



Designation: F2836 – 18 (Reapproved 2024)

Standard Practice for Gasket Constants for Bolted Joint Design¹

This standard is issued under the fixed designation F2836; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice determines room temperature gasket tightness design constants for pressurized bolted flanged connections such as those designed in accordance with the ASME Boiler and Pressure Vessel Code.

1.2 This practice applies mainly to all types of circular gasket products and facings typically used in process or power plant pressure vessels, heat exchangers, and piping including solid metal, jacketed, spiral wound, and sheet-type gaskets. As an optional extension of this practice, the maximum assembly stress for those gaskets may also be determined by this procedure.

1.3 *Units*—The values stated in SI units are to be regarded as the standard, but other units may be included.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 ASME Standards:²

- ASME B16.5 Steel Pipe Flanges and Flanged Fittings
- ASME B16.20 Metallic Gaskets for Pipe Flanges—Ring-Joint, Spiral-Wound, and Jacketed
- ASME B16.21 Nonmetallic Flat Gaskets for Pipe Flanges

¹ This practice is under the jurisdiction of ASTM Committee F03 on Gaskets and is the direct responsibility of Subcommittee F03.20 on Mechanical Test Methods.

Current edition approved Sept. 1, 2024. Published September 2024. Originally approved in 2018. Last previous edition approved in 2018 as F2836 – 18. DOI: 10.1520/F2836-18R24.

² Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Two Park Ave., New York, NY 10016-5990, <http://www.asme.org>.

ASME Boiler and Pressure Vessel Code Section VIII Division 1, Appendix 2

3. Terminology

3.1 Definitions of Terms Specific to This Standard:

3.1.1 *ASME Class 150, n*—refers to the dimensions and pressure rating of Class 150 of standard flanges in ASME Standard B16.5.

3.1.2 *flange rotation, n*—rotation of the flange face surfaces so that the gasket outside diameter (OD) is compressed more than the gasket inside diameter (ID) when the bolts are tightened to compress the gasket.

3.1.3 *gasket constants, n*—if a log-log plot of gasket stress versus tightness (S_g - T_p graph) is made and an analysis of the data is performed in accord with this practice, then (see Fig. 1):

(1) The value, G_b , is the stress intercept (at $T_p = 1$) associated with a regression of the Part A tightness data.

(2) The value, a , is the slope associated with the Part A data and combined values of G_b and a describe the seating or loading characteristic of a gasket and give an indication of the gasket capacity to develop tightness upon initial seating.

(3) The value, G_s , is the stress intercept (at $T_p = 1$) associated with Part B tightness data and values of G_s represent the gasket potential to maintain tightness after pressurization and during operation and indicate the gasket's sensitivity to unloading excursions or susceptibility to crushing.

(4) The combined effect of constants G_b and a is best represented by the value of $S_{Tp} = G_b \times T_p^a$ calculated for typical values of T_p such as 100, 1000, or 10 000 where S_{Tp} tells us what the minimum gasket stress shall be to maintain a specified level of minimum tightness.

(5) The value, G_s , is an independent constant that represents operation and it characterizes the gasket tightness sensitivity to operating bolt load reductions that occur during pressurization or gasket creep or thermal disturbances.

3.1.4 *gasket contact area, A_g , n*—initial (nominal) area of the gasket that is considered to be loaded by the flange surfaces.

3.1.5 *gasket stress, S_g , n*—gasket stress is the ratio of the applied load by the fixture over the gasket contact area, A_g .

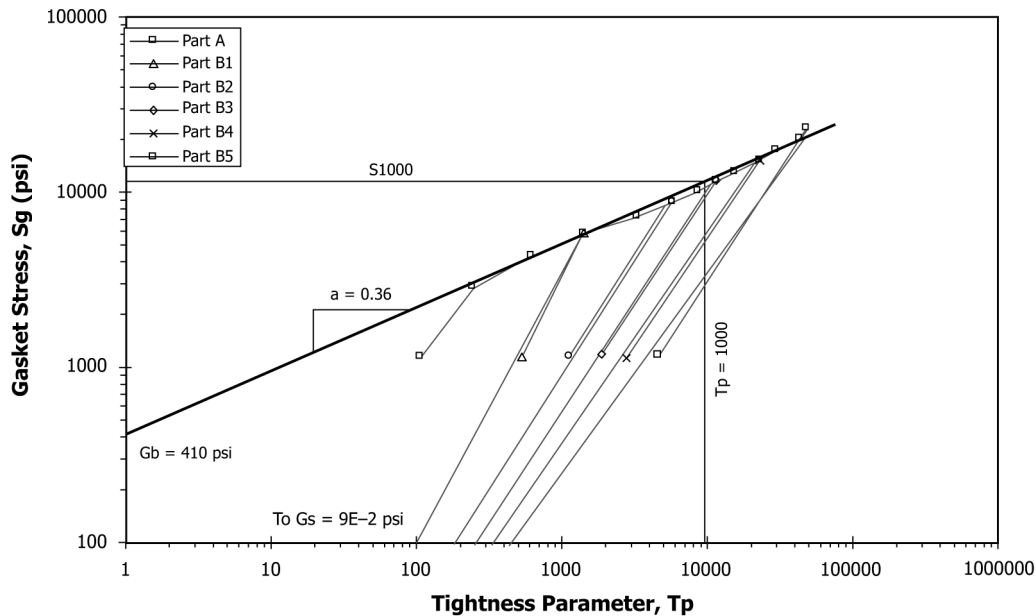


FIG. 1 Typical Representation of Gasket Constant G_b , a , and G_s

3.1.6 *gasket types, n* —for this practice, it is convenient to differentiate gasket styles as:

(1) Sheet gasket materials typically from 0.5 to 5 mm thick commonly in use and in which circular gasket samples are cut, such as compressed or beater-added fiber-reinforced, flexible graphite and polytetrafluoroethylene (PTFE)-based sheet products;

(2) Preformed gaskets with a flat seal element that contacts the raised faced flange surfaces as intended by the manufacturer, such as solid flat metal gaskets with and without nubbin, spiral wound gaskets, flat metal jacketed with nonmetallic filler gasket, and so on;

(3) Preformed gaskets with one or several cambered seal elements in which the nominal contact area is not obvious such as solid metal oval rings, hollow metal rings, elastomer O-rings, corrugated gaskets, and so on; and

(4) Formed-in-place sealing products such as expanded PTFE rope and so on.

3.1.7 *known volumes, n* —volume of the internal high-pressure chamber or volume of the external low-pressure leak collection chamber used, respectively, in pressure decay or pressure rise methods to measure gasket specimen leaks.

3.1.8 *leakage rate, L_{rm} , n* —total rate of internal fluid leakage around or through the gasket expressed as milligrams per second, L_{rm} , reduced to standard conditions.

3.1.9 *maximum assembly stress, S_c , n* —maximum gasket stress found to achieve a minimum acceptable tightness when the gasket is unloaded to the minimum allowed stress level, S_1 , of the procedure (see Section 13).

3.1.10 *maximum and minimum tightness, T_{pmax} and T_{pmin} , n* —highest and lowest level of tightness, T_p , achieved, respectively, during Part A and Part B of the test procedure.

3.1.11 *nominal pipe size, NPS, “d,” n* —refers to the nominal pipe size in which “d” is the nominal size in inches, for example, NPS 12 refers to standard 305-mm pipe.

3.1.12 *pressure decay method, n* —this method measures, at regular intervals of time, the helium pressure decay of the internal high-pressure chamber of known volume upstream of the gasket.

3.1.13 *pressure rise method, n* —this method measures, at regular intervals of time, the pressure rise of an external low-pressure leak collection chamber of known volume built at the external periphery of the gasket.

3.1.14 *range of gasket behavior possibilities, n* —various gasket behaviors ranging from tightness softening to extreme tightness hardening are illustrated in Fig. 2(a-f).

3.1.15 *reference gasket diameter, n* —outside gasket diameter, 150 mm (~5.9 in.).

