WRC Bulletin 297

Published in August of 1984, Welding Research Council (WRC) 297 attempts to extend the existing analysis tools for the evaluation of stresses in cylinder-to-cylinder intersections. WRC 297 differs from the widely-used WRC 107 primarily in that WRC 297 is designed for larger d/D ratios (up to 0.5). WRC 297 also computes stresses in the nozzle and the vessel, whereas WRC 107 only computes stresses in the vessel.

The CAESAR II WRC 297 module provides input tabs for vessel data, nozzle data, and imposed loads. WRC 297 supports one set of loads. You can enter the loads in either global CAESAR II convention or in the local WRC 297 coordinate system. If the global CAESAR II convention is selected, vessel and nozzle direction cosines must be present in order to convert the loads into the local WRC 297 convention as discussed in the WRC 297 bulletin.

The CAESAR II version of WRC 297 adds the pressure component of the stress using Lame's equations, multiplied by the stress intensification factors found in ASME Section VIII, Div. 2, Table AD-560.7. The pressure stress calculation is not a part of the WRC 297 bulletin but is added here for your convenience.

NOTE CAESAR II also uses, through **Input > Piping**, the nozzle flexibility calculations described in WRC 297. For more information, see *Piping Input Reference* (on page 106).

After you provide the necessary input, CAESAR II calculates the stress components at the four locations on the vessel around the nozzle and also the corresponding locations on the nozzle. Stresses are calculated on both the outer and inner surfaces (upper and lower). These stress components are resolved into stress intensities at these 16 points around the connection. For more information on the allowable limits for these stresses and output processing, see *WRC Bulletin 107* (see "*WRC Bulletin 107*(537)" on page 799).

Flange Leakage/Stress Calculations

Analysis > Flanges performs flange stress and leakage calculations. Historically, there have been two different ways to calculate stress and one way to estimate leakage for flanges that have received general application over the past 20 years. The stress calculation methods are from the following sources:

- ASME Section VIII
- ANSI B16.5 Rating Tables

The leakage calculations are also based on the B16.5 rating table approach. Leakage is a function of the relative stiffnesses of the flange, gasket and bolting. Using the B16.5 estimated stress calculations to predict leakage does not consider the gasket type, stiffness of the flange, or the stiffness of the bolting. Using B16.5 to estimate leakage makes the tendency to leak proportional to the allowable stress in the flange. A flange with a higher allowable is able to resist higher moments without leakage. Leakage is very weakly tied to allowable stress, if at all.

Flanges attempts to improve upon the solution of this difficult analysis problem. Equations model the flexibility of the annular flange plate and its ability to rotate under moment, axial force, and pressure. The results compare favorably with three-dimensional finite element analysis of the flange junction. These correlations assume that the distance between the inside diameter of the flange and the center of the effective gasket loading diameter is smaller than the distance between the effective gasket loading diameter. In other words, that

(G-ID) < (BC-G), where, G is the effective gasket loading diameter, ID is the inside diameter of the flange, and BC is the diameter of the bolt circle.

The following trends apply:

- Thinner flanges have a greater the tendency to leak.
- Larger diameter flanges have a greater tendency to leak.
- Stiffer gaskets have a greater tendency to leak.
- Leakage is a function of bolt tightening stress.

To begin working with the flange stress and leakage calculations, specify a new job name in the **New Job Name Specification** dialog box or click **Browse** to navigate to an existing job file.

NOTE All CAESAR II analyses require a job name for identification purposes. After you create or open a job, you can enter input data and then define, analyze, and review your data.

The software opens the Flange Leakage/Stress Calculations window.

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10) C 🖄 🌋 🗃 🖕			
Flan	ge Bolts and Gasket Ma	terial Data Loads			^
	1	Flang	е Тире		
	Integral Weld Neck	Integral Slip On	Integral Ring	Loose Slip On	
	e 🗖 o	c 💭	c 🛅	c 🗇	
	Loose Ring	Lap Joint	Blind	Reverse	
	o 🛄	c 🏳	o 🖵	c 🚰	
		Flange Class : 300	•		=
		Flange Grade: 1.2000)		
	Flange	e Outside Diameter [A]: 41.500	00 in.		
	Flan	ge Inside Diameter [B]: 30.560	00 in.		
		Flange Thickness [t]: 4.0600) in.		
	Flang	e Face OD or Lapit ont 34.500	00 in.		
	Flange F	ace ID or Lapit ont ID: 33.000	00 in.		
	Small Er	d Hub Thickness [g0]: 1.6900) in.		
	Large Er	nd Hub Thickness [g1]: 3.4400) in.		
		Hub Length [h]: 6.6200) in.		
		III			-
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Input for the flange stress and leakage calculations is divided into four input tabs:

- Flange (see "Flange Tab" on page 804) Describes flange geometry.
- Bolts and Gasket (see "Bolts and Gasket Tab" on page 807) Defines data for the bolts and gasket.

- Material Data (see "Material Data Tab" on page 816) Defines material and stress-related data.
- Loads (see "Loads Tab" on page 818) Describes the imposed loads.

Flange Tab

The following options are used to describe flange geometry.

Topics

Flange Type	804
Flange Class	804
Flange Grade	805
Flange Outside Diameter (A)	805
Flange Inside Diameter (B)	805
Flange Thickness (t)	806
Flange Face OD or Lapit Cnt	806
Flange Face ID or Lapit Cnt ID	806
Small End Hub Thickness	807
Large End Hub Thickness	807
Hub Length	807
5	

Flange Type

Specifies the flange type. Selecting a flange type is required only if an ASME stress calculation for the flange is needed. If you are performing only a leakage check, you can omit this entry.

Flange Class

Identifies the ANSI B16.5 or API 605 flange rating, (class).

- B16.5 valid classes are **150**, **300**, **400**, **600**, **900**, **1500**, **2500**
- API 605 valid classes are **75**, **150**, **300**, **400**, **600**, **900**

B16.5 specifications govern up to, and including 24-inch pipe; API 605 specifications govern nominal pipe sizes 26- though 60-inch.

The flange rating entry is used to access the B16.5 or API pressure/temperature rating table. Minimum and maximum allowed ratings for all different materials available in the tables are stored. Minimum and maximum computed allowed equivalent pressures, and safety factors are found from this data. API 605 does not have minimum and maximum data. The minimum and maximum data is the same when the nominal English pipe size is greater than 24-inches.

Flange Grade

Specifies the grade of the attached flange. The grade of the attached flange is a value such as 1.1, 1.2, or 2.1. It can be found in the ANSI Standard B16.5 code for flanges and fittings. The flange grade is used in conjunction with the flange class and design temperature to look up the allowable pressure rating for the ANSI flange.

If the grade is 1.10, then type **1.101**. If you are designing a custom flange and do not want the printout for the allowable pressure, then type **0**.

Flange Outside Diameter (A)

Defines the flange outside diameter if an ASME stress calculation for the flange is needed. You can omit this entry if only a leakage check is to be performed.

NOTE This value is required only for ASME stress calculations. It is available in the flange ANSI B16.5/API dimensional database. You can access the flange database properties by pressing **Ctrl+F** from any data input field in the **Flange** tab.

Flange Inside Diameter (B)

Specifies the inner diameter of the flange. For integral type flanges, this value will also be the inner pipe diameter. This value is referred to as "B" in the ASME code.

NOTE The flange inside diameter is contained in the flange database. The software looks up this value whenever you press **Ctrl+ F** in the **Flange** tab. The flange database contains properties of ANSI B16.5 and API 605 flanges.

For inside diameters not specified in B16.5, the matching ID of standard wall pipe is used. Verify this dimension based on the actual application and use of the flange. The following table shows pipe inside diameters for various nominal sizes. All sizes are shown in inches.

Nominal Size	Matching Inside Pipe Diameter			
	STD	Sch 40	Sch 60	Sch 80
1	1.049	1.049	-	0.957
2	2.067	2.067	-	1.939
3	3.068	3.068	-	2.900
4	4.026	4.046	-	3.826
5	5.047	5.047	-	4.813
6	6.065	6.065	-	5.671
8	7.981	7.981	7.813	7.625

10	10.020	10.020	9.750	9.564
12	12.000	11.938	11.626	11.376
14	13.250	13.126	12.814	12.500
16	15.250	15.000	14.688	14.314
18	17.250	16.876	16.500	16.126
20	19.250	18.814	18.376	17.938
24	23.250	22.626	22.064	21.564

Flange Thickness (t)

Specifies the thickness of the flange.

The flange thickness is contained in the flange database. The software looks up this value whenever you press **Ctrl+F** while working in the **Flange** tab. The flange database contains properties of ANSI B16.5 and API 605 flanges.

Flange Face OD or Lapjt Cnt

Indicates one of the following:

- For all except lap joints The outer diameter of the flange face. The software uses the minimum of the flange face outer diameter and the gasket outer diameter to calculate the outside flange contact point but uses the maximum in design when selecting the bolt circle. This is done so that the bolts do not interfere with the gasket. The software uses the maximum of the flange face ID and the gasket ID to calculate the inside contact point of the gasket. This value is required for calculating the contact gasket width and the effective gasket diameter, G.
- For lap joints The lap joint contact outer diameter. This is usually the flange face outer diameter. For additional details, see ASME Section VIII, Division 1, Appendix 2, Figure 2-4, Sketches 1 and 1A.

Flange Face ID or Lapjt Cnt ID

Indicates one of the following:

- For all except lap joints The inner diameter of the flange face. The software uses the maximum of the flange face ID and the gasket ID to calculate the inner contact point of the gasket. This value is required for calculating the contact gasket width and the effective gasket diameter, G.
- For lap joints The lap joint contact inner diameter. This is usually the flange inner diameter. For additional details, see ASME Section VIII, Division 1, Appendix 2, Figure 2-4, Sketches 1 and 1A.

Small End Hub Thickness

Specifies the thickness of the small end of the hub. This value is referred to as **g0** in the ASME code.

For weld neck flange types, this is the thickness of the shell at the end of the flange. For slip on flange geometries, this is the thickness of the hub at the small end. For flange geometries without hubs, this thickness can be entered as zero, or omitted.

NOTE This value is required only for ASME stress calculations. It is available in the flange ANSI B16.5/API dimensional database. You can access the flange database properties by pressing **Ctrl+F** from any data input field in the **Flange** tab.

Large End Hub Thickness

Specify the thickness of the large end of the hub. This value is referred to as **g1** in the ASME code. It can be the same as **Small Hub Thickness**.

For flange geometries without hubs, this thickness can be entered as zero, or left blank.

NOTE This value is required only for ASME stress calculations. It is available in the flange ANSI B16.5/API dimensional database. You can access the flange database properties by pressing **Ctrl+F** from any data cell in the **Flange** tab.

Hub Length

Defines the hub length. This value is referred to as **h** in the ASME code. For flange geometries without hubs, this length can be entered as zero, or left blank.

NOTE This value is required only for ASME stress calculations. It is available in the flange ANSI B16.5/API dimensional database. You can access the flange database properties by pressing **Ctrl+F** from any data input field in the **Flange** tab.

When analyzing an optional type flange that is welded at the hub end, enter the hub length as the leg of the weld, and include the thickness of the weld in the large end.

When analyzing a flange with no hub, such as a ring flange or a lap joint flange, enter a zero or leave the field blank for the **Hub Length**, **Small End Hub Thickness**, and **Large End Hub Thickness**. When designing a loose, ring-type flange that has a fillet weld at the back, enter the size of a leg of the fillet weld as the large end of the hub.

Bolts and Gasket Tab

The following options are used to define data for the bolts and gasket.

Topics

Number of Bolts	808
Bolt Diameter	808
Bolt Initial Tightening Stress	808
Gasket Outer Diameter	809
Gasket Inner Diameter	809
Uncompressed Gasket Thickness	809
Effective Gasket Modulus	809
Leak Pressure Ratio	810
Gasket Seating Stress	812
Nubbin Width or Ring	814
Facing Sketch	814
Facing Column	814

Number of Bolts

Specifies the number of bolts.

NOTE The number of bolts in standard ANSI B16.5 and API 605 flanges is contained in the flange database and is accessed by the software whenever you press **Ctrl+F**.

Bolt Diameter

Specifies the nominal diameter of the bolts. Standard bolt diameters for ANSI B16.5 and API 605 flanges are contained in the flange database and are accessed by the software whenever press **Ctrl+F**.

