Title

Standardization
Topic: Nozzle loads for vessels and equipment

INTERNAL STANDARDIZATION DOCUMENT

Business Unit

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Discipline: Mechanical

Category

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1 INTRODUCTION

This document comprises the Frames standard approach for the topic mentioned on the front sheet. It reflects the standard to date as given by the latest revision and as validated by the relevant disciplines.

1.1 Document setup

The document comprises various chapters formalized as part of standardization management. These chapters are the result of interdisciplinary review, addition of and/or changing the document basic structure shall be avoided or discussed and agreed upon in an interdisciplinary meeting. Addition of sub chapters, as required, is free to the author.

The following topic related chapters are applicable for the document:
- Reason for standardization
- Standard approach

2 REASON FOR STANDARDIZATION

Nozzle loads are an integral factor in every Frames project, in the past, several non-standardized nozzle load tables where used without any control. In order to standardize these loads, this standard has been written.

The nozzle loads as specified in this standard have been selected so that there is a balanced equilibrium between applicable nozzle loads for pressure vessels/heat exchangers and allowable nozzle loads which may be induced by piping configuration. This method will ensure an optimized design for a complete system.

The nozzle loads as described in this document are to be used in case that no nozzle loads are specified in client specification or code/norm requirements, and none of the limitation as described in paragraph 3.3 apply.

3 STANDARD APPROACH

This standard is applicable for nozzle loads on pressure vessels, heat exchangers and similar equipment. In case of applying this standard to different kinds of equipment, the selection of nozzle loads shall always be re-considered with respect to code/norm and system requirements.

3.1 Implementation

Nozzle loads are to be considered for vessel/equipment design as well as for piping design. When no nozzle loads are available from client specification, the nozzle loads as specified in Appendix I and Appendix II in this standard will be issued to vessel/equipment vendors and to the pipe stress engineer as a design basis.

Pressure vessels and equipment
For the designer of a vessel/piece of equipment it is preferable to lower the nozzle loads as much as possible. High nozzle loads have a negative effect on the design of the nozzle, flange and reinforcement plates of the nozzle.

Piping
For the designer of piping/pipe stress engineer it is preferable to have high nozzle loads, for piping the nozzle loads mean the maximum loads which the piping can apply to a vessel/piece of equipment. Higher nozzle loads will result in less anchors/supports in piping design and will prevent the introducing of loops in the piping.

The nozzle loads as specified in appendix I and II of this standard should be considered at the base of the nozzle, not at the flange face. This location should be considered by the pipe stress engineer when considering the vessel to pipe connection.

3.2 Applicability

As mentioned before the nozzle loads as specified in this standard cannot always be applied, as an example, pumps and compressors are often constructed according to API norms. Most of these norms specify their own nozzle loads which are normally lower than the loads as specified in this standard.

Some common used codes with specified nozzle loads are API 610, API 674, API 676 and API 685. No nozzle loads are specified within API 675.

System requirements can always require higher nozzle loads as for which a standard piece of equipment is designed. In those cases that this arises, the nozzle loads should be discussed with the equipment supplier, in order to validate the design. In these cases, nozzle loads on specific nozzles shall be mutually agreed by engineers of all concerned parties (e.g. not pressure vessels design engineer and piping stress engineer). This shall be closely monitored by the mechanical engineer.

The engineer which is designing the system should always consider the applicability of the nozzle loads in this document with respect to the designed system.

3.3 Limitations

When working with nozzle loads, there are some limitations which have to be taken into account, these are described in the paragraphs below.

3.3.1 Load combinations

In the design calculations of both vessels, equipment and piping, the flange rating is often the limiting factor when it comes to nozzle loads. Nozzle loads can be 'translated' into an equivalent internal pressure. Hence, nozzle loads vertically increase the design pressure. Therefore higher nozzle loads can result in the requirement for flanges with a higher flange rating because of the additional stresses in the flange.

Referring to below equations, the condition in equation i should always be met, if this is not met, a higher flange rating should be considered for the design. The equivalent pressure can be calculated according to equations ii and iii. In the equations, Fe is a resultant external force which is acting on the flange and Me is a resultant external moment which is acting on the flange. Dg is the mean gasket diameter.

i) $P_{rating} \geq P_{design} + P_{equivalent}$

ii) $P_{equivalent,F} = \dfrac{4 * F_e}{\pi * {D_g}^2}$

iii) $P_{equivalent,M} = \dfrac{16 * M_e}{\pi * {D_g}^3}$

When the conditions in equation i are not met, you could change the flange rating which result in higher cost, or you could chose for one of the two below options:

1) Lower the nozzle loads, lowering the nozzle loads will have a positive effect on the additional stresses in the flange which could result in not changing the flange rating.
2) Perform detailed calculations: Applicable nozzle loads as specified in this standard are not required by any code or law, therefore can be changed. Detailed analysis of the nozzle/flange can result in maximum allowable nozzle loads, which can then be passed on to the pipe stress engineer. This engineer will have to redesign there piping system so that nozzle loads will not exceed those as per nozzle/flange calculation. These calculation can be performed by:
   - Finite element method
   - WRC-107/279 calculations
   - Calculation of equivalent pressure caused by the nozzle loads

3.3.2 Type of flange

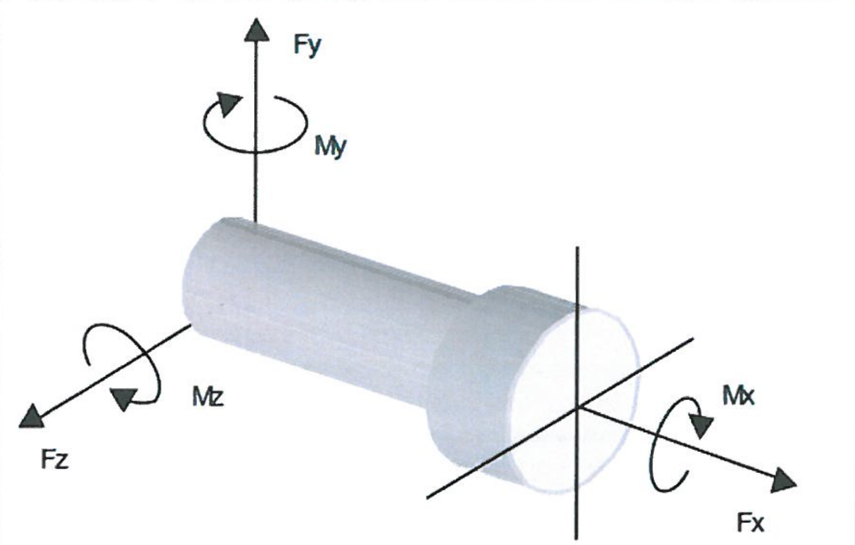
The nozzle loads as specified in this standard are applicable for ANSI B16.5 flanges. In case of using different type of flanges, use of loads may not be suitable with consideration to flange strength and other factors.

For example: flanges according to EN 1092-1, external loads according to Annex E.3.1 should be considered.

TBV. 40-VL-001.
TBV 40-CA-001.

FRAMES

Appendix I - Nozzle loads for pressure vessels



Fx = Force in Radial Direction [N]

Fy = Force in Circumferential Direction [N]

Fz = Force in Longitudinal Direction[N]

Mx =Torsional Moment [Nm]

My = Longitudinal Moment [Nm]

Mz = Circumferential Moment [Nm]

	Pressure class 150 #			ß= 0,6		
Nozzle	Forces (N)			Moments (Nm)		
size D (")	Fx	Fy	Fz	Mx	My	Mz
1	1200	900	1200	90	78	60
1,5	1800	1350	1800	203	176	135
40VL001 2	2400	1800	2400	360	312	240
3	3600	2700	3600	810	702	540
40CA001 4	4800	3600	4800	1440	1248	960
6	7200	5400	7200	3240	2808	2160
8	9600	7200	9600	5760	4992	3840
10	12000	9000	12000	9000	7800	6000
12	14400	10800	14400	12960	11232	8640
14	16800	12600	16800	17640	15288	11760
16	19200	14400	19200	23040	19968	15360
18	21600	16200	21600	29160	25272	19440
20	24000	18000	24000	36000	31200	24000
24	28800	21600	28800	51840	44928	34560

