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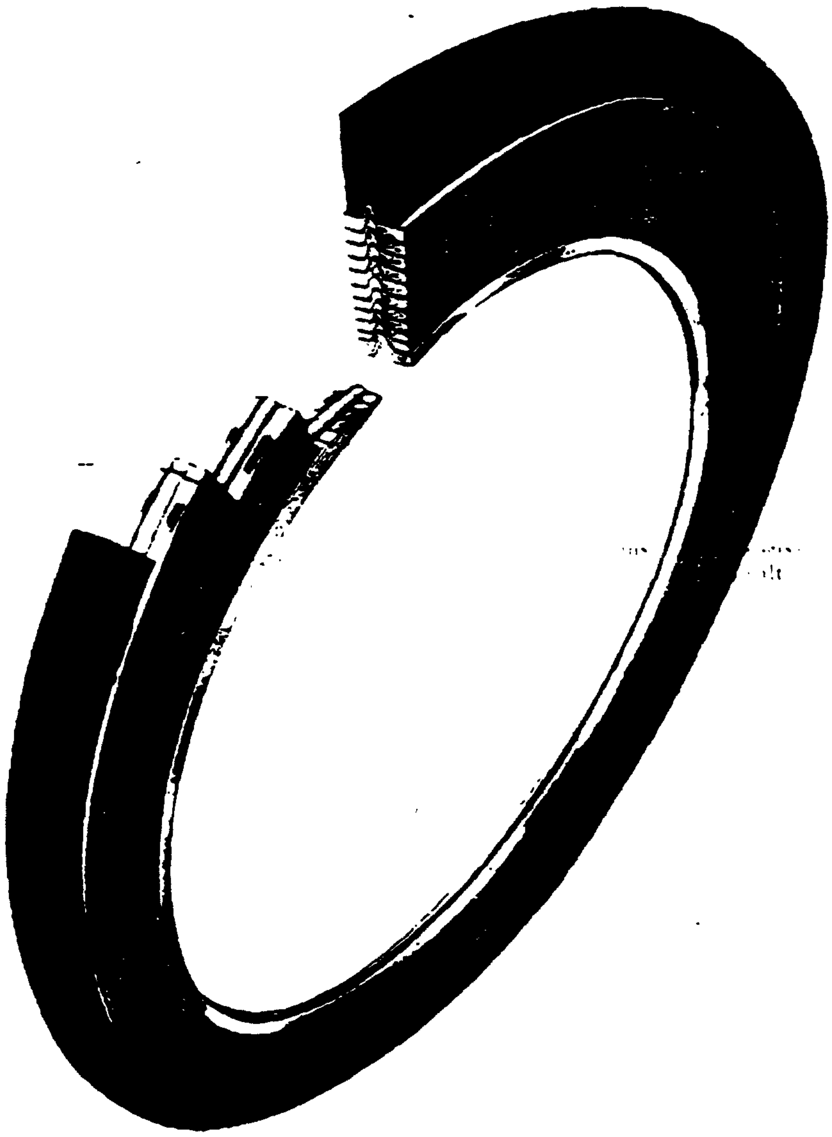
Flexitallic®

SPIRAL WOUND GASKETS
DESIGN CRITERIA



Flexitallic

SPIRAL WOUND GASKETS
DESIGN CRITERIA

INTRODUCTION

This paper has been prepared as the result of many requests received from design engineers, users and others for more detailed information on the design and use of FLEXITALLIC spiral-wound gaskets.

The concept of spiral-wound gasket construction was originated in 1912 by the FLEXITALLIC GASKET COMPANY. With the introduction of FLEXITALLIC gaskets, a new era in safe, effective sealing of joints was inaugurated. The versatility of this design concept is now attested by the wide range of successful applications, ranging from extremely high vacuums to pressures in excess of present flange standards of 2500 psi and from cryogenic temperatures to beyond 2000° F and against virtually every known corrosive media. The FLEXITALLIC design has not only kept pace with modern trends, but has been constantly in advance of such progress that combines materials and construction techniques which result in effective sealing that could not be achieved by any other known type of gasket.

Since 1912, the FLEXITALLIC GASKET COMPANY has had a record of steady growth and today is the largest organization in the world that exists solely to produce a spiral-wound gasket. Our entire efforts are directed toward producing for our customers, the highest quality and the most reliable gasket at competitive prices.

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WHAT IS A FLEXITALLIC GASKET

Gaskets are essentially a packing designed for inclusion between rigid parts of a fluid container in an essentially stationary relationship. A FLEXITALLIC gasket consists of laminated, preformed metal strips and filler materials selected to meet the conditions of service required. Its construction provides inherent resilience enabling it to follow flange movement within reasonable limits. Unfