

AMERICAS

NOZZLE LOADS and ANSI FLANGE DERATING

Wade Armer, Vice President-Engineering, Ohmstede Ltd.





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Overview

Design Requirements





American Petroleum Institute

Effects of ASME UG-44(b)

Review



ASME B16.5 Pressure-Temperature Ratings

lable	II-2-1.1 Flessule-le	riessure-remperature katiligs for Group 1.1 materials						
Nominal Designation	Forgings	Castings	Plates					
C-Si	A105 (1)	A216 Gr. WCB (1)	A515 Gr. 70 (1)					
C-Mn-Si	A350 Gr. LF2 (1)		A516 Gr. 70 (1), (2) A537 Cl. 1 (4)					
C-Mn-Si-V	A350 Gr. LF6 Cl. 1 (3)							
3 ¹ / ₂ Ni	A350 Gr. LF 3							

Table II.2.1.1 Processo Tomporature Patings for Group 1.1 Materials

Working Pressures by Classes, psig										
				Class						
Temp., °F	150	300	400	600	900	1500	2500			
-20 to 100	285	740	985	1,480	2,220	3,705	6,170			
200	260	680	905	1,360	2,035	3,395	5,655			
300	230	655	870	1,310	1,965	3,270	5,450			
400	200	635	845	1,265	1,900	3,170	5,280			
500	170	605	805	1,205	1,810	3,015	5,025			
600	140	570	755	1,135	1,705	2,840	4,730			
650	125	550	730	1,100	1,650	2,745	4,575			
700	110	530	710	1,060	1,590	2,655	4,425			
750	95	505	675	1,015	1,520	2,535	4,230			
800	80	410	550	825	1,235	2,055	3,430			
850	65	320	425	640	955	1,595	2,655			
900	50	230	305	460	690	1,150	1,915			
950	35	135	185	275	410	685	1,145			
1,000	20	85	115	170	255	430	715			

NOTES:

 Upon prolonged exposure to temperatures above 800°F, the carbide phase of steel may be converted to graphite. Permissible but not recommended for prolonged use above 800°F.

(2) Not to be used over 850°F.

(3) Not to be used over 500°F.

(4) Not to be used over 700°F.



[1]

But then, these external forces and moments loads are introduced ...



Equipment Nozzle Loads



Passive

Active

 2nd Consideration – Translation of loads to supports.



Methods to Obtain Stress or Strain Limits

Codes:



Design

Sec VIII Div 1

FEA

- ASME VIII Div. 2
- ASME Sec III NB-3200

Standards:



American Petroleum Institute



Bulletins 537/107 & 297





Failure to Consider and Design for all Nozzle Loads



API 660 – Nozzle and Other Connections – Para 7.6



Highpoints:

Section 7.6.9

- Design for Simultaneous application of forces and moments.
- Designed for corroded condition.
- Non-piped auxiliary connections excluded.
- Purchaser specifies type of analysis.

Section 7.6.10

 Purchaser shall specify the moments and forces for nozzle sizes larger than sizes listed in Table 2.



[2]

API 660

Nominal Diameter		Flange	M _X		My		Mz		Fx		Fy		Fz	
DN	(NPS)	Rating	N·m	(lbf-ft)	N∙m	(lbf-ft)	N∙m	(lbf·ft)	N	(lbf)	N	(lbf)	N	(Ibf)
50	2	150	270	200	430	320	340	250	1590	370	1270	290	1590	370
		300	340	250	540	400	430	320	1990	450	1590	360	1990	450
		600	470	350	750	560	590	440	2780	630	2220	500	2780	630
		900	600	440	970	720	760	560	3580	820	2860	650	3580	820
		1500	600	440	970	720	760	560	3580	820	2860	650	3580	820
		2500	670	490	1080	790	850	630	3970	900	3170	720	3970	900
80	3	150	580	430	940	690	740	540	2340	530	1870	420	2340	530
		300	720	540	1170	860	920	680	2930	670	2340	530	2930	670
		600	1010	750	1630	1210	1280	950	4090	930	3270	740	4090	930
		900	1300	960	2100	1550	1650	1220	5270	1190	4210	950	5270	1190
		1500	1300	960	2100	1550	1650	1220	5270	1190	4210	950	5270	1190
		2500	1590	1170	2560	1890	2010	1490	6430	1450	5140	1160	6430	1450

Table 2—Nozzle Allowable Forces and Moments at the Nozzle Neck to Shell/Channel Interface