	Pressure class 300 #			ß= 0,7		
Nozzle	Forces (N)			Moments (Nm)		
size D (")	Fx	Fy	Fz	Mx	My	Mz
1	1400	1050	1400	105	91	70
1,5	2100	1575	2100	236	205	158
2	2800	2100	2800	420	364	280
3	4200	3150	4200	945	819	630
4	5600	4200	5600	1680	1456	1120
6	8400	6300	8400	3780	3276	2520
8	11200	8400	11200	6720	5824	4480
10	14000	10500	14000	10500	9100	7000
12	16800	12600	16800	15120	13104	10080
14	19600	14700	19600	20580	17836	13720
16	22400	16800	22400	26880	23296	17920
18	25200	18900	25200	34020	29484	22680
20	28000	21000	28000	42000	36400	28000
24	33600	25200	33600	60480	52416	40320

	Pressure class 600 #			ß= 0,8		
Nozzle	Forces (N)			Moments (Nm)		
size D (")	Fx	Fy	Fz	Mx	My	Mz
1	1600	1200	1600	120	104	80
1,5	2400	1800	2400	270	234	180
2	3200	2400	3200	480	416	320
3	4800	3600	4800	1080	936	720
4	6400	4800	6400	1920	1664	1280
6	9600	7200	9600	4320	3744	2880
8	12800	9600	12800	7680	6656	5120
10	16000	12000	16000	12000	10400	8000
12	19200	14400	19200	17280	14976	11520
14	22400	16800	22400	23520	20384	15680
16	25600	19200	25600	30720	26624	20480
18	28800	21600	28800	38880	33696	25920
20	32000	24000	32000	48000	41600	32000
24	38400	28800	38400	69120	59904	46080

	Pressure class 900 #			ß= 1,8		
Nozzle	Forces (N)			Moments (Nm)		
size D (")	Fx	Fy	Fz	Mx	My	Mz
1	3600	2700	3600	270	234	180
1,5	5400	4050	5400	608	527	405
2	7200	5400	7200	1080	936	720
3	10800	8100	10800	2430	2106	1620
4	14400	10800	14400	4320	3744	2880
6	21600	16200	21600	9720	8424	6480
8	28800	21600	28800	17280	14976	11520
10	36000	27000	36000	27000	23400	18000
12	43200	32400	43200	38880	33696	25920
14	50400	37800	50400	52920	45864	35280
16	57600	43200	57600	69120	59904	46080
18	64800	48600	64800	87480	75816	58320
20	72000	54000	72000	108000	93600	72000
24	86400	64800	86400	155520	134784	103680

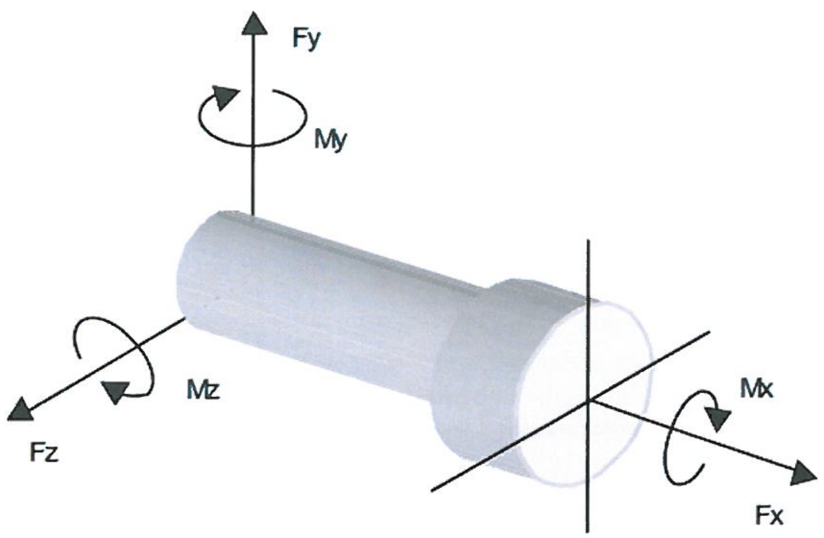
Notes:

1) Nozzle loads combined with loads due to internal pressure to be taken into account for nozzle/flange assessment.
2) All forces and moments act at the nozzle to shell and nozzle to head junction.
3) Tables are to be applied for nozzles with standard ANSI flanges.
4) No loadings shall be applied to manways, handholes and instrument nozzles
5) Nozzle loads calculated as per below formula:
   - Fx=ß*2000*D (N)
   - Fy=ß*1500*D (N)
   - FZ=ß*2000*D (N)
   - Mx=ß*150*D^2 (Nm)
   - My=ß*130*D^2 (Nm)
   - Mz=ß*100*D^2 (Nm)

	Pressure class 1500 #			ß= 3,0		
Nozzle	Forces (N)			Moments (Nm)		
size D (")	Fx	Fy	Fz	Mx	My	Mz
1	6000	4500	6000	450	390	300
1,5	9000	6750	9000	1013	878	675
2	12000	9000	12000	1800	1560	1200
3	18000	13500	18000	4050	3510	2700
4	24000	18000	24000	7200	6240	4800
6	36000	27000	36000	16200	14040	10800
8	48000	36000	48000	28800	24960	19200
10	60000	45000	60000	45000	39000	30000
12	72000	54000	72000	64800	56160	43200
14	84000	63000	84000	88200	76440	58800
16	96000	72000	96000	115200	99840	76800
18	108000	81000	108000	145800	126360	97200
20	120000	90000	120000	180000	156000	120000
24	144000	108000	144000	259200	224640	172800

	Pressure class 2500 #			ß= 3,3		
Nozzle	Forces (N)			Moments (Nm)		
size D (")	Fx	Fy	Fz	Mx	My	Mz
1	6600	4950	6600	495	429	330
1,5	9900	7425	9900	1114	965	743
2	13200	9900	13200	1980	1716	1320
3	19800	14850	19800	4455	3861	2970
4	26400	19800	26400	7920	6864	5280
6	39600	29700	39600	17820	15444	11880
8	52800	39600	52800	31680	27456	21120
10	66000	49500	66000	49500	42900	33000
12	79200	59400	79200	71280	61776	47520
14	92400	69300	92400	97020	84084	64680
16	105600	79200	105600	126720	109824	84480
18	118800	89100	118800	160380	138996	106920
20	132000	99000	132000	198000	171600	132000
24	158400	118800	158400	285120	247104	190080

Appendix II - Nozzle loads for heat exchangers



Fx = Force in Radial Direction [N]
Fy = Force in Circumferential Direction [N]
Fz = Force in Longitudinal Direction[N]
Mx =Torsional Moment [Nm]
My = Longitudinal Moment [Nm]
Mz = Circumferential Moment [Nm]

Pressure class 150 #				ß= 0,75		
Nozzle size D (")	Forces (N)			Moments (Nm)		
	Fx	Fy	Fz	Mx	My	Mz
1	1500	1125	1500	113	98	75
1,5	2250	1688	2250	253	219	169
2	3000	2250	3000	450	390	300
3	4500	3375	4500	1013	878	675
4	6000	4500	6000	1800	1560	1200
6	9000	6750	9000	4050	3510	2700
8	12000	9000	12000	7200	6240	4800
10	15000	11250	15000	11250	9750	7500
12	18000	13500	18000	16200	14040	10800
14	21000	15750	21000	22050	19110	14700
16	24000	18000	24000	28800	24960	19200
18	27000	20250	27000	36450	31590	24300
20	30000	22500	30000	45000	39000	30000
24	36000	27000	36000	64800	56160	43200

Pressure class 300 #				ß= 0,75		
Nozzle size D (")	Forces (N)			Moments (Nm)		
	Fx	Fy	Fz	Mx	My	Mz
1	1500	1125	1500	113	98	75
1,5	2250	1688	2250	253	219	169
2	3000	2250	3000	450	390	300
3	4500	3375	4500	1013	878	675
4	6000	4500	6000	1800	1560	1200
6	9000	6750	9000	4050	3510	2700
8	12000	9000	12000	7200	6240	4800
10	15000	11250	15000	11250	9750	7500
12	18000	13500	18000	16200	14040	10800
14	21000	15750	21000	22050	19110	14700
16	24000	18000	24000	28800	24960	19200
18	27000	20250	27000	36450	31590	24300
20	30000	22500	30000	45000	39000	30000
24	36000	27000	36000	64800	56160	43200

