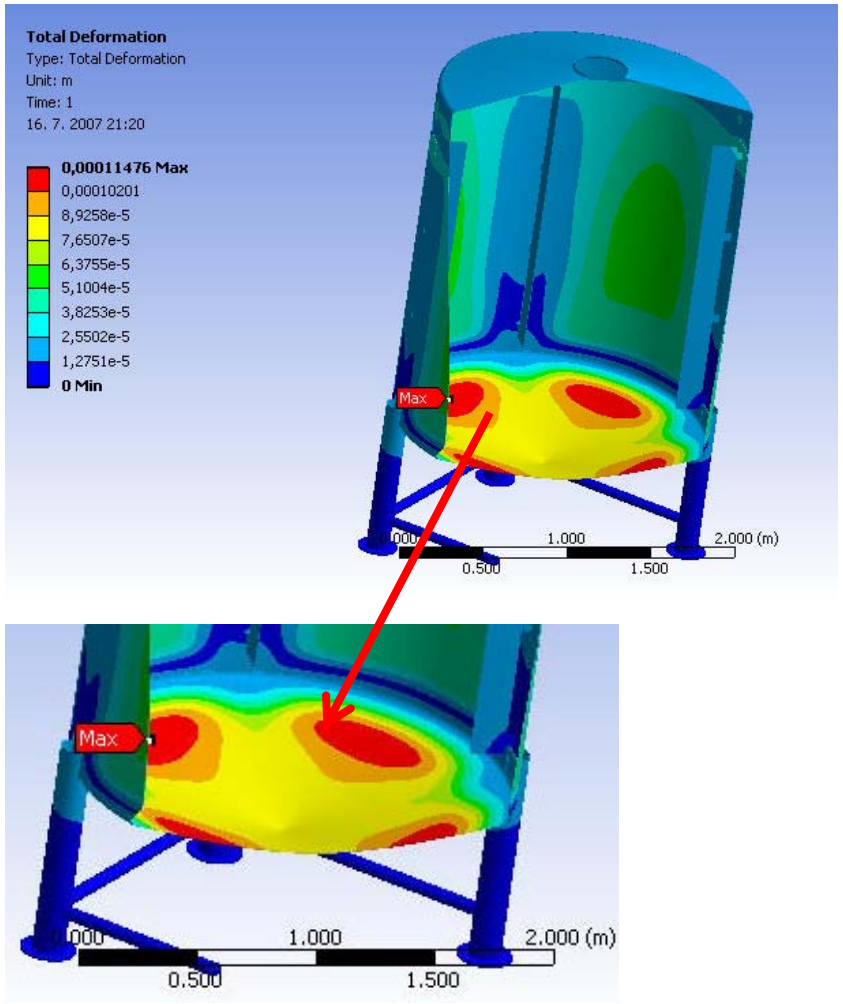
$$e_y = \frac{\beta \cdot P\,(0{,}75R + 0{,}2D_i)}{f} \qquad (7.5\text{-}2)$$

Strength calculation
According to 13 445-3

The calculation can also be carried out according to other standards (ASME, BS, etc.) It depends on the investor

By calculation, document each standard part of the pressure vessel -
cylindrical shell
torispherical head
etc.

Process Equipment Design: Vessel



Strength calculation
According to 13 445-3

Specific segments of the pressure vessel are most often dealt with by FEM. / finite element method/

- Extremely important nodes.

- Analysis of the impact of additional stress from e.g. pipes

- Etc ..

Process Equipment Design: Vessel

Process Equipment Design: Vessel

Atmospheric vessel
(no pressure)

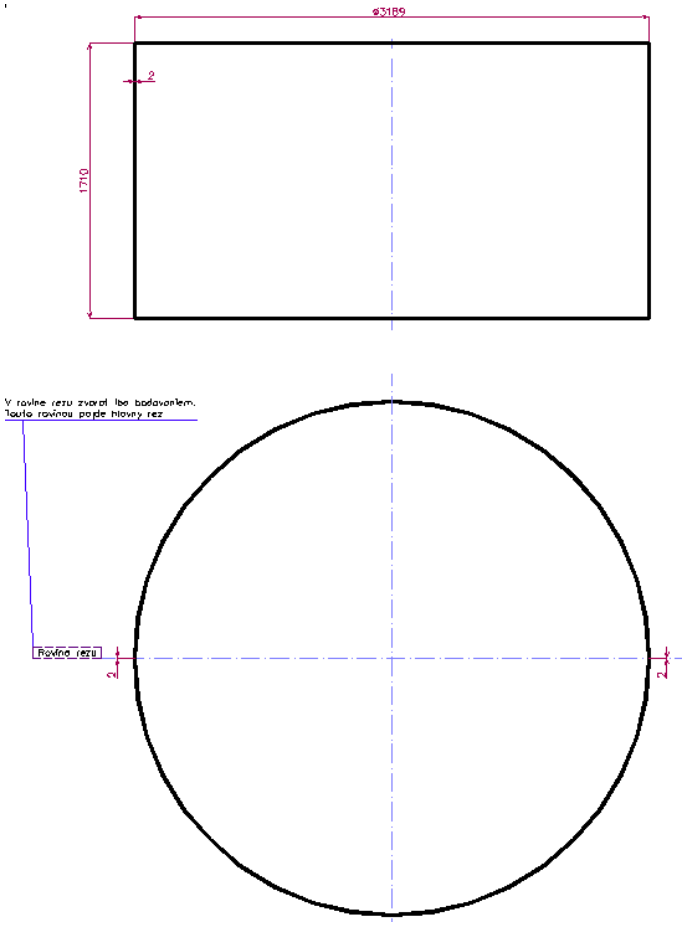
Design based on experience. (SEP).

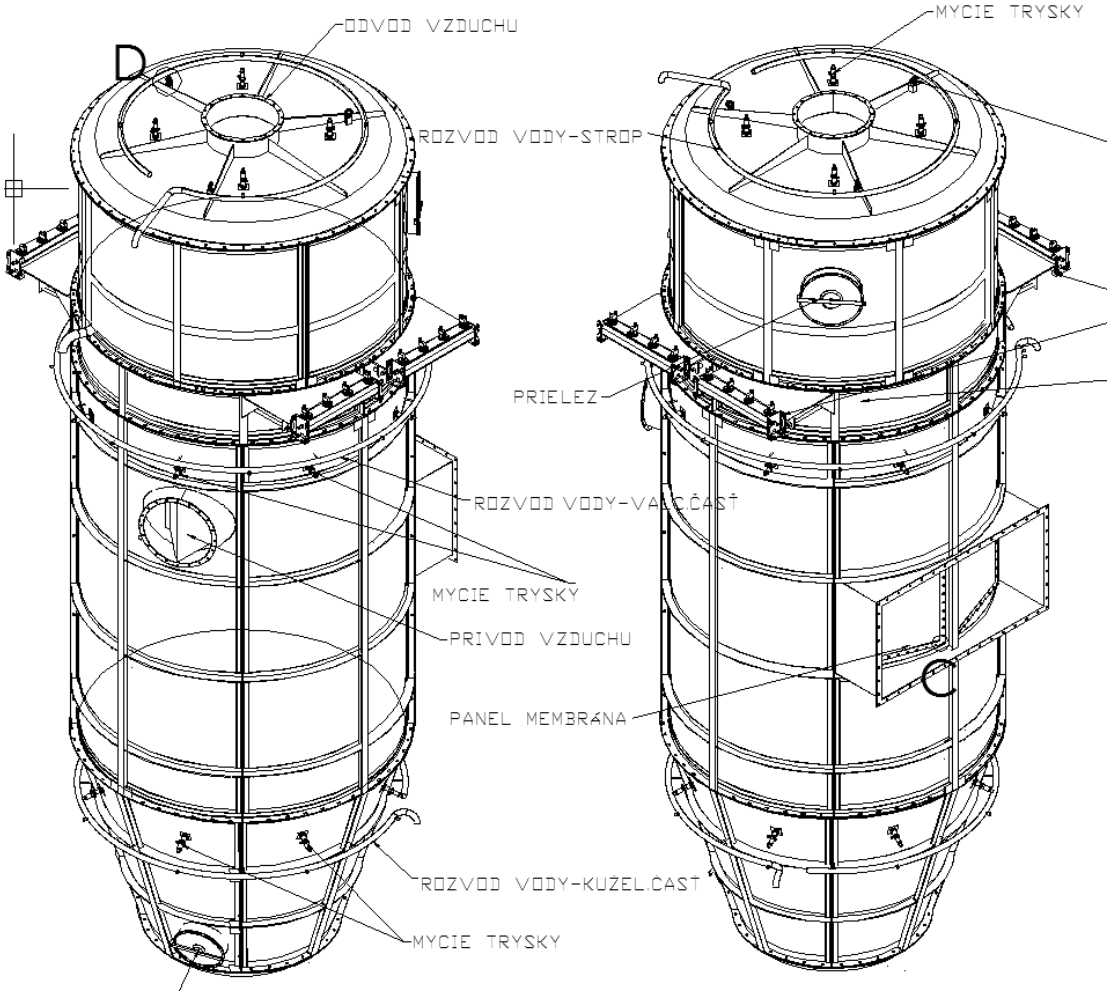
Detail design - only for selected parts

Basic load
hydrostatic pressure
Weight
+ other loads ./

We choose min. wall thickness 2-3 mm.
/manufacture requirement /

Process Equipment Design: Vessel





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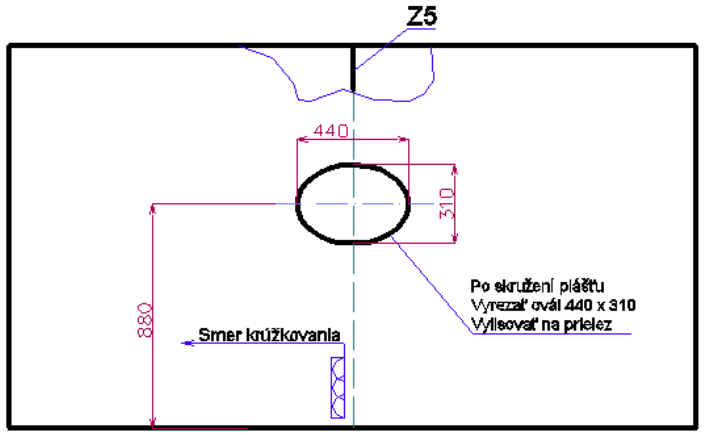
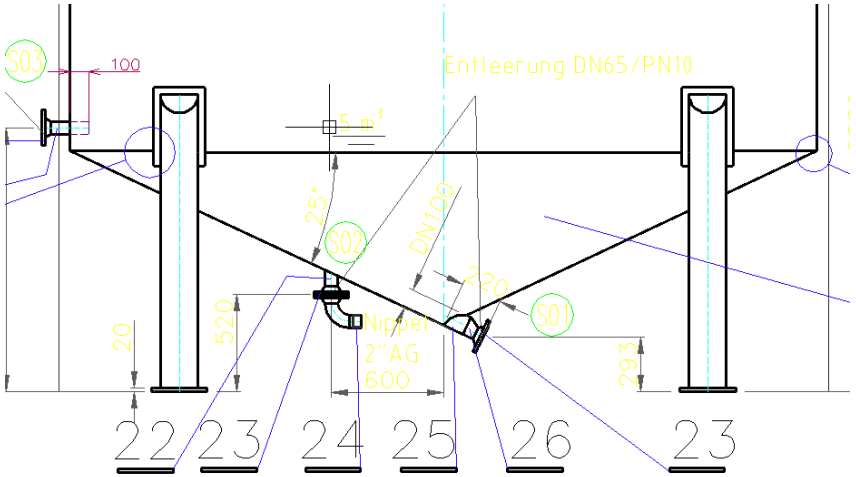
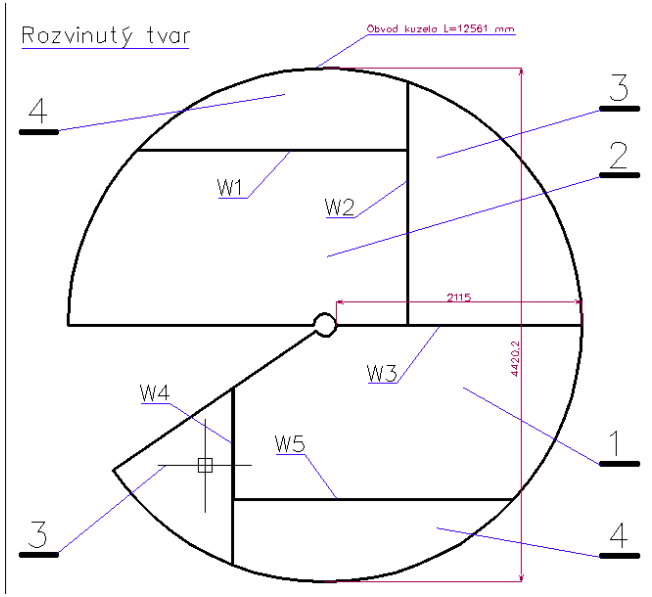