Bolt Initial Tightening Stress

Specifies the stress induced in the bolt during tightening after the flange has been seated. This is the stress in the bolt when the system is about to be pressurized and thermally loaded.

If this value is omitted, the software uses the following bolt tightening rule to compute the tightening stress in the bolt. (In English units: $a(i) = 45,000 / \hat{u}(d)$.

This entry is used only in the flexibility model of the flange to estimate the initial compression of the gasket.

Bolt Tightening Stress Notes

This is a critical item for leakage determination and for computing stresses in the flange. The ASME Code bases its stress calculations on a predetermined, specified, fixed equation for the bolt stress. The resulting value is however often not related to the actual tightening stress that appears in the flange when the bolts are tightened. For this reason, **Bolt Initial Tightening Stress**, is used only for the flexibility/leakage determination. The value for the bolt tightening stress used in the ASME Flange Stress Calculations is as defined by the ASME Code:

Bolt Load = Hydrostatic End Force + Force for Leaktight Joint

If Bolt Initial Tightening Stress is left blank, CAESAR II uses the value

45000/(*\scileta*)

Where 45,000 psi is a constant and d is the nominal diameter of the bolt.

This is a rule of thumb tightening stress that will typically be applied by field personnel tightening the bolts. This computed value is printed in the output from the **Flanges** output. Compare this value to the bolt stress printed in the ASME stress report (also in the output). The "rule-of-thumb" tightening stress is frequently larger than the ASME required stress. When the ASME required stress is entered into the **Bolt Initial Tightening Stress** field, a comparison of the leakage safety factors can be made and the sensitivity of the joint to the tightening torque can be determined. You are strongly encouraged to adjust these numbers to get a feel for the relationship between all of the factors involved.

Gasket Outer Diameter

Specifies the outer diameter of the gasket. The software uses the minimum of the flange face outer diameter and the gasket outer diameter to calculate the outside flange contact point, but uses the maximum in design when selecting the bolt circle. This is done so that the bolts do not interfere with the gasket. The software uses the maximum of the flange face ID and the gasket ID to calculate the inside contact point of the gasket.

This value is required for calculating the contact gasket width and the effective gasket diameter, G.

Gasket Inner Diameter

Specifies the inner diameter of the gasket. The software uses the maximum of the flange face ID and the gasket ID to calculate the inner contact point of the gasket.

This value is required for calculating the contact gasket width and the effective gasket diameter, G.

Uncompressed Gasket Thickness

Specifies the uncompressed thickness of the gasket. The software uses this value to construct an elastic compression model of the gasket reaction at the effective gasket diameter.

Effective Gasket Modulus

Specifies the modulus of elasticity of the gasket material that occurs during loading and unloading of the gasket. Several sources have shown this modulus to be somewhat higher than the initial tightening modulus for spiral wound metal gaskets. Typical values used for spiral wound metal gaskets are:

- High End: 437500.0
- Low End: 347000.0

NOTE Typical values are between 300,000 and 400,000 psi for spiral wound gaskets. The higher the modulus the greater the tendency for the software to predict leakage. Errors on the high side when estimating this value will lead to a more conservative design.

Leak Pressure Ratio

Specifies the ratio of gasket pressure to internal pressure at the instant when leakage starts multiplied by a factor of safety. This is termed the "Gasket Factor" in ASME Sect. VIII Div. 1

The following table, extracted from Sect VIII Div. 1 gives gasket factors for some common types of gaskets.

Gasket Materials and Contact Facings Notes Table 2-5.1				
Gasket Material	Gasket Factor m	Seating Stress y (^06)		
Self-energizing types (O rings, metallic elastomer, and other self-sealing types)	0.	0.		
Elastomers without fabric or a high percent of asbestos fiber:				
Below 75A Shore Durometer 75A or higher Shore Durometer	.50 1.00	0. 200.		
Asbestos with Suitable Binder 1/8" thick 1/16" thick 1/32" thick	2.00 2.75 3.50	600. 3700. 6500.		
Elastomers with cotton fabric	1.25	400.		
Elastomers with Asbestos fabric 3 ply 2 ply 1 ply	2.25 2.50 2.75	2200. 2900. 3700.		
Vegetable fiber	1.75	1100.		
Spiral-wound, asbestos filled: Carbon Stainless, Monel, Nickel alloys	2.50 3.00	10000. 10000.		