3.1.16 *reference mass leak, L_{rm}^* , n* —defined as 1.0 mg/s (0.008 lbm/h) for a gasket of 150 mm outside diameter.

3.1.17 *tightness hardening, n* —refers to behavior in which large increases of gasket stress (S_g) cause small or no increase of tightness parameter (T_p).

3.1.17.1 *Discussion*—There is typically an increasing slope in log-log S_g - T_p plots resulting in a reverse “knee” in the Part A curve [see Fig. 2(d-e)].

3.1.18 *tightness parameter, T_p , n* —dimensionless sealability measure that is proportional to pressure and inversely proportional to the square root of leak rate.

3.1.18.1 *Discussion*—More precisely, T_p is the pressure relative to the atmospheric pressure required to cause a helium leak of 1 mg/s for a 150 mm OD gasket. Since this is about the same as the OD of an NPS 4 joint, the pressure to cause a leak of 1 mg/s of that joint is its tightness. (Tightness is a measure of the gasket’s ability to control the leak rate of the joint for a given load. With all other variables equal, a tighter gasket requires higher internal pressure to push the same rate of fluid through the joint. In other words, the tighter the seal, smaller the leak).

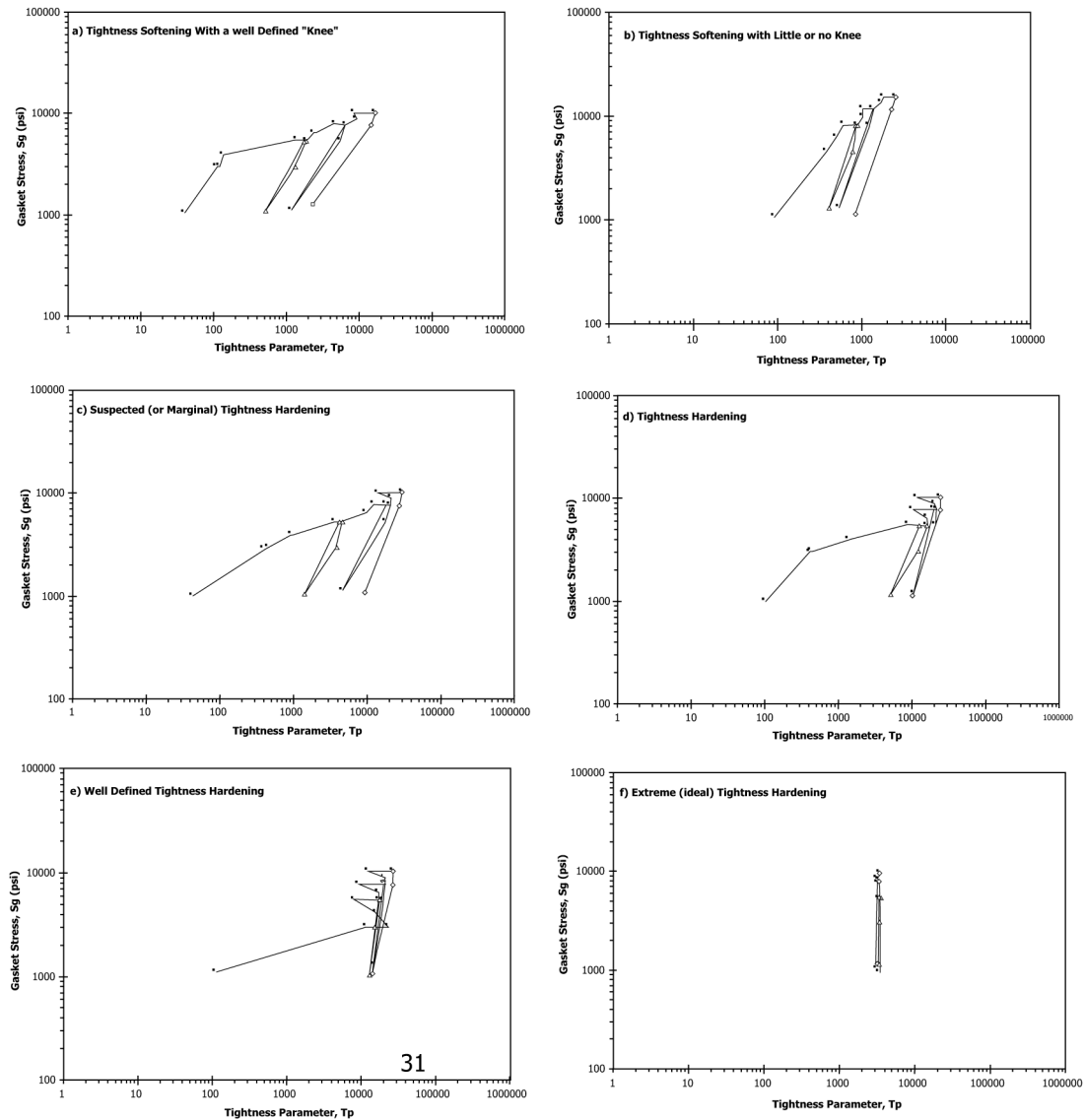


FIG. 2 Range and Definition of Typical Behaviors from Softening to Extreme Hardening

$$Tp = \frac{P}{P^*} \left(\frac{Lrm^*}{Lrm} \right)^{0.5} \quad (1)$$

where:

- P = fluid pressure (MPa),
- P^* = reference pressure (0.1013 MPa), (14.69 psi),
- Lrm = mass leak rate (mg/s) of ROTT gasket specimens as defined per 8.1, and
- Lrm^* = unit mass leak rate equal to 1 mg/s for a 150 mm OD gasket in a joint.

3.1.18.2 *Discussion*—The Tp equation can be rewritten as follows:

$$Tp = \frac{P}{0.1013} \left(\frac{1}{Lrm} \right)^{0.5} \quad (\text{For } P \text{ in MPa}) \quad (2)$$

$$Tp = \frac{P}{14.69} \left(\frac{1}{Lrm} \right)^{0.5} \quad (\text{For } P \text{ in psi}) \quad (3)$$

3.1.19 *tightness softening*, n —refers to behavior in which small increases of gasket stress (Sg) cause large increases of tightness parameter (Tp).

3.1.19.1 *Discussion*—There is typically a decreasing slope in log-log Sg - Tp plots resulting in a “knee” in the Part A curve (see Fig. 2a).

3.2 *Acronyms*:

- 3.2.1 $AARH$ —arithmetic average roughness height in meters (m)
- 3.2.2 Ag —nominal contact area of the gasket, mm^2
- 3.2.3 Ai —pressurized area, mm^2
- 3.2.4 Dg —gasket deflection, mm
- 3.2.5 *Extended LP*—extended low-pressure test sequence
- 3.2.6 *HP*—high-pressure test sequence. Part B of the testing sequence
- 3.2.7 *ID*—identification of gasket test specimen, mm
- 3.2.8 *LP*—low-pressure test sequence. Part A of the testing sequence
- 3.2.9 Lrm —mass leakage rate, mg/s

3.2.10 L_{rmin} —minimum mass leakage rate of the system, mg/s

3.2.11 L_{rm}^* —unit mass leak defined as 1.0 mg/s for a 150 mm outside gasket diameter

3.2.12 NPS —nominal pipe size

3.2.13 OD —outside diameter of gasket test specimen, mm

3.2.14 P —internal fluid pressure, MPa

3.2.15 P^* —standard pressure, 0.1013 MPa

3.2.16 $ROTT$ —room temperature tightness test procedure

3.2.17 R_{LM} —ratio of mass leak rates, L_{rm1} and L_{rm2} , measured at the same step of the $ROTT$ test procedure (see [Tables 1 and 2](#)) in two different $ROTT$ tests performed on a gasket style

3.2.18 S —level of gasket stress defined in [Table 3](#), MPa

3.2.19 S_c —the highest gasket stress of the optional extended LP tests preceding the stress level that resulted in T_{pc} , MPa