Process Equipment Design: Vessel





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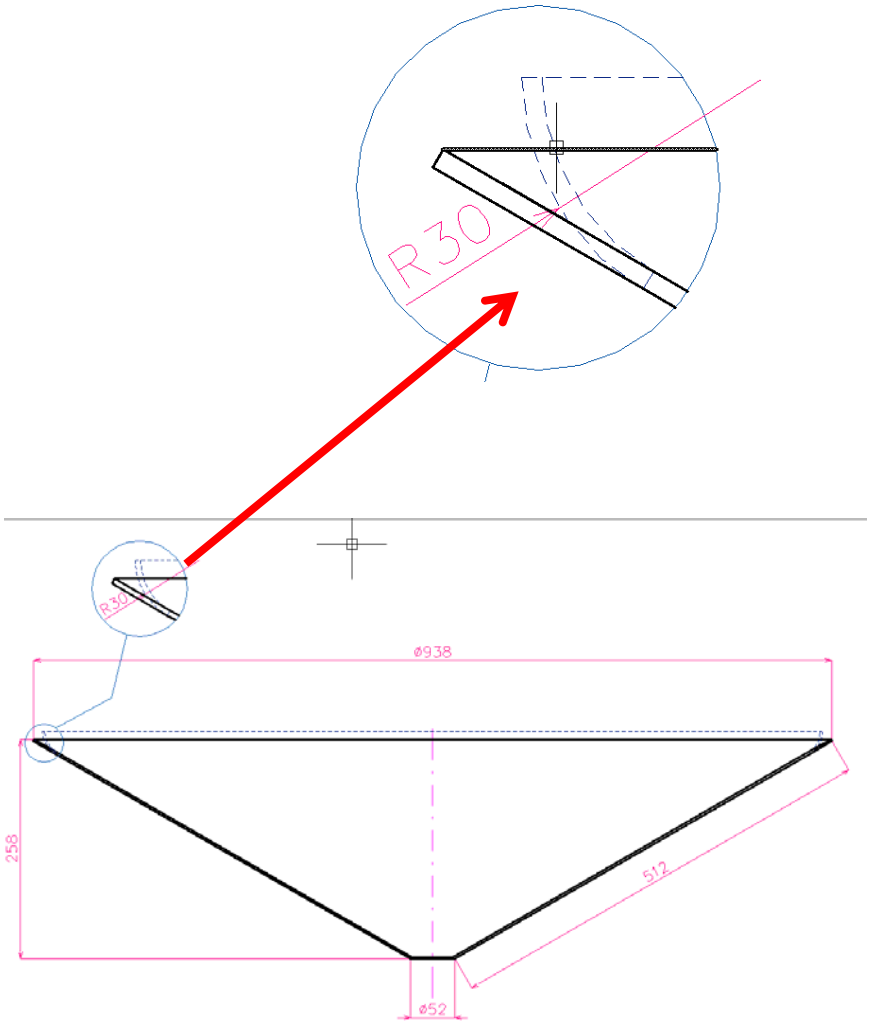

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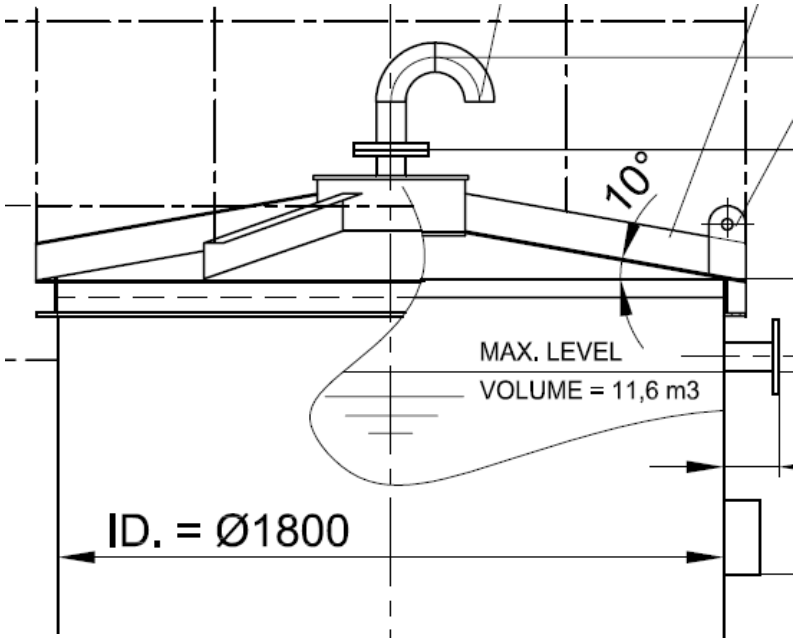

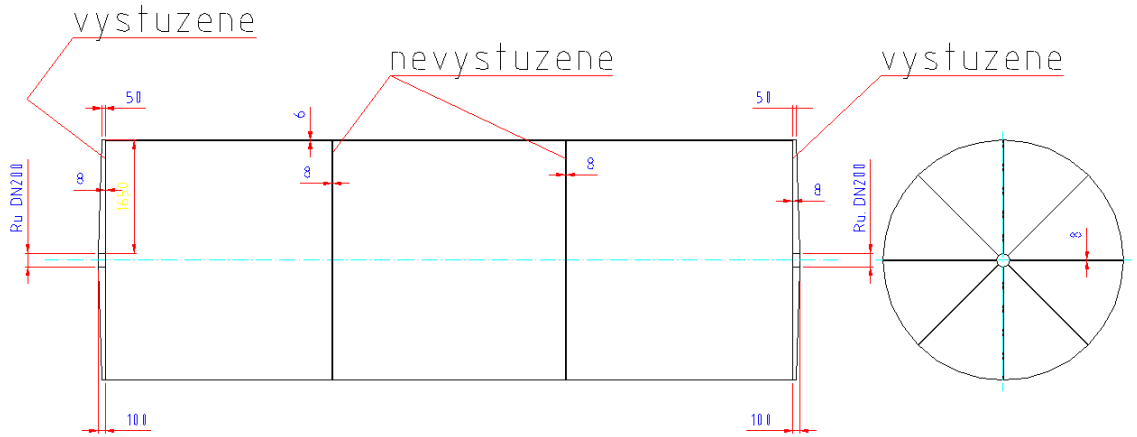

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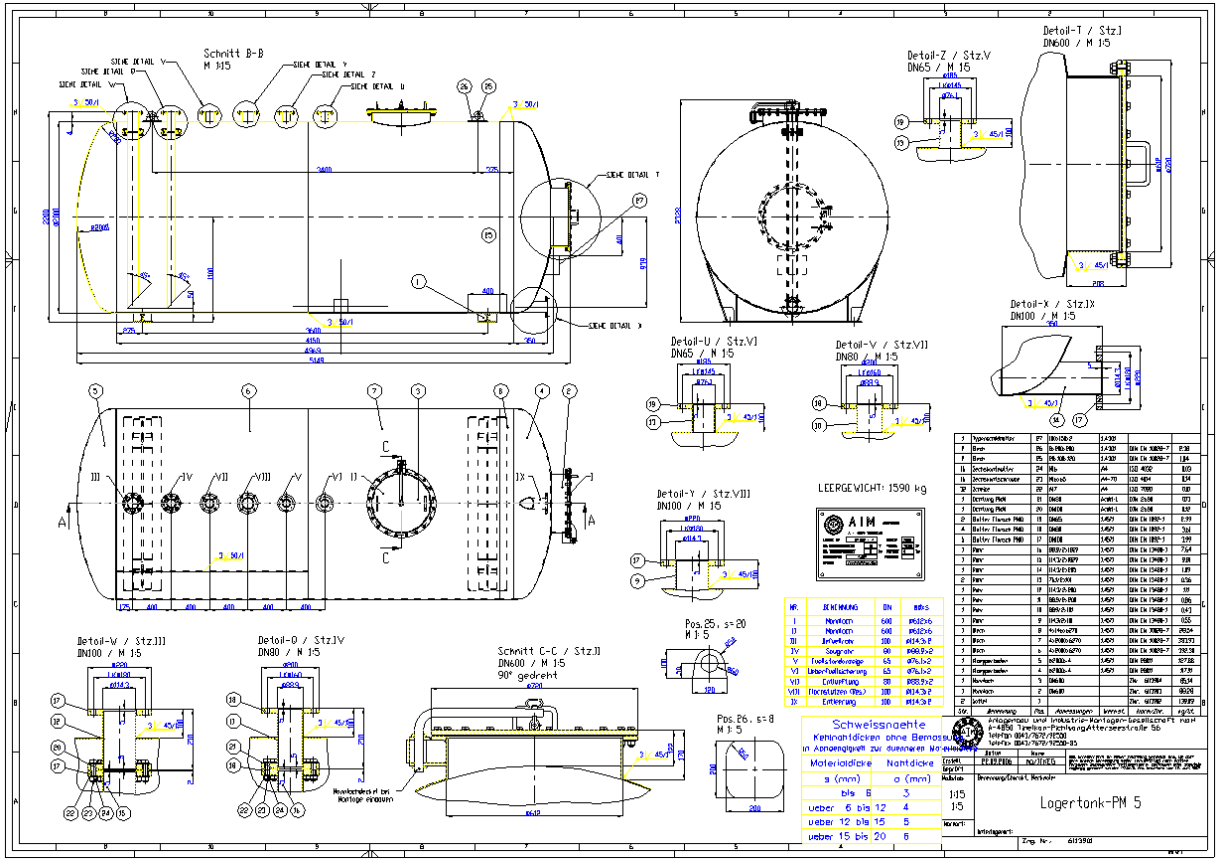

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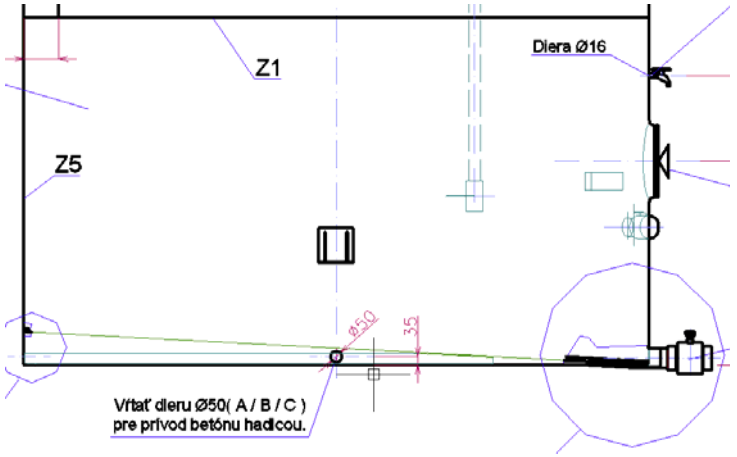

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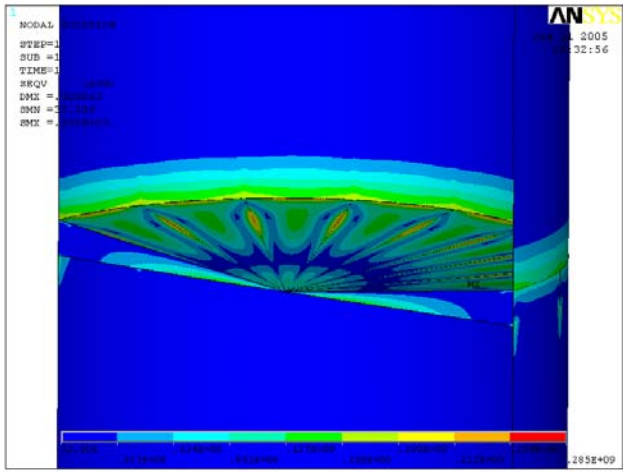
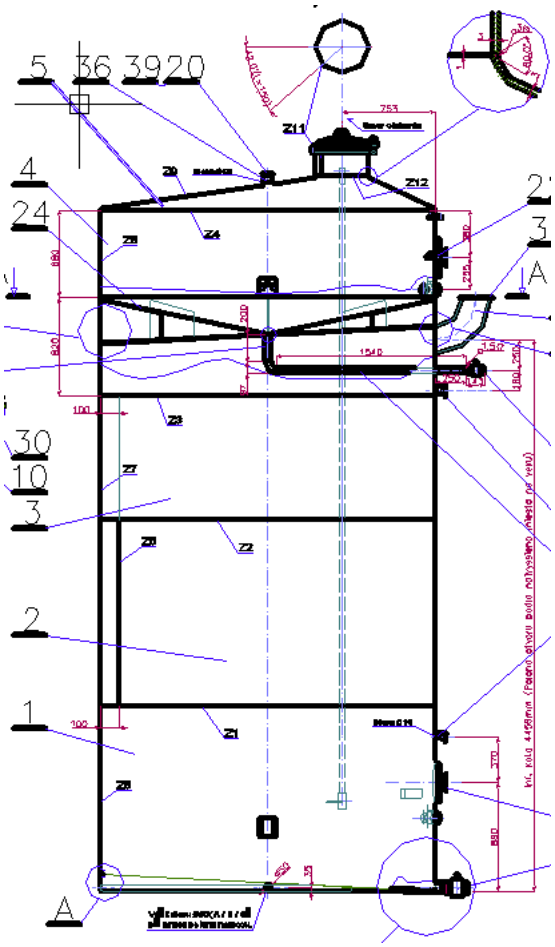
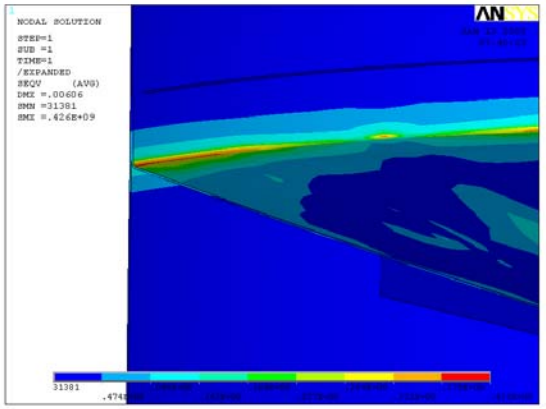




Flat bottom

Mostly necessary to reinforce



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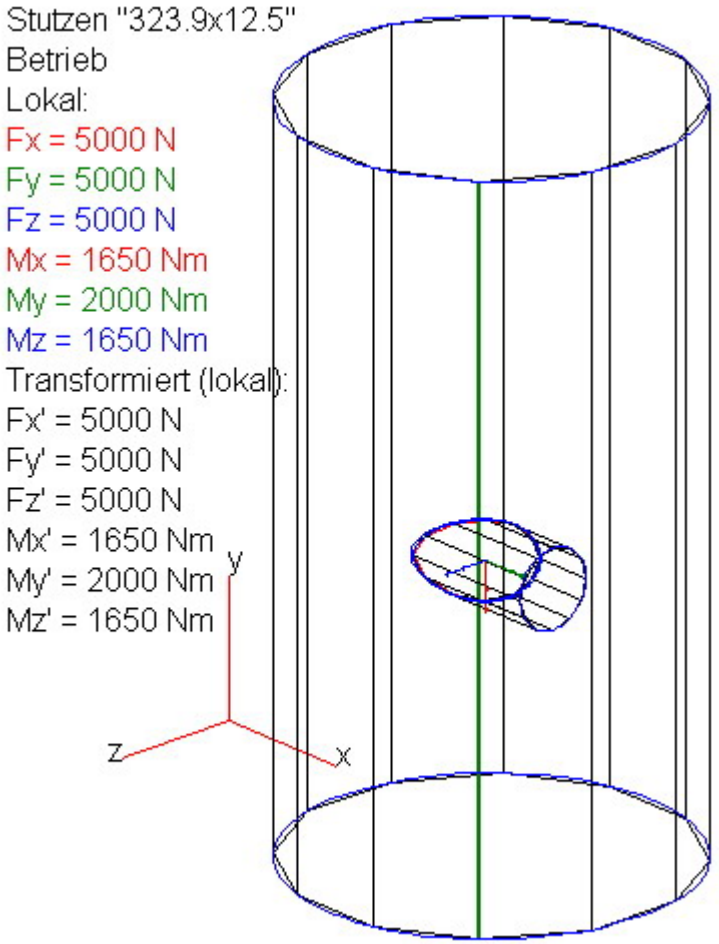
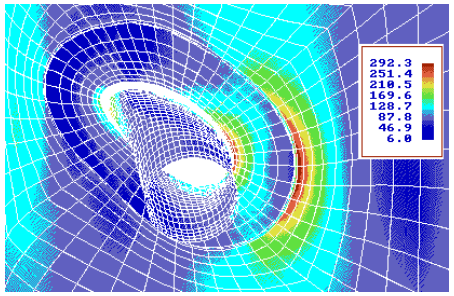
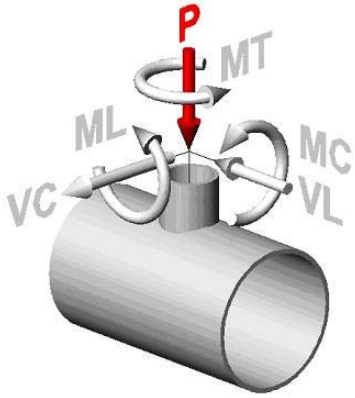


Nozzle and connections

Maximum available forces/moments





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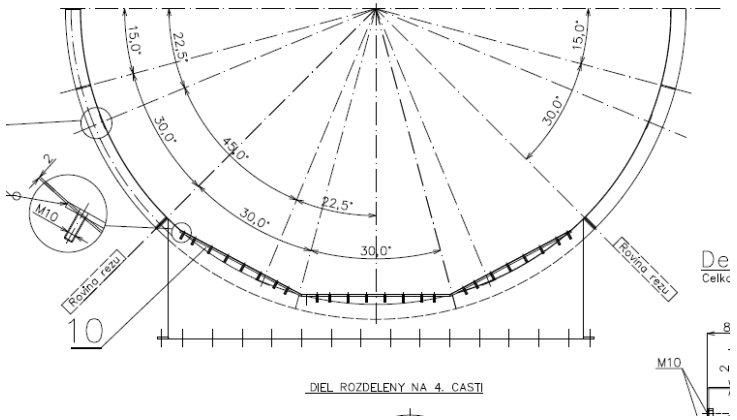

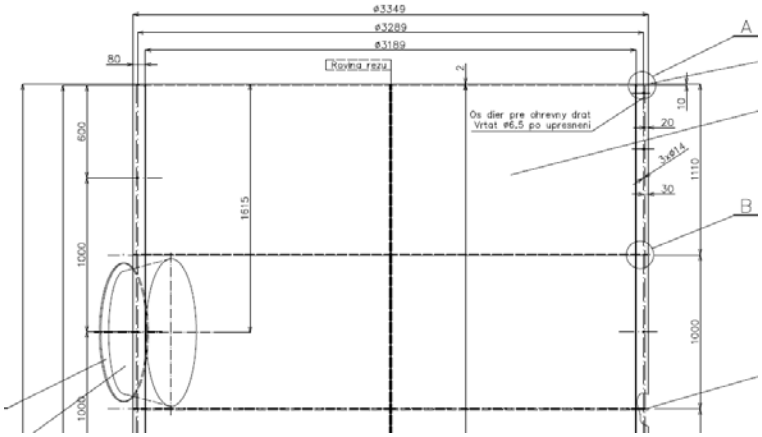

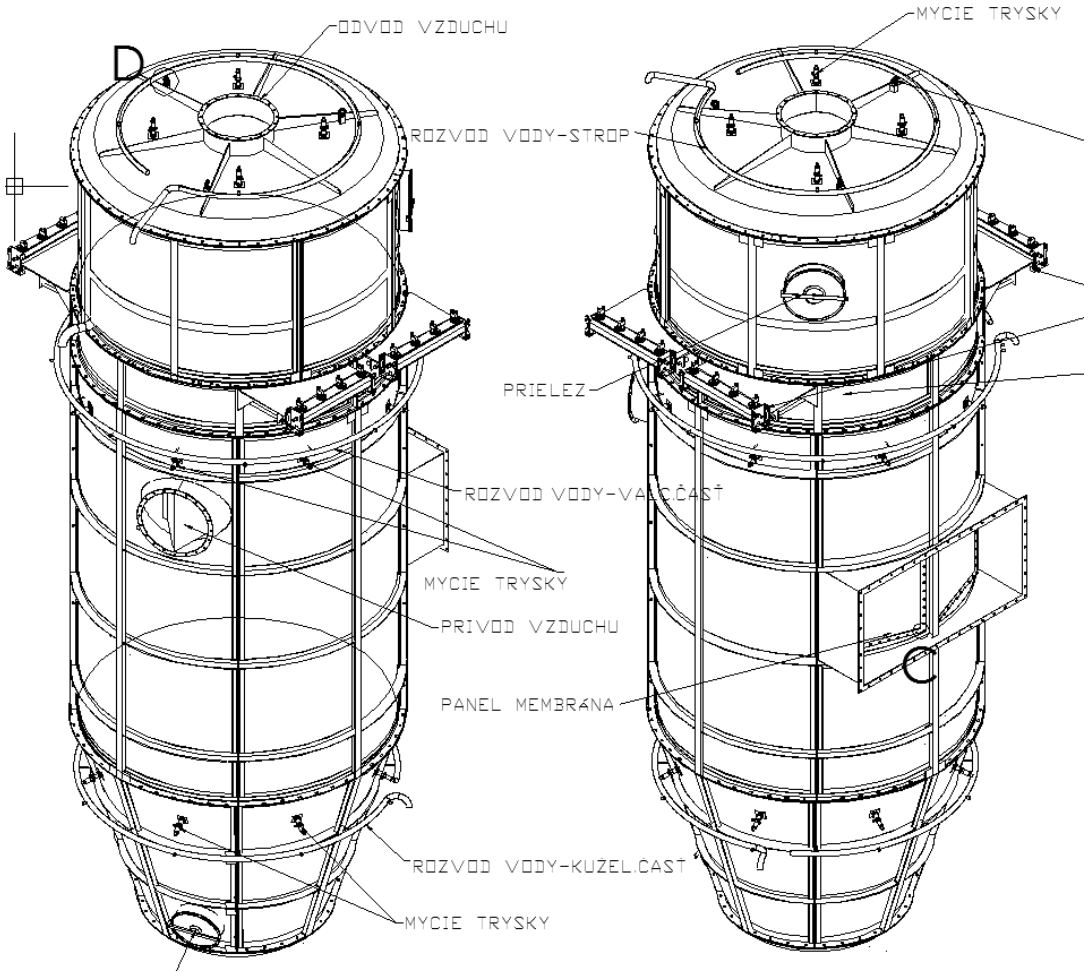

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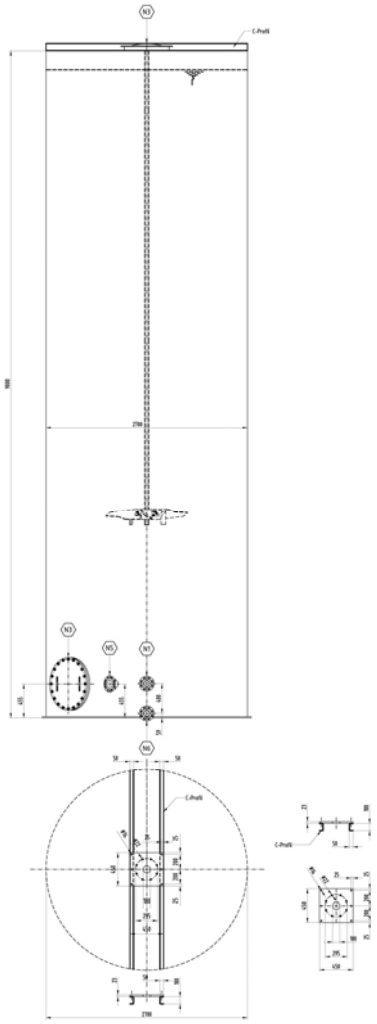
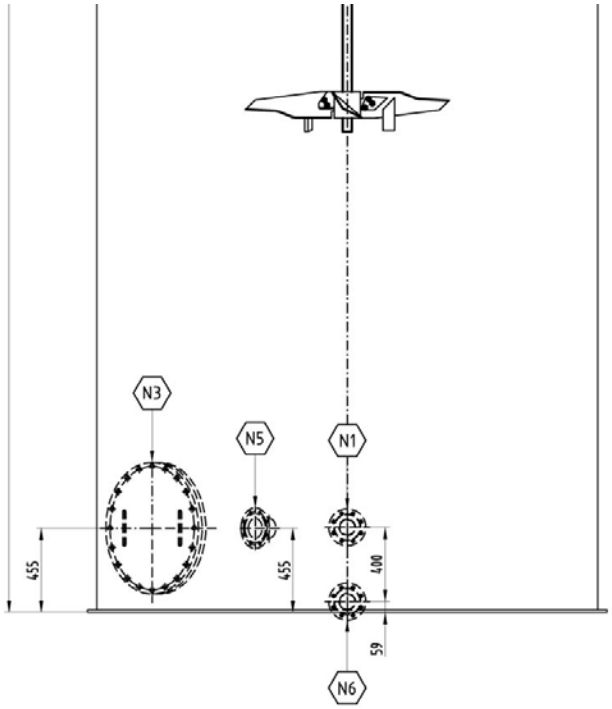


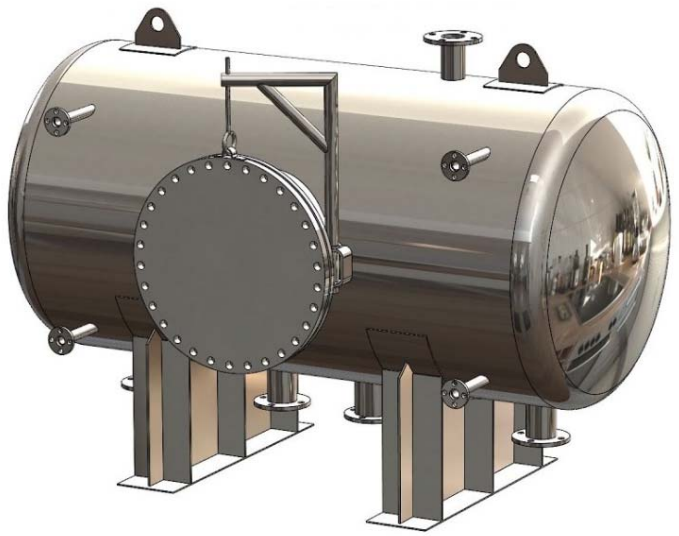


STUTZENTABELLE / NOZZLE INFORMATION

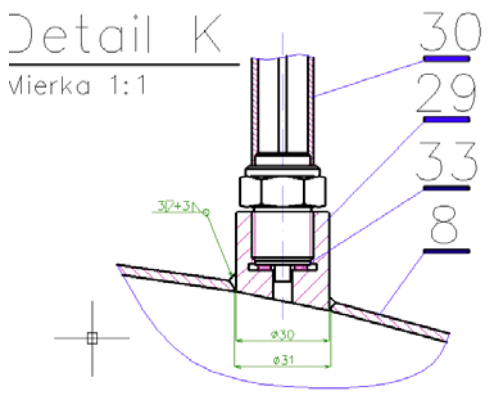
Name Symbol	Anzahl Piece	Benennung Description	DN	PN	Norm Standard	Rohr Φ x s Pipe Φ x s	Dichtfläche Facing
N1	1	Zulauf	80	16	DIN 2633	88,9 x 3	C
N2	1	Rührwerksflansch	200	16	DIN 2633	273,2 x 3	C
N3	2	Mannloch	600	16	DIN 2633	614,3 x 3,6	C
N4	1	Entlüftung	100	16	DIN 2633	114,3 x 3,6	C
N5	1	Drucksensor	100	16	DIN 2633	114,3 x 3,6	C
N6	1	Ablauf	80	16	DIN 2633	88,9 x 3	C