Corrugated Metal, w/ Asbestos or corrugated metal, jacketed with: soft aluminum soft copper or brass iron or soft steel Monel or 4%-6% chrome Stainless steels and nickel alloys	2.50 2.75 3.00 3.25 3.50	2900. 3700. 4500. 5500. 6500.
Corrugated Metal:		
soft aluminum soft copper or brass iron or soft steel Monel or 4%-6% chrome Stainless steels and nickel alloys	2.75 3.00 3.25 3.50 3.75	3700. 4500. 5500. 6500. 7600.
Flat metal, jacketed asbestos filled	2.25	5500
soft aluminum soft copper or brass iron or soft steel Monel 4%-6% chrome Stainless steels and nickel alloys	3.25 3.50 3.75 3.50 3.75 3.75	5500. 6500. 7600. 8000. 9000. 9000.
Grooved Metal		
soft aluminum soft copper or brass iron or soft steel Monel or 4%-6% chrome Stainless steels and nickel alloys	3.25 3.50 3.75 3.75 4.25	5500. 6500. 7600. 9000. 10100.
Solid flat metal		
soft aluminum soft copper or brass iron or soft steel Monel or 4%-6% chrome Stainless steels and nickel alloys	4.00 4.75 5.50 6.00 6.50	8800. 13000. 18000. 21800. 26000.

Gasket Seating Stress

Specifies the initial seating stress required for the gasket being used. This entry is required only if ASME stress calculations are to be performed.

The following table, extracted from Sect VIII Div. 1 gives gasket factors for some common types of gaskets.

Gasket Materials and Contact Facings Notes Table 2-5.1				
Gasket Material	Gasket Factor m	Seating Stress y (^06)		
Self-energizing types (O rings, metallic elastomer, and other self-sealing types)	0.	0.		
Elastomers without fabric or a high percent of asbestos fiber:				
Below 75A Shore Durometer 75A or higher Shore Durometer	.50 1.00	0. 200.		
Asbestos with Suitable Binder				
1/8" thick 1/16" thick 1/32" thick	2.00 2.75 3.50	600. 3700. 6500.		
Elastomers with cotton fabric	1.25	400.		
Elastomers with Asbestos fabric 3 ply 2 ply 1 ply	2.25 2.50 2.75	2200. 2900. 3700.		
Vegetable fiber	1.75	1100.		
Spiral-wound, asbestos filled: Carbon Stainless, Monel, Nickel alloys	2.50 3.00	10000. 10000.		

Corrugated Metal, w/ Asbestos or corrugated metal, jacketed with: soft aluminum soft copper or brass iron or soft steel Monel or 4%-6% chrome Stainless steels and nickel alloys	2.50 2.75 3.00 3.25 3.50	2900. 3700. 4500. 5500. 6500.
Corrugated Metal:	0.75	0700
soft aluminum soft copper or brass iron or soft steel Monel or 4%-6% chrome Stainless steels and nickel alloys	2.75 3.00 3.25 3.50 3.75	3700. 4500. 5500. 6500. 7600.
Flat metal, jacketed asbestos filled	3 25	5500
soft aluminum soft copper or brass iron or soft steel Monel 4%-6% chrome Stainless steels and nickel alloys	3.50 3.75 3.50 3.75 3.75 3.75	6500. 7600. 8000. 9000. 9000.
Grooved Metal		
soft aluminum soft copper or brass iron or soft steel Monel or 4%-6% chrome Stainless steels and nickel alloys	3.25 3.50 3.75 3.75 4.25	5500. 6500. 7600. 9000. 10100.
Solid flat metal		
soft aluminum soft copper or brass iron or soft steel Monel or 4%-6% chrome Stainless steels and nickel alloys	4.00 4.75 5.50 6.00 6.50	8800. 13000. 18000. 21800. 26000.

Nubbin Width or Ring

Specifies the nubbin width, if applicable. This value is required only for facing sketches 1c, 1d, 2 and 6 (FLANGE) equivalents 3, 4, 5, and 9). For sketch 9, this is not a nubbin width but the contact width of the metallic ring.

Facing Sketch

Specifies the facing sketch number according to the following correlations, according to Table 2-5-2 of the ASME code.