3.2.20 S_g —gasket stress calculated from the net applied load and the nominal area, Ag, MPa

3.2.21 $slpm$ —standard litre per minute

3.2.22 S_s —gasket stress developed when contact is initiated with a compression limiting device, or stop, such as a groove containing the gasket, a gage ring, or a stress associated with a tightness limit such as T_{pmax}

3.2.23 T —test fixture temperature in the vicinity of the tested gasket

3.2.24 T_p —tightness parameter (dimensionless)

3.2.25 T_{pmax} —average of highest two levels of tightness obtained from each test

3.2.26 T_{pmin} —lowest tightness value achieved during Part B of all HP tests

TABLE 1 ROTT HP Test Sequence (with $P = 6$ MPa)

Test Step	Test Part	“S” Stress Level	Gasket Stress	Type of Measurement
			MPa	(1) Leakage (2) Mechanical
1	A	S1	8	(1+2)
2	A	S2	20	(1+2)
3	A	S3	30	(1+2)
4	A, B1	S4	40	(1+2)
5	B1	S1	8	(1+2)
6	A, B1	S5	50	(1+2)
7	A, B2	S6	60	(1+2)
8	B2	S2	20	(2)
9	B2	S1	8	(1+2)
10	A, B2	S7	70	(1+2)
11	A, B3	S8	80	(1+2)
12	B3	S3	30	(2)
13	B3	S1	8	(1+2)
14	A, B3	S9	90	(1+2)
15	A, B4	S10	105	(1+2)
16	B4	S4	40	(2)
17	B4	S1	8	(1+2)
18	A, B4	S11	120	(1+2)
19	A	S12	140	(1+2)
20	A, B5	S13	160	(1+2)
21	B5	S5	50	(2)
22	B5	S1	8	(1+2)

TABLE 2 ROTT LP and Extended LP Test Sequences (with $P = 2$ MPa)

Test Step	Test Part	“S” Stress Level	Gasket Stress	Type of Measurement
			MPa	(1) Leakage
				(2) Mechanical Only
LP Test Sequence				
1	A	S1	8	(1+2)
1a	A	S2	20	(1+2)
2	A	S3	30	(1+2)
3	A	S5	50	(1+2)
4	A	S7	70	(1+2)
5	A	S10	105	(1+2)
6	A	S12	140	(1+2)
Extended LP Test Sequence				
7	A	S14	170	(1+2)
8	B	S1	8	(1+2)
9	A	S15	190	(1+2)
10	B	S1	8	(1+2)
11	A	S16	210	(1+2)
12	B	S1	8	(1+2)
13	A	S17	230	(1+2)
14	B	S1	8	(1+2)
15	A	S18	250	(1+2)
16	B	S1	8	(1+2)
17	A	S19	270	(1+2)
18	B	S1	8	(1+2)

TABLE 3 Nominal Values for Gasket Stress Levels

NOTE 1—Multiply the gasket stress values by Ag to obtain the total load required for a particular gasket.

NOTE 2—The nominal “S” load stresses correspond to a low to high range of typical pipe fitter imposed bolting stresses. For example, S1 is typical of the low gasket stresses resulting from (69 MPa) bolt stresses on a NPS 12 ASME/ANSI cl 68 kg joint and S10 is typical of high (414 MPa) bolt stresses on a NPS 12 ASME/ANSI cl 272 kg joint.

(1) S Load Value	Gasket Stress
	MPa
S1	8
S2	20
S3	30
S4	40
S5	50
S6	60
S7	70
S8	80
S9	90
S10	105
S11	120
S12	140
S13	160

3.2.27 T_{pc} —first tightness value of the optional extended LP tests less than T_{pmin}

4. Summary of Practice

4.1 This test procedure consists of two parts (see [Fig. 1](#)):

4.1.1 *Part A*—At the fluid test pressure, obtain gasket leak rate and deflection measurements for several levels of gasket stress, each stress level being higher than any previously applied stress. Part A may be interrupted to perform Part B sequences (see [4.1.2](#)). Part A provides information on initial loading known as gasket seating and yields the constants G_b and a (see [3.1.3](#)).