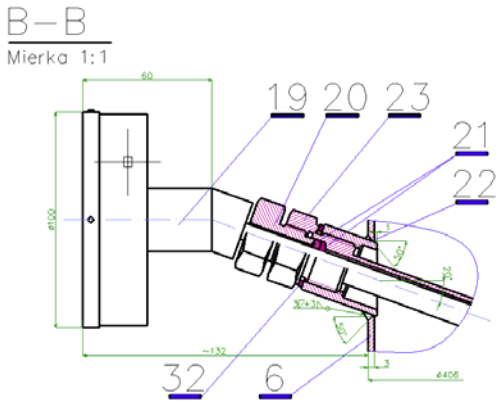
Nozzle connection

Types
Position



Process Equipment Design: Vessel





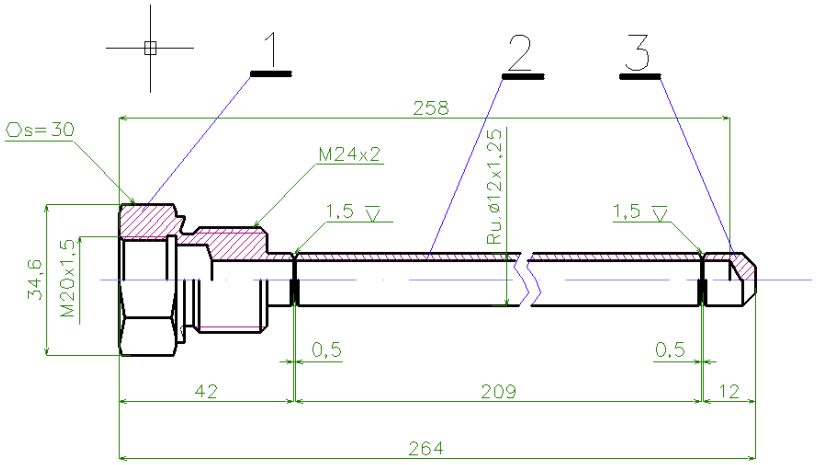
Control and Regulation

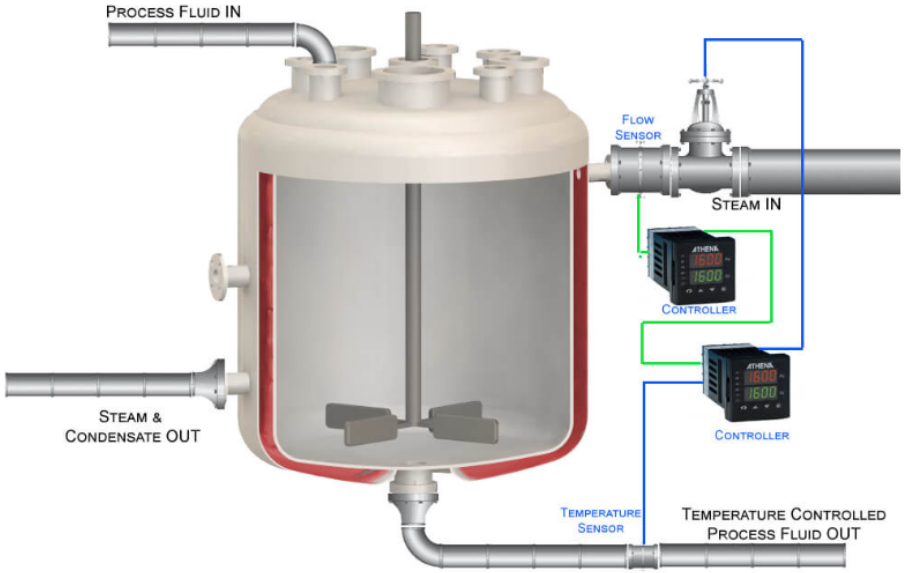
P

T

F

L





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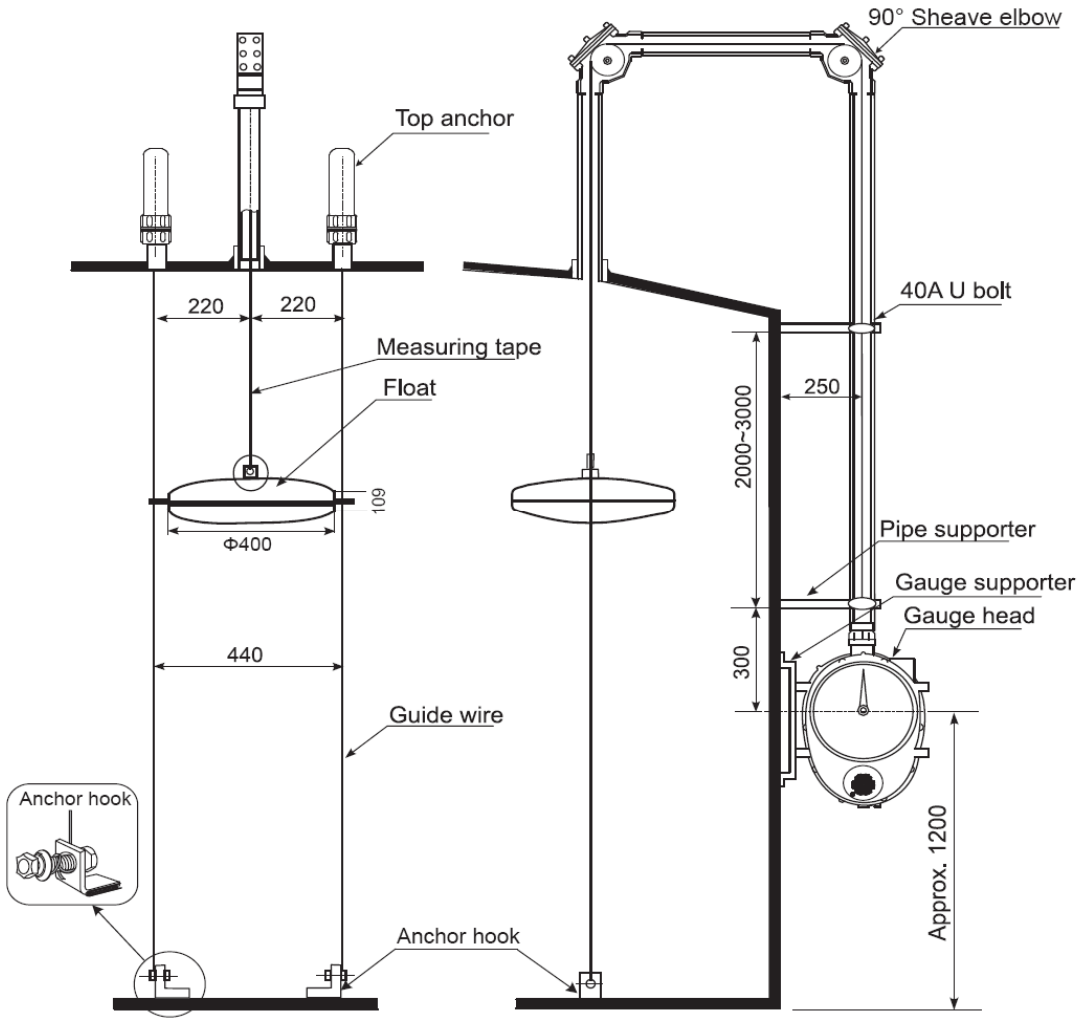
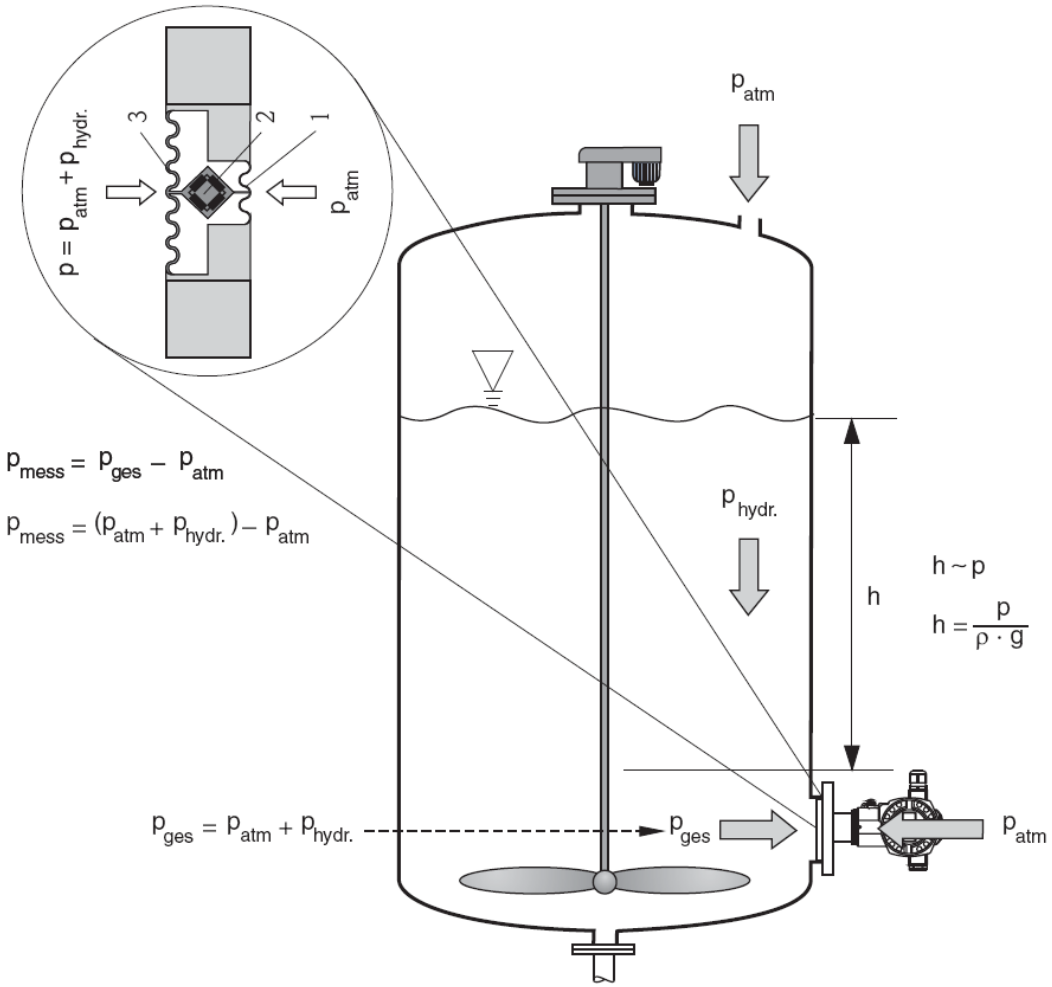