Facing Sketch	CAESAR II Equivalent	Description
1a	1	flat finish faces
1b	2	serrated finish faces
1c	3	raised nubbin-flat finish
1d	4	raised nubbin-serrated finish
2	5	1/64 inch nubbin
3	6	1/64 inch nubbin both sides
4	7	large serrations, one side
5	8	large serrations, both sides
6	9	metallic O-ring type gasket

This value is required for calculating the contact gasket width and the effective gasket diameter, G.

Facing Column

Specifies the facing column number according to the following correlations:

Gasket Material	Facing Column
Self-energizing types (O rings, metallic elastomer, and other self-sealing types)	2
Elastomers without fabric or a high percent of asbestos fiber: Below 75A Shore Durometer 75A or higher Shore Durometer	2 2

Asbestos with Suitable Binder 1/8" thick 1/16" thick 1/32" thick	2 2 2
Elastomers with cotton fabric	2
Elastomers with Asbestos fabric 3 ply 2 ply 1 ply	2 2 2
Vegetable fiber	2
Spiral-wound, asbestos filled: Carbon Stainless, Monel, Nickel alloys	2 2
Corrugated Metal, w/ Asbestos or corrugated metal, jacketed with: soft aluminum soft copper or brass iron or soft steel Monel or 4%-6% chrome Stainless steels and nickel alloys	2 2 2 2 3.50
Corrugated Metal: soft aluminum soft copper or brass iron or soft steel Monel or 4%-6% chrome Stainless steels and nickel alloys	2 2 2 2 2 2
Flat metal, jacketed asbestos filled soft aluminum soft copper or brass iron or soft steel Monel 4%-6% chrome Stainless steels and nickel alloys	2 2 2 2 2 2 2 2
Grooved Metal soft aluminum soft copper or brass iron or soft steel Monel or 4%-6% chrome Stainless steels and nickel alloys	2 2 2 2 2 2

Solid flat metal	2
soft aluminum	2
soft copper or brass	2
iron or soft steel	2
Monel or 4%-6% chrome	2
Stainless steels and nickel alloys	2

Material Data Tab

The following options are used to define material and stress-related data.

Topics

	040
Flange Material	. 816
Bolt Material	. 816
Design Temperature	. 816
Flange Allowable @ Design Temperature	. 817
Flange Allowable @ Ambient Temperature	. 817
Flange Modulus of Elasticity @ Design	. 817
Flange Modulus of Elasticity @ Ambient	. 817
Bolt Allowable @ Design Temperature	. 817
Bolt Allowable @ Ambient Temperature	. 818
Flange Allowable @ Stress Multiplier	. 818
Bolt Allowable Stress Multiplier	. 818
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Flange Material

Displays the material database for flanges, taken from ASME Section VIII, Division 1.

Bolt Material

Displays the material database for bolting, taken from ASME Section VIII, Division 1.

Design Temperature

Specifies the flange design temperature. This value is required for ASME stress calculations, and for ANSI B16.5/API rating table look-ups.

The design temperature is not used in the flexibility model of the flange.

Flange Allowable @ Design Temperature

Specifies the allowable stress for the flange material at the design temperature. This value is required only if an ASME stress analysis of the flange is to be performed.

This value is available in the ASME Sect. VIII Div. 1 material database delivered with the software. You can access the database by typing a material name in the **Flange Material** box or by clicking **Browse** and selecting a material in the **Material Selection** list.

When you select a material in the database, fill in the spaces for any material values where the defaults are not sufficient. Press **F1** for guidance on the material values.

Flange Allowable @ Ambient Temperature

Specifies the allowable stress for the flange material at the ambient temperature. This value is only required if an ASME stress analysis of the flange is to be performed.

This value is available in the ASME Sect. VIII Div. 1 material database delivered with the software. You can access the database by typing a material name in the **Flange Material** box or by clicking **Browse** and selecting a material in the **Material Selection** list.

When you select a material in the database, fill in the spaces for any material values where the defaults are not sufficient. Press **F1** for guidance on the material values.

Flange Modulus of Elasticity @ Design

Defines the value of the modulus of elasticity to be used for the determination of the Flange Rigidity Factor "J", for the DESIGN case defined in Appendix S of the A93 addendum.