[3]

WRC vs API 660 Nomenclature

WRC

API 660





Initial Inquiry to ASME & Response

Interpretation Detail

Standard Designation: Edition/Addenda: Para./Fig./Table No: Subject Description: Date Issued: Record Number: Interpretation Number : Question(s) and Reply(ies):

BPV Section VIII Div 1 2015 UG-44 & UG-11(a)& (c) External loads Applied to Nozzle Standard Flange 10/25/2016 16-1609 BPV VIII-1-16-85

Question: When superimposed static or dynamic reactions, as required by UG-22, are specified for the design of a pressure vessel, is it permitted to use an ASME standard product as defined in UG-11(c) produced in accordance with an ASME Standard referenced in UG-44 without performing supporting calculations that indicate the component is acceptable for all design conditions?

Reply: No.



[5]



ASME Code Case



ASME BPVC VIII-Div 1 – 2019 Addition

(19) UG-44 FLANGES AND PIPE FITTINGS

(b) External loads (forces and bending moments) may be evaluated for flanged joints with welding neck flanges chosen in accordance with (a)(2), (a)(9), and (a)(10), using the following requirements:

(1) The vessel MAWP (corrected for the static pressure acting on the flange) at the design temperature cannot exceed the pressure-temperature rating of the flange.

(2) The actual assembly bolt load (see Nonmandatory Appendix S) shall comply with ASME PCC-1, Nonmandatory Appendix O.

(3) The bolt material shall have an allowable stress equal to or greater than SA-193 B8 Cl. 2 at the specified bolt size and temperature.

(4) The combination of vessel MAWP (corrected for the static pressure acting on the flange) with external moment and external axial force shall satisfy the following equation (the units of the variables in this equation shall be consistent with the pressure rating):

$$16M_E + 4F_EG \leq \pi G^3 \Big[\Big(P_R - P_D \Big) + F_M P_R \Big]$$

where

 F_E = external tensile axial force

 F_M = moment factor, in accordance with Table UG-44-1

G = gasket reaction diameter

 M_E = external moment

 P_D = vessel MAWP (corrected for static pressure acting on the flange) at design temperature

 P_R = flange pressure rating at design temperature



Basically ...

The External Forces & Moments from the nozzle loads must be less than or equal to the Pressure-Temperature rating remaining above the MAWP.



For Replacement Equipment, the Piping Already Exists ...



What are some options when the existing flange CLASS is insufficient to meet the Design Pressure + External Loads ?

- 1. Change out the existing ASME/ANSI flange to a higher CLASS.
- 2. Reduce the External Loads to a level sustainable by the current CLASS.
- 3. Exclude the ASME/ANSI flange from the scope of the pressure vessel or exchanger Code stamp and include the ASME/ANSI flanges in the piping system design.





- ASME Code requires the exchanger design address Nozzle Loads when they are in the scope of Design.
- API 660 has Nozzle Loads as does most Customer Specifications.
- Nozzle Loads are to be addressed in the design & cost estimate at Quotation.
- Check Nozzle Load table force/moment orientation against WRC force/moment orientation.
 - Check Thrust Load (P) in both (+) and (-) directions

The following options can be considered when the design or existing ASME / ANSI Flange Class is insufficient to support the specified nozzle Loads:

- Increase the ASME / ANSI Class of the flange.
- **Reduce or remove Nozzle Loads.**
- **Exclude the ASME / ANSI flanges from the scope of the vessel Code stamp.**



Questions?

Wade Armer

Ohmstede Ltd. VP Mechanical Engineering 895 N. Main Street • Beaumont, Texas 77701 Ph No.: 409.730.1147 Email: warmer@ohmstede.net





American Society of Mechanical Engineers. (2019). ASME B16.5, Table II-2-1-1. [1]

American Petroleum Institute. API 660 Ninth Edition. (2015). Addendum 1. (2020). Figure 4 [2] [2]

American Petroleum Institute. API 660 Ninth Edition. (2015). Addendum 1. (2020). Table 2 3

Welding Research Council. (1965). Bulletin 107. Figure 1. [4]





American Society of Mechanical Engineers. Boiler and Pressure Vessel Code, Interpretation BPV VIII-1-16-85. [5]

American Society of Mechanical Engineers. Boiler and Pressure Vessel Code, Code Case 2901. [6]

American Society of Mechanical Engineers. (2019). UG Paragraph UG-44. [7]