Control and Regulation

Principle:
Float level gauge

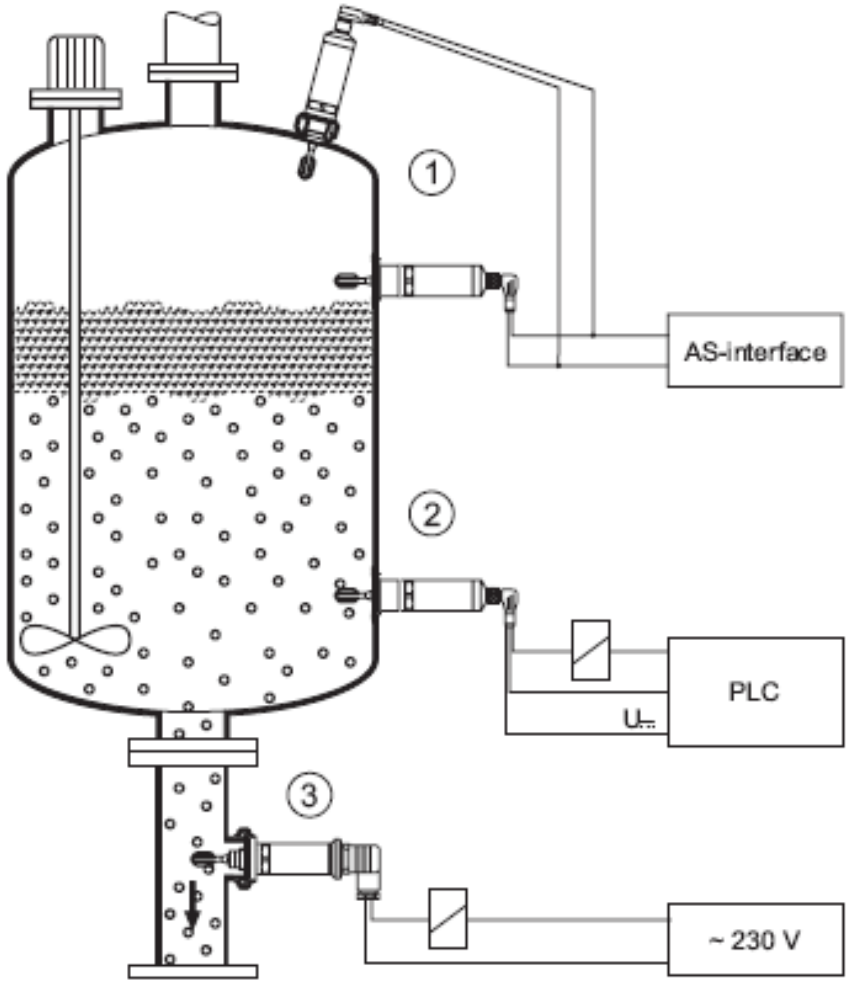
Process Equipment Design: Vessel



Control and Regulation

Principle:
Pressure gauge

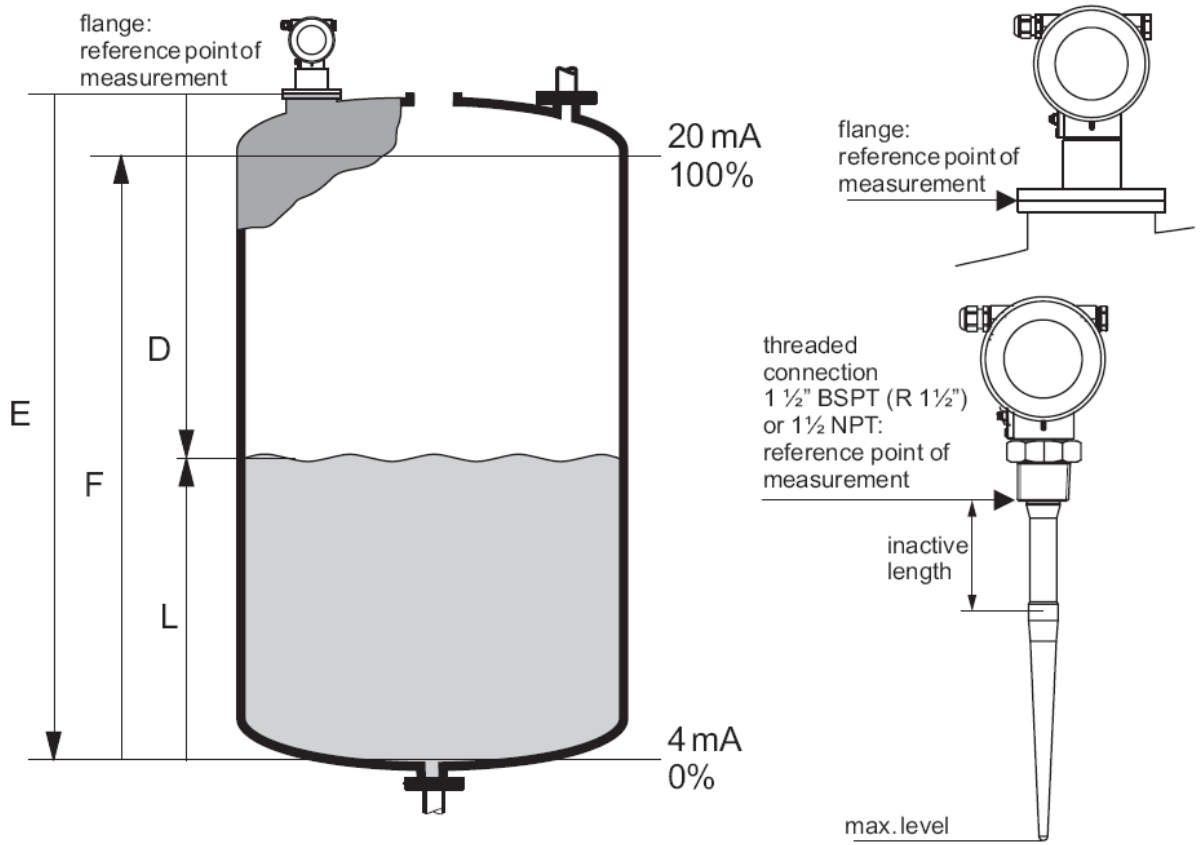
Process Equipment Design: Vessel



Control and Regulation

Principle:
Vibrating level gauge

Process Equipment Design: Vessel



Control and Regulation

Principle:
Radar gauge

Process Equipment Design: Vessel

50	Process Connection
GGJ	Thread EN10226 R1-1/2, 316L
GNJ	Thread ANSI NPT1-1/2, 316L
TDJ	Tri-Clamp ISO2852 DN40-51 (2"), 316L
TLJ	Tri-Clamp ISO2852 DN70-76.1 (3"), 316L
CFJ	DN50 PN10/16 B1, 316L flange EN1092-1 (DIN2527 C)
CGJ	DN50 PN25/40 B1, 316L flange EN1092-1 (DIN2527 C)
CFM	DN50 PN10/16, AlloyC22 > 316L flange EN1092-1 (DIN2527)
CGM	DN50 PN25/40, AlloyC22 > 316L flange EN1092-1 (DIN2527)
CMJ	DN80 PN10/16 B1, 316L flange EN1092-1 (DIN2527 C)
CNJ	DN80 PN25/40 B1, 316L flange EN1092-1 (DIN2527 C)
CMM	DN80 PN10/16, AlloyC22 > 316L flange EN1092-1 (DIN2527)
CNM	DN80 PN25/40, AlloyC22 > 316L flange EN1092-1 (DIN2527)
CQJ	DN100 PN10/16 B1, 316L flange EN1092-1 (DIN2527 C)
CRJ	DN100 PN25/40 B1, 316L flange EN1092-1 (DIN2527 C)
CQM	DN100 PN10/16, AlloyC22 > 316L flange EN1092-1 (DIN2527)
CRM	DN100 PN25/40, AlloyC22 > 316L flange EN1092-1 (DIN2527)
CWJ	DN150 PN10/16 B1, 316L flange EN1092-1 (DIN2527 C)
CWM	DN150 PN10/16, AlloyC22 > 316L flange EN1092-1 (DIN2527)
AEJ	2" 150lbs RF, 316/316L flange ANSI B16.5
AFJ	2" 300lbs RF, 316/316L flange ANSI B16.5
AEM	2" 150lbs, AlloyC22 > 316/316L flange ANSI B16.5
AFM	2" 300lbs, AlloyC22 > 316/316L flange ANSI B16.5
ALJ	3" 150lbs RF, 316/316L flange ANSI B16.5

50	Process Connection
AMJ	3" 300lbs RF, 316/316L flange ANSI B16.5
ALM	3" 150lbs, AlloyC22 > 316/316L flange ANSI B16.5
AMM	3" 300lbs, AlloyC22 > 316/316L flange ANSI B16.5
APJ	4" 150lbs RF, 316/316L flange ANSI B16.5
AQJ	4" 300lbs RF, 316/316L flange ANSI B16.5
APM	4" 150lbs, AlloyC22 > 316/316L flange ANSI B16.5
AQM	4" 300lbs, AlloyC22 > 316/316L flange ANSI B16.5
AWJ	6" 150lbs RF, 316/316L flange ANSI B16.5
AWM	6" 150lbs, AlloyC22 > 316/316L flange ANSI B16.5
KEJ	10K 50A RF, 316L flange JIS B2220
KEM	10K 50A, AlloyC22 > 316L flange JIS B2220
KLJ	10K 80A RF, 316L flange JIS B2220
KLM	10K 80A, AlloyC22 > 316L flange JIS B2220
KPJ	10K 100A RF, 316L flange JIS B2220
KPM	10K 100A, AlloyC22 > 316L flange JIS B2220
KWJ	10K 150A RF, 316L flange JIS B2220
KWM	10K 150A, AlloyC22 > 316L flange JIS B2220
YY9	Special version, TSP-No. to be spec.

Control and Regulation

Specification
Process Connection

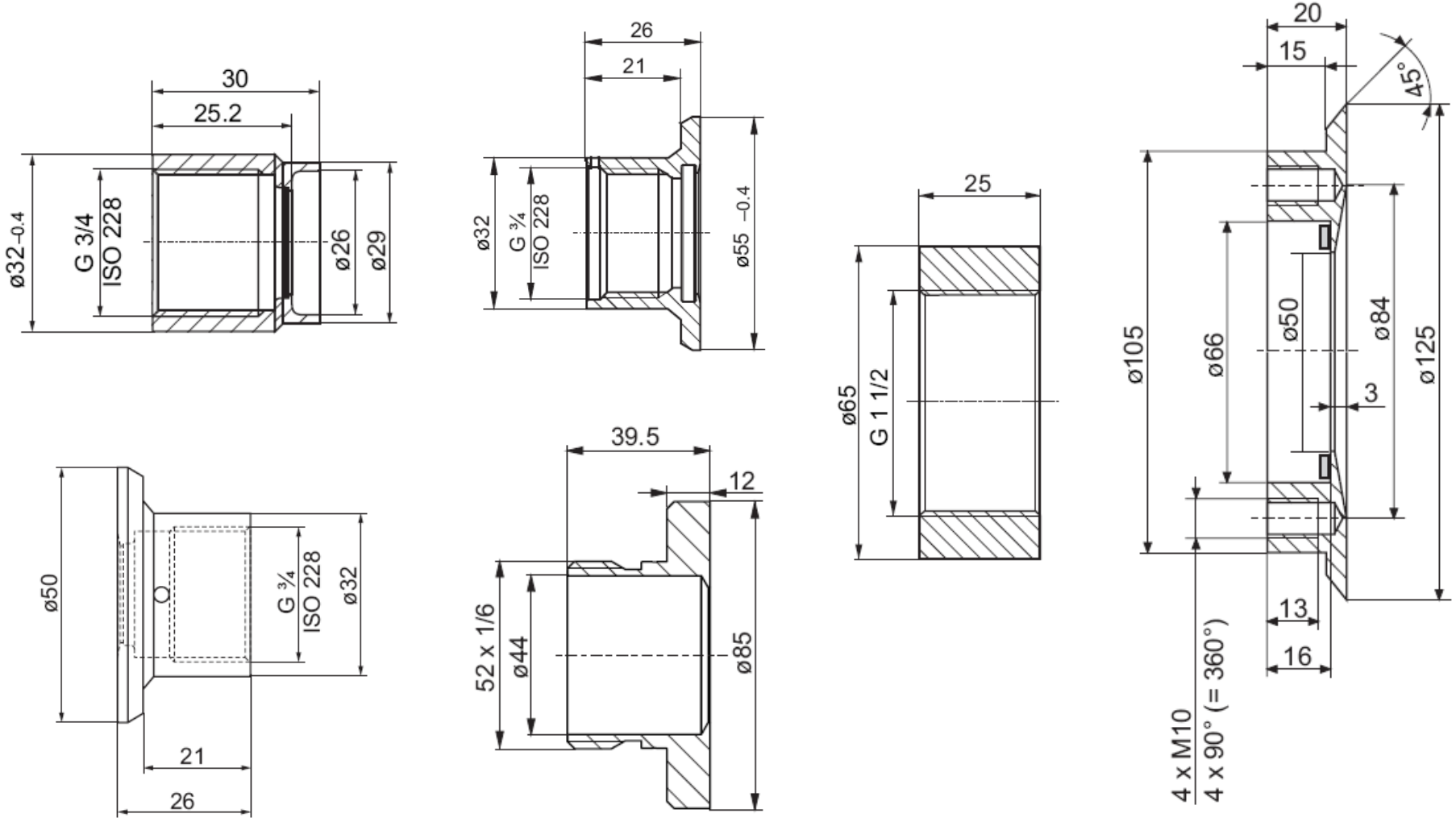
60	Cable Entry
2	Gland M20 (EEx d > thread M20)
3	Thread G1/2
4	Thread NPT1/2
5	Plug M12
6	Plug 7/8"
9	Special version, TSP-no. to be spec.

70	Additional Option
A	Basic version
C	EN10204-3.1 material, pressurized, (316/316L pressurized) inspection certificate
F	Advanced dynamics, max. MB=70m liquids, MB=measuring range
G	Advanced dynamics, 3.1, max. MB=70m liquids, MB=measuring range, EN10204-3.1 material (316L pressurized) inspection certificate
H	5-point linearity protocol, see additional spec.
K	5-point, 3.1, pressurized, 5-point linearity protocol, see additional spec., EN10204-3.1 material, pressurized, (316/316L pressurized) inspection certificate
L	5-point, advanced dynamics, 3.1, 5-point linearity protocol, see additional spec., Advanced dynamics, 3.1 material, max MB=70m liquids, MB=measuring range EN10204-3.1 material, (316L pressurized) inspection certificate
S	GL/ABS/NK marine certificate
Y	Special version, TSP-no. to be spec.