Flange Modulus of Elasticity @ Ambient

Defines the value of the modulus of elasticity to be used for the determination of the Flange Rigidity Factor "J", for the SEATING case defined in Appendix S of the A93 addendum.

Bolt Allowable @ Design Temperature

Indicates the allowable stress for the bolt material at the design temperature. This value is only required if an ASME stress analysis of the flange is to be performed.

This value is available in the ASME Sect. VIII Div. 1 material database delivered with the software. You can access the database by typing a material name in the **Flange Material** box or by clicking **Browse** and selecting a material in the **Material Selection** list.

When you select a material in the database, fill in the spaces for any material values where the defaults are not sufficient. Press **F1** for guidance on the material values.

Bolt Allowable @ Ambient Temperature

Specify the allowable stress for the bolt material at the ambient temperature. This value is only required if an ASME stress analysis of the flange is to be performed.

This value is available in the ASME Sect. VIII Div. 1 material database delivered with the software. You can access the database by typing a material name in the **Flange Material** box or by clicking **Browse** and selecting a material in the **Material Selection** list.

When you select a material in the database, fill in the spaces for any material values where the defaults are not sufficient. Press **F1** for guidance on the material values.

Flange Allowable @ Stress Multiplier

Applies the increased allowable (1.5) for the radial and tangential operating ASME flange allowables. This increase is implied in B31.1 Appendix II Section 4.2.3 when it states that the longitudinal hub, tangential and radial stress allowables are equal to the yield stress at design temperature, which is essentially 1.5(S).

NOTE Prior to the 1992 edition of the ASME NC code, NC paragraph 3658.1(d) also stated that the tangential and radial stress allowables could be increased by 50%. The 1992 edition of NC eliminated this increase on these allowables.

Bolt Allowable Stress Multiplier

Designates a factor by which to increase the operating bolt allowables.

Section VIII Division 2, Article 4-141 of the ASME Boiler and Pressure Vessel Code allows for operating loads on bolts to equal two times the standard table allowables. In some cases, this increase can be by as much as three times the table allowables.

Loads Tab

The following options are used to describe the imposed loads.

Topics

819
819
819
819
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819

Design Pressure

Indicates the internal line pressure (lbs./sq.in.) in gage. This pressure is used in the flexibility model of the flange in the ASME stress calculations and is the B16.5/API rating.

Axial Force

Defines the externally applied axial force applied to the flange joint by the attached piping. The software does not include the effect of shear forces in the flexibility model.

Bending Moment

Specifies the external moment applied to the flange joint by the attached piping. If you have two bending moments, SRSS them and enter the result here.

Disable Leakage Calculations

Turns off the leakage calculations performed by CAESAR II. Use this option if you want a flange report, which only contains ASME Section VIII, Division 1, Appendix 2 results.

Disable Stress Calculations

Turns off the flange stress calculations performed by CAESAR II. Use this option if you want a flange report, which only contains leakage calculations and omits ASME Section VIII, Division 1, Appendix 2 results.

Disable ANSI B16.5 Check

Turns off the report for the ANSI B16.5 Equivalent Pressure check. This check compares the equivalent pressure to the MAWP (as listed in ANSI B16.5) for the flange class and material. The ANSI MAWP does not consider bolting or gasket properties, and it is not a good indicator of the leakage characteristics of the flange.

Flange Rating

This is an optional input. It has been a common practice in the industry to use the ANSI B16.5 and API 605 temperature/pressure rating tables as a gauge for leakage. Because these rating tables are based on allowable stresses and are not intended for leakage prediction, the leakage predictions that resulted are a function of the allowable stress for the flange material, not the flexibility, or modulus of elasticity, of the flange. To give you a comparison to the old practice, the minimum and maximum rating table values from ANSI and API are stored and are used to print minimum and maximum leakage safety factors that are predicted from this method. An example of the output that you get upon entering the flange rating is shown below:

According to the older method, this shows that leakage occurred if a carbon steel flange is used, and leakage does not occur if an alloy flange is used. Both flanges have essentially the same flexibility tendency to leak.