Pressure class 600 #				ß= 1,25		
Nozzle size D (")	Forces (N)			Moments (Nm)		
	Fx	Fy	Fz	Mx	My	Mz
1	2500	1875	2500	188	163	125
1,5	3750	2813	3750	422	366	281
2	5000	3750	5000	750	650	500
3	7500	5625	7500	1688	1463	1125
4	10000	7500	10000	3000	2600	2000
6	15000	11250	15000	6750	5850	4500
8	20000	15000	20000	12000	10400	8000
10	25000	18750	25000	18750	16250	12500
12	30000	22500	30000	27000	23400	18000
14	35000	26250	35000	36750	31850	24500
16	40000	30000	40000	48000	41600	32000
18	45000	33750	45000	60750	52650	40500
20	50000	37500	50000	75000	65000	50000
24	60000	45000	60000	108000	93600	72000

Pressure class 900 #				ß= 3,0		
Nozzle size D (")	Forces (N)			Moments (Nm)		
	Fx	Fy	Fz	Mx	My	Mz
1	6000	4500	6000	450	390	300
1,5	9000	6750	9000	1013	878	675
2	12000	9000	12000	1800	1560	1200
3	18000	13500	18000	4050	3510	2700
4	24000	18000	24000	7200	6240	4800
6	36000	27000	36000	16200	14040	10800
8	48000	36000	48000	28800	24960	19200
10	60000	45000	60000	45000	39000	30000
12	72000	54000	72000	64800	56160	43200
14	84000	63000	84000	88200	76440	58800
16	96000	72000	96000	115200	99840	76800
18	108000	81000	108000	145800	126360	97200
20	120000	90000	120000	180000	156000	120000
24	144000	108000	144000	259200	224640	172800

Notes:
1) Nozzle loads combined with loads due to internal pressure to be taken into account for nozzle/flange assessment.
2) All forces and moments act at the nozzle to shell and nozzle to head junction.
3) Tables are to be applied for nozzles with standard ANSI flanges.
4) No loadings shall be applied to manways, handholes and instrument nozzles
5) Nozzle loads calculated as per below formula:
   Fx=ß*2000*D (N)
   Fy=ß*1500*D (N)
   FZ=ß*2000*D (N)
   Mx=ß*150*D^2 (Nm)
   My=ß*130*D^2 (Nm)
   Mz=ß*100*D^2 (Nm)

Pressure class 1500 #				ß= 4,0		
Nozzle size D (")	Forces (N)			Moments (Nm)		
	Fx	Fy	Fz	Mx	My	Mz
1	8000	6000	8000	600	520	400
1,5	12000	9000	12000	1350	1170	900
2	16000	12000	16000	2400	2080	1600
3	24000	18000	24000	5400	4680	3600
4	32000	24000	32000	9600	8320	6400
6	48000	36000	48000	21600	18720	14400
8	64000	48000	64000	38400	33280	25600
10	80000	60000	80000	60000	52000	40000
12	96000	72000	96000	86400	74880	57600
14	112000	84000	112000	117600	101920	78400
16	128000	96000	128000	153600	133120	102400
18	144000	108000	144000	194400	168480	129600
20	160000	120000	160000	240000	208000	160000
24	192000	144000	192000	345600	299520	230400

Pressure class 2500 #				ß= 5,6		
Nozzle size D (")	Forces (N)			Moments (Nm)		
	Fx	Fy	Fz	Mx	My	Mz
1	11200	8400	11200	840	728	560
1,5	16800	12600	16800	1890	1638	1260
2	22400	16800	22400	3360	2912	2240
3	33600	25200	33600	7560	6552	5040
4	44800	33600	44800	13440	11648	8960
6	67200	50400	67200	30240	26208	20160
8	89600	67200	89600	53760	46592	35840
10	112000	84000	112000	84000	72800	56000
12	134400	100800	134400	120960	104832	80640
14	156800	117600	156800	164640	142688	109760
16	179200	134400	179200	215040	186368	143360
18	201600	151200	201600	272160	235872	181440
20	224000	168000	224000	336000	291200	224000
24	268800	201600	268800	483840	419328	322560