995	Marking
1	Tagging (TAG), see additional spec.
2	Bus address, see additional spec.

FMR245-	Complete product designation

Process Equipment Design: Vessel

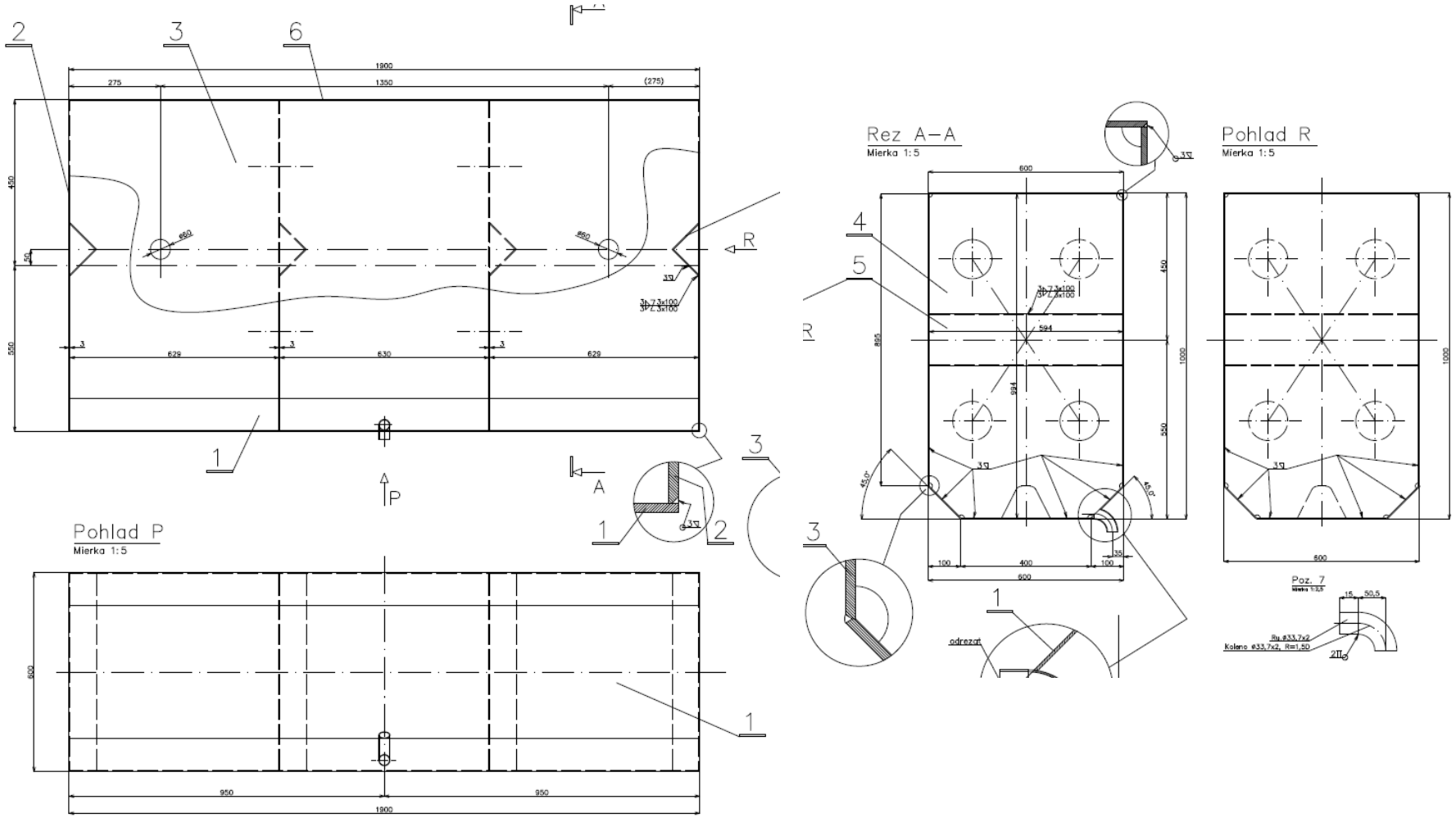


Process Equipment Design: Rectangular Vessel

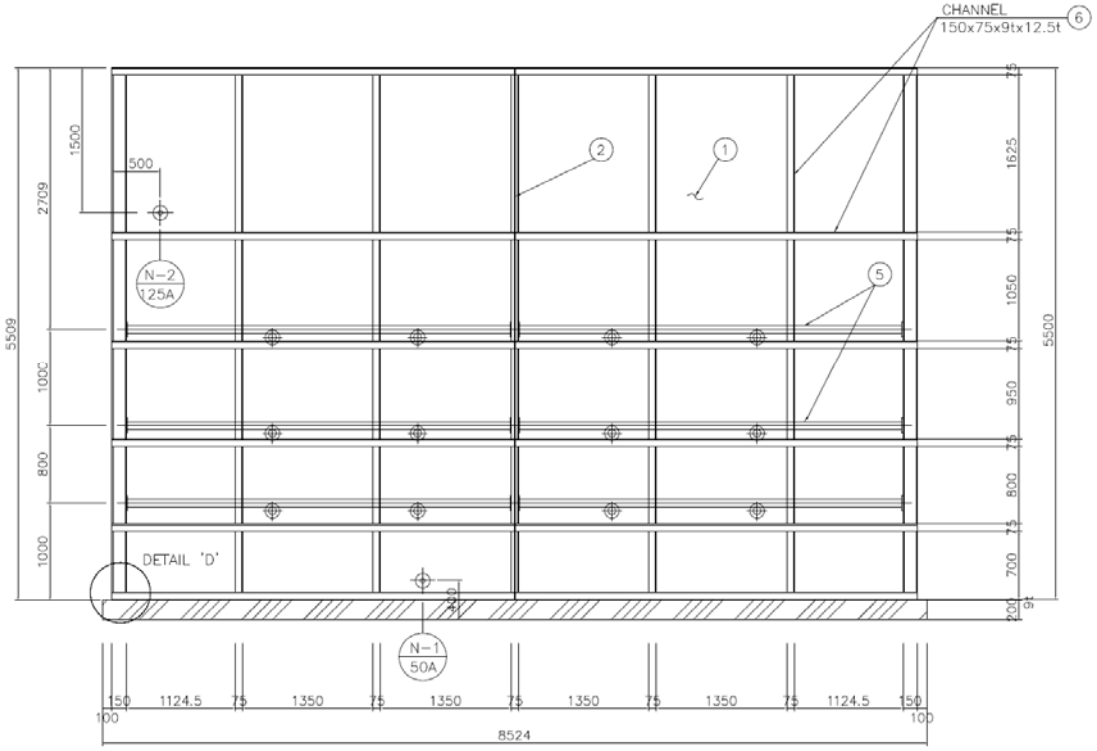
Advantages
Disadvantages.

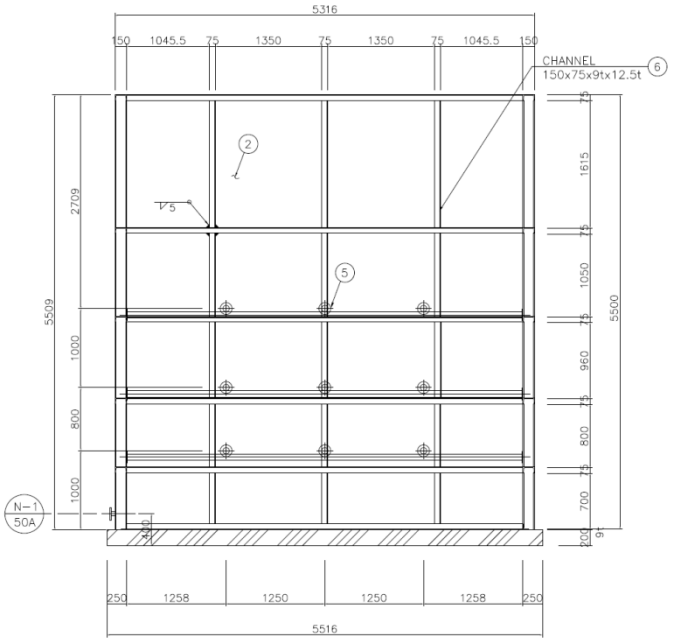
Open
Closed
Container
Hopper

Process Equipment Design: Rectangular Vessel

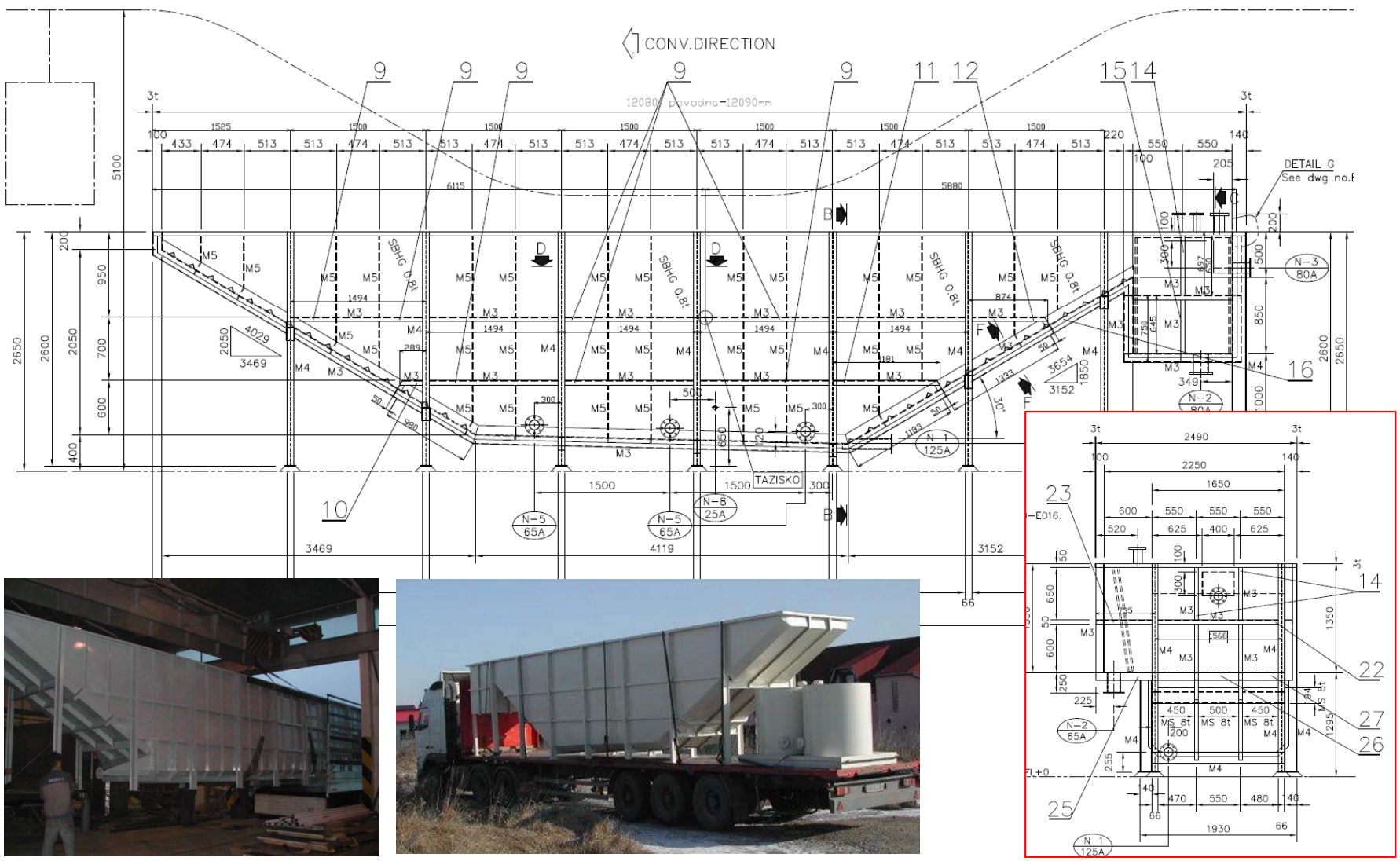


Process Equipment Design: Rectangular Vessel

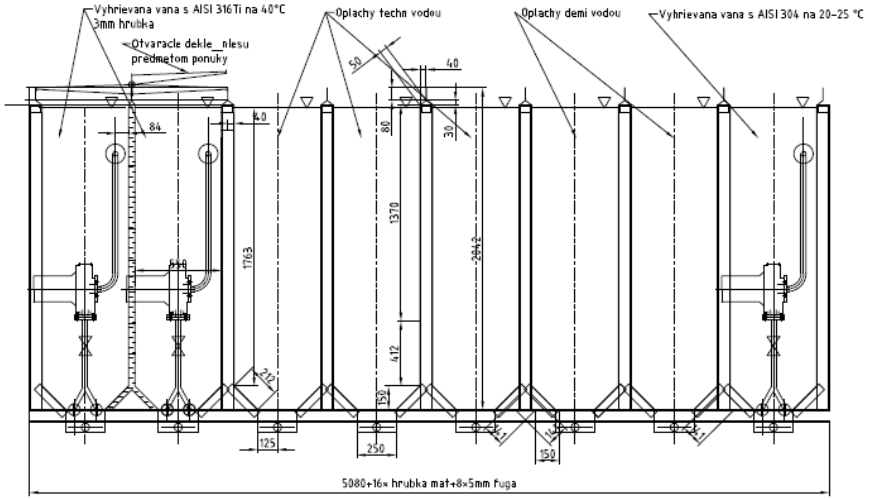


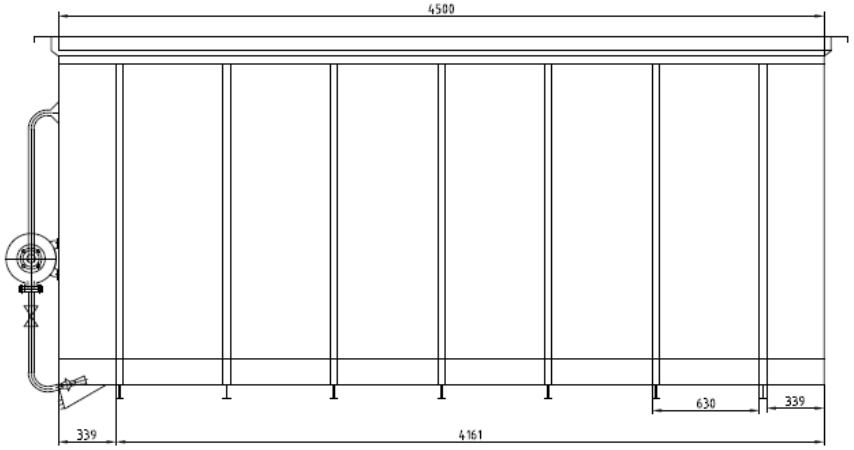


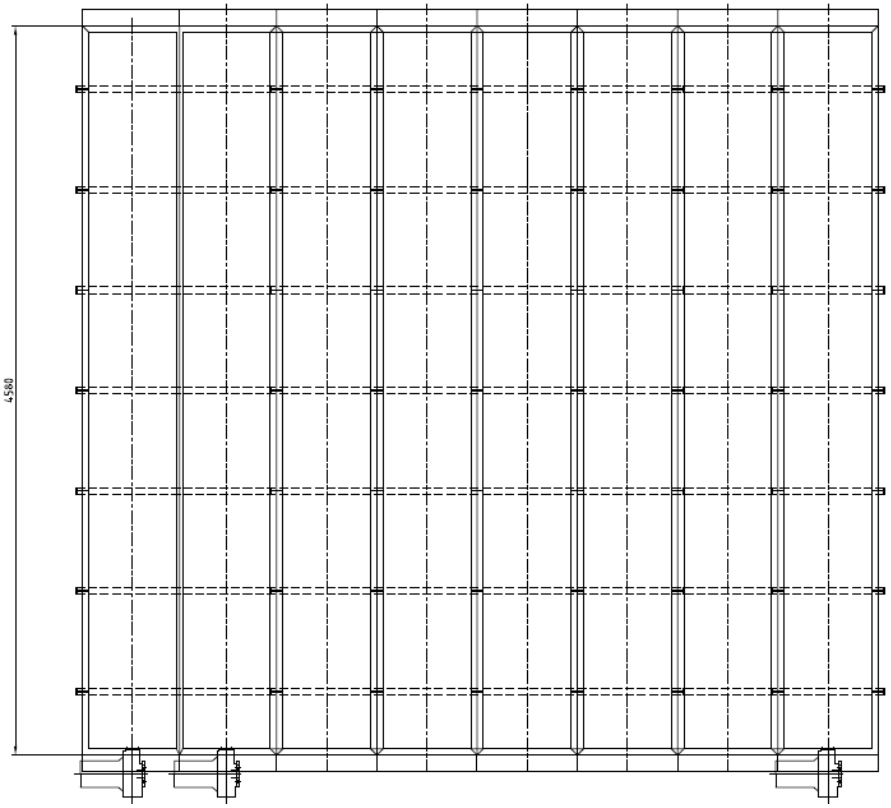
Process Equipment Design: Rectangular Vessel



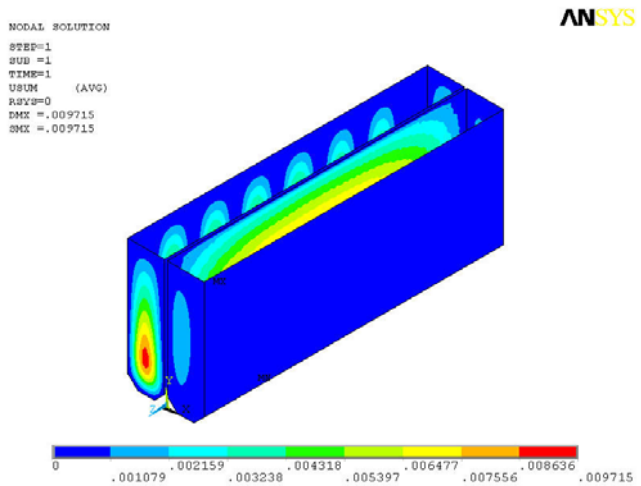
Process Equipment Design: Rectangular Vessel

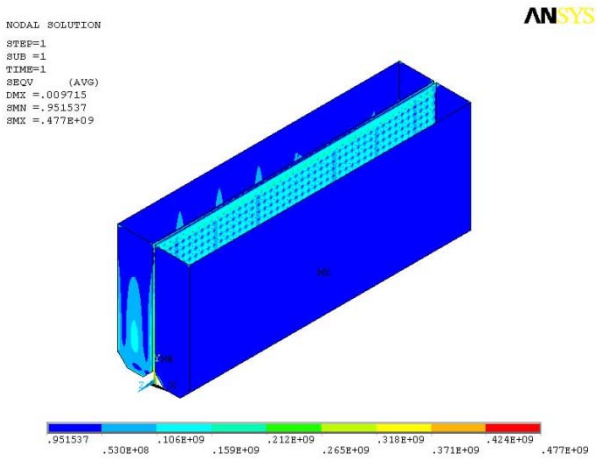


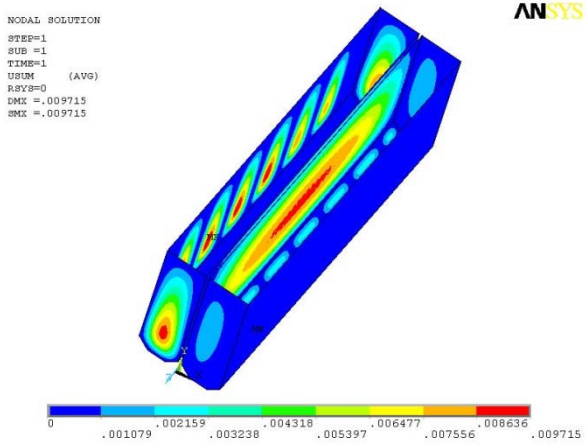


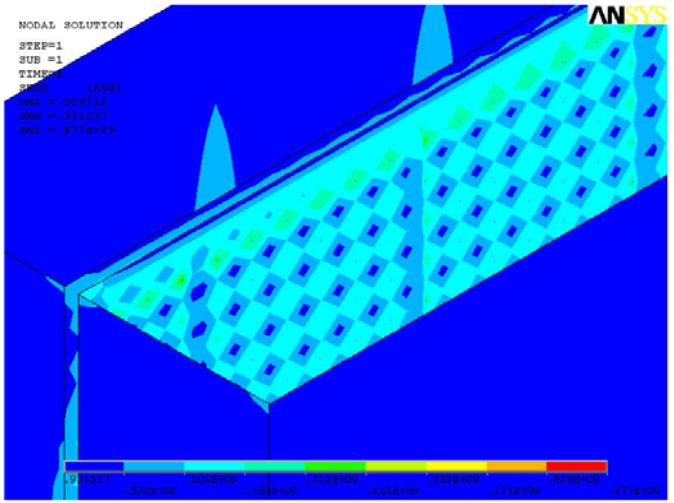


Process Equipment Design: Rectangular Vessel









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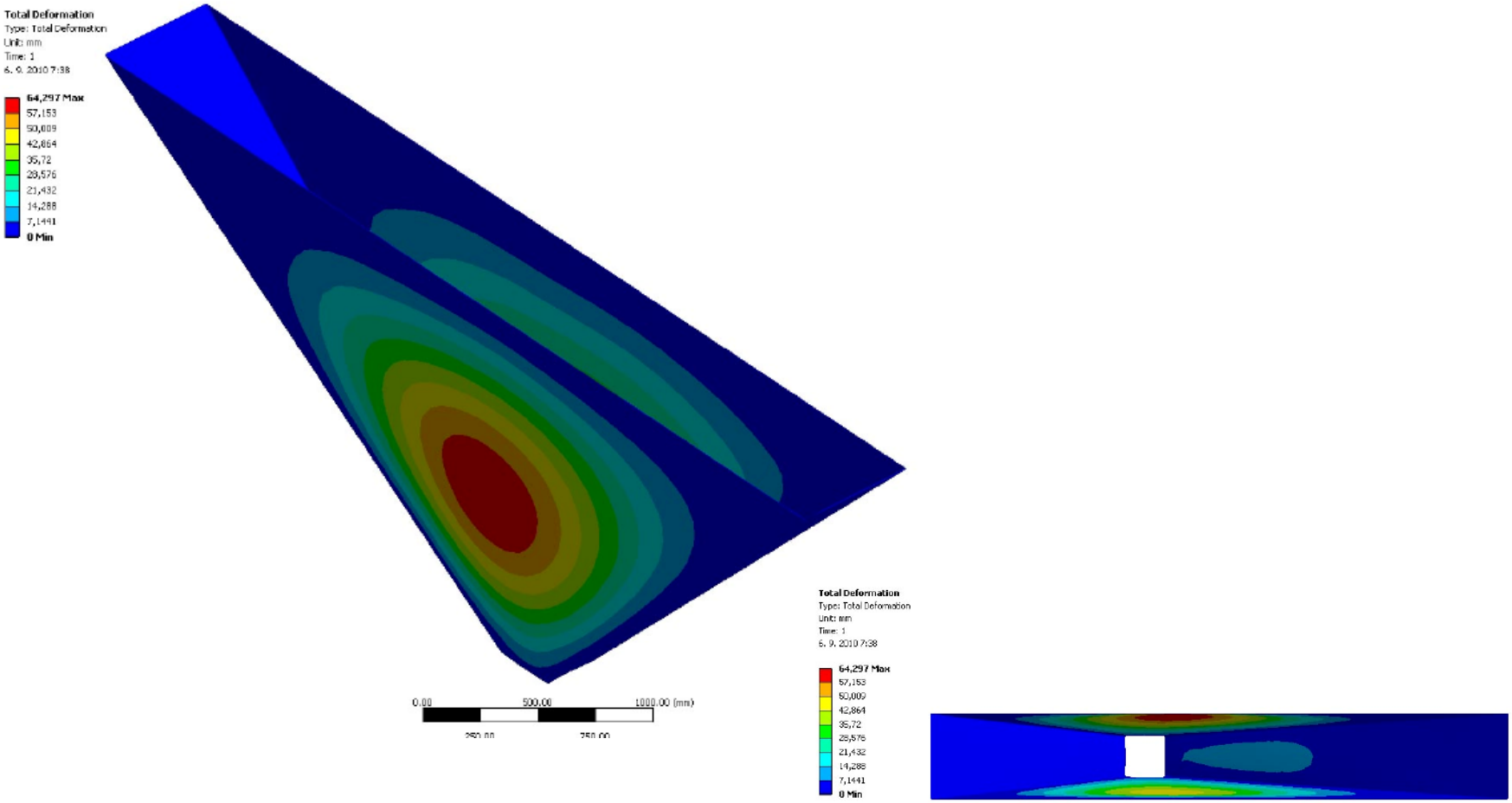
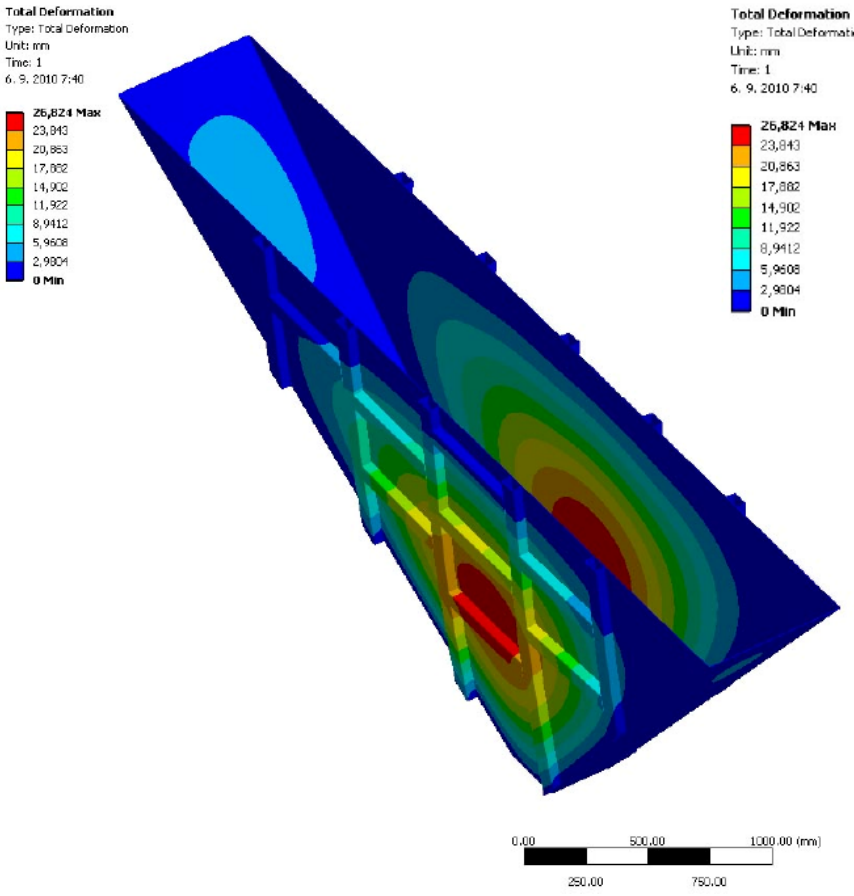
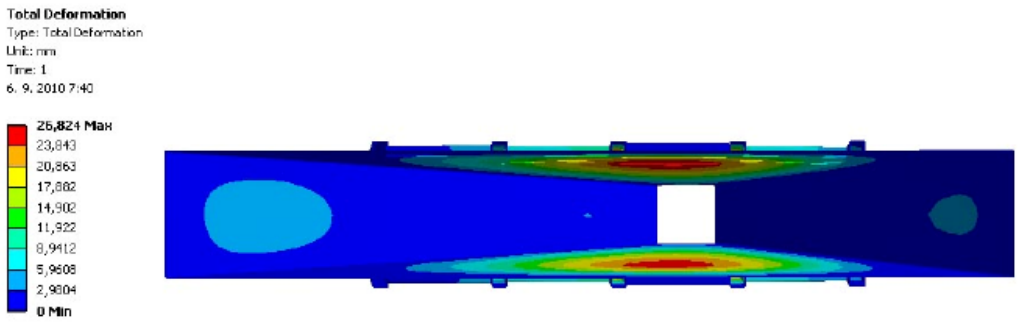


Process Equipment Design: Rectangular Vessel





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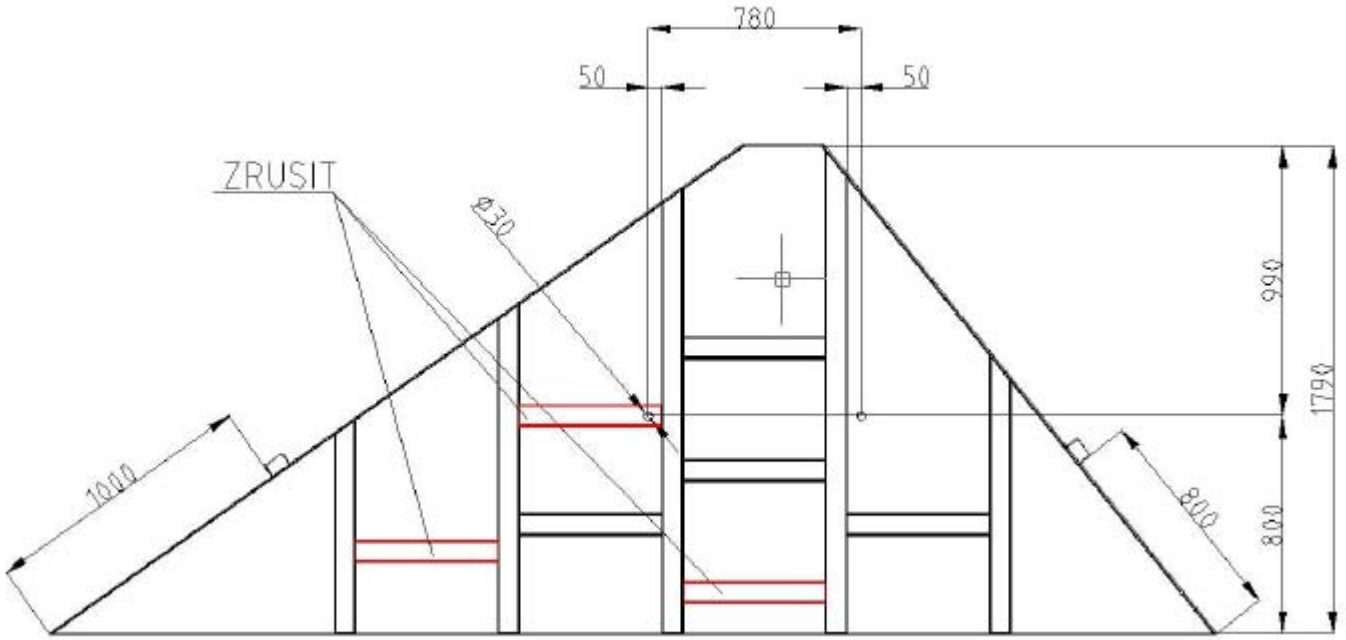
Process Equipment Design: Rectangular Vessel



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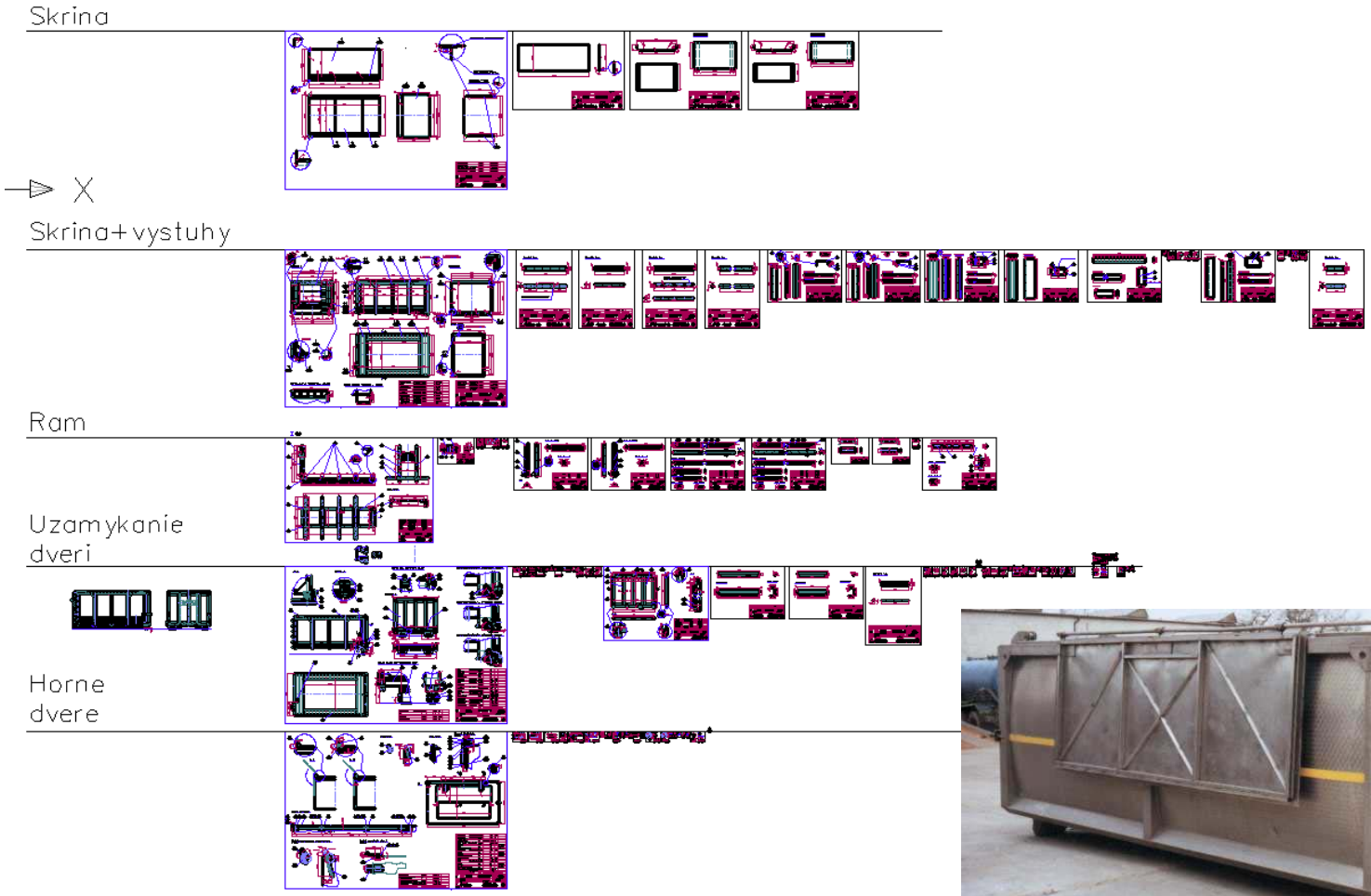
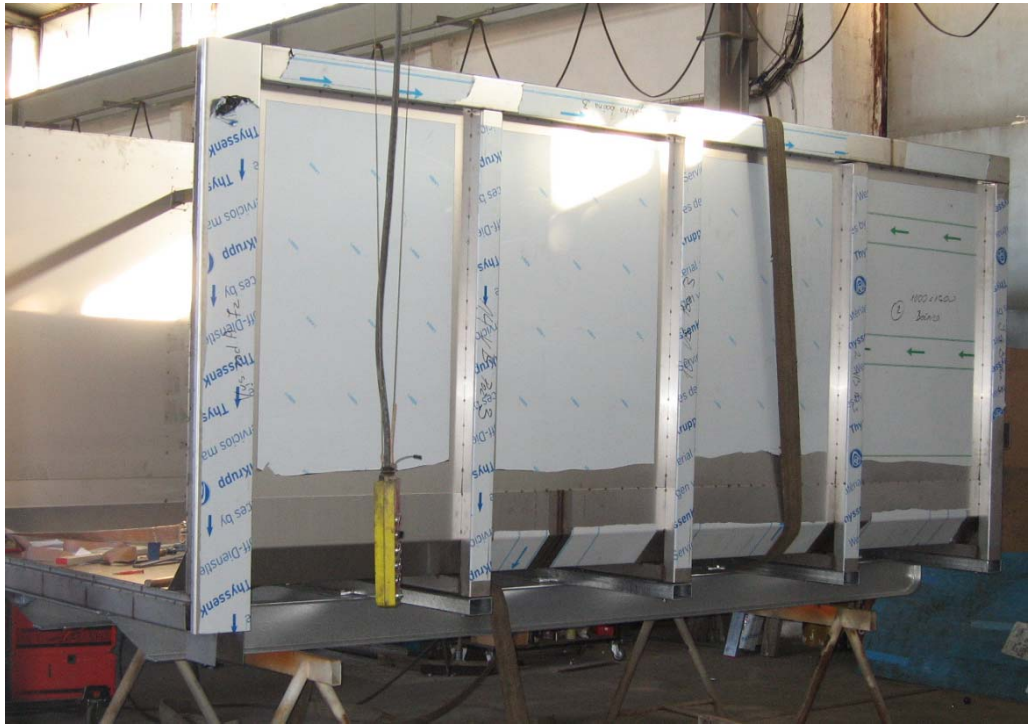
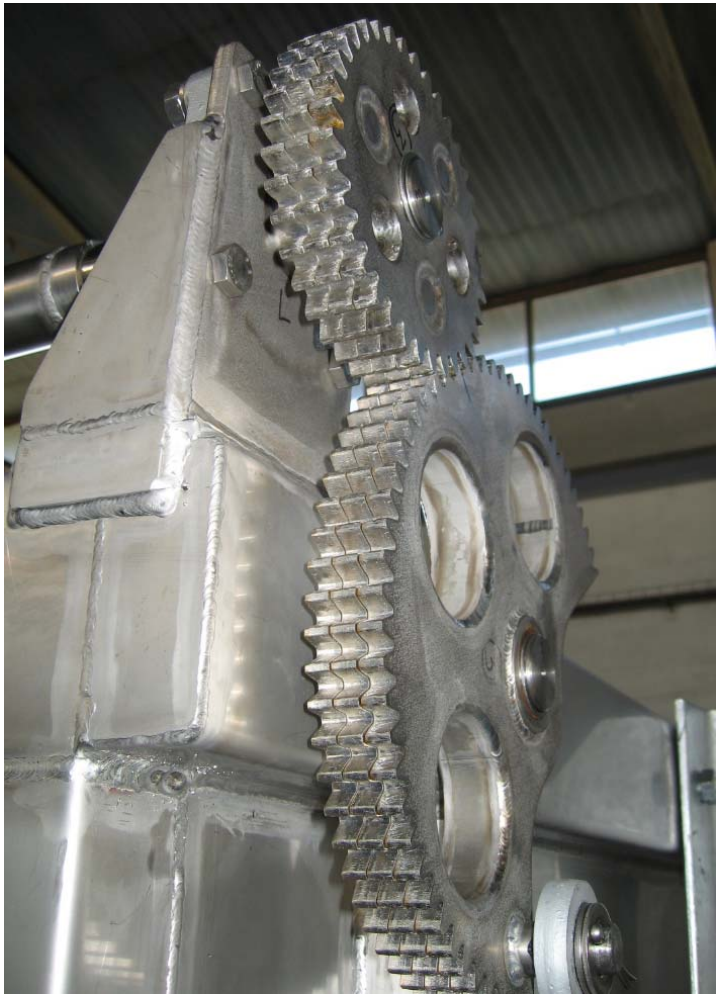


Process Equipment Design: Rectangular Vessel



Process Equipment Design: Rectangular Vessel



Process Equipment Design: Rectangular Vessel

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