The following input parameters are used only for the ASME Section VIII Division 1 stress calculations:

- Flange Type
- Flange Outside Diameter
- Design Temperature
- Small End Hub Thickness
- Large End Hub Thickness
- Hub Length
- Flange Allowables
- Bolt Allowables
- Gasket Seating Stress
- Optional Allowable Multipliers
- Flange Face & Gasket Dimensions

Specify the **Flange Type** (on page 804) on the *Flange* (see "*Flange Tab*" on page 804) tab. To acquire material allowables from the Section VIII, Division 1 material library, use the **Flange** Material (on page 816) list on the *Material Data* (see "*Material Data Tab*" on page 816) tab.

An input listing for a typical flange analysis is shown below:

```
CA E S A R I I MISCELLANEOUS REPORT ECHO
Flange Inside Diameter [B] (in.) 30.560
Flange Thickness [t] (in.) 4.060
Flange Rating (Optional) 300.000
Bolt Circle Diameter (in.) 38.500
Number of Bolts 32.000
Bolt Diameter (in.) 1.500
Bolt Initial Tightening Stress(lb./sq.in.)
Effective Gasket Diameter [G] (in.) 33.888
Uncompressed Gasket Thickness (in.) 0.063
Basic Gasket Width [b0] (in.) 0.375
Leak Pressure Ratio [m] 2.750
Effective Gasket Modulus(b./sq.in.) 300,000.000
Externally Applied Moment (optional) (in.lb.) 24,000.000
Externally Applied Force (optional) (lb.) 1,000.000
Pressure [P] (lb./sq.in.) 400.000
The following inputs are required only if you wish to perform stress calcs
as per Sect VIII Div. 1
Flange Type (1-8, see ?-Help or Alt-P to plot) 1.000
Flange Outside Diameter [A] (in.) 41.500
Design Temperature°F 650.000
Small End Hub Thickness [g0] (in.) 1.690
Large End Hub Thickness [g1] (in.) 3.440
Hub Length [h] (in.) 6.620
Flange Allowable @Design Temperature(lb./sq.in.) 17,500.000
```

```
Flange Allowable @Ambient Temperature(lb./sg.in.) 17,500.000
Flange Modulus of Elasticity @Design(lb./sq.in.) 0.279E+08
Flange Modulus of Elasticity @Ambient(lb./sq.in.) 0.279E+08
Bolt Allowable @Design Temperature(lb./sg.in.) 25,000.000
Bolt Allowable @Ambient Temperature(lb./sq.in.) 25,000.000
Gasket Seating Stress [y](lb./sq.in.) 3,700.000
Flange Allowable Stress Multiplier 1.000
Bolt Allowable Stress Multiplier (VIII Div 2 4-1411.000
Disable Leakage Calculations (Y/N) N
Flange Face OD or Lapjt Cnt OD(in.) 34.500
Flange Face ID or Lapjt Cnt ID(in.) 33.000
Gasket Outer Diameter (in.) 36.000
Gasket Inner Diameter (in.) 33.000
Nubbin Width (in.)
Facing Sketch 1.000
Facing Column 2.000
Disable Leakage Calculations (Y/N) N
```

Pipeline Remaining Strength Calculations (B31G)

Analysis > B31G evaluates corroded pipelines to determine when specific pipe segments must be replaced. The original B31G document is conservative. CAESAR II performs additional calculations to modify the original criteria. This additional work can be found in project report PR-3805, by Battelle, Inc. The details of the original B31G criteria, as well as the modified methods, are discussed in detail in this report.

CAESAR II determines the following values according to the original B31G criteria and four modified methods. The values are

- The hoop stress to cause failure
- The maximum allowed operating pressure
- The maximum allowed flaw length

The four modified methods vary in the manner in which the corroded area is estimated. The methods are:

- .85dL Approximates the corroded area as 0.85 times the maximum pit depth times the flaw length.
- Exact Determines the corroded area numerically using the trapezoid method.
- Equivalent Determines the corroded area by multiplying the average pit depth by the flaw length. Additionally, an equivalent flaw length (flaw length * average pit depth / maximum pit depth) is used in the computation of the Folias factor.
- Effective Uses a numerical trapezoid summation; however, various sub-lengths of the total flaw length are used to arrive at a worst case condition. If the sub-length that produces the worst case coincides with the total length, the Exact and Effective methods yield the same result.

To begin, specify a new job name in the **New Job Name Specification** dialog box or click **Browse** to navigate to an existing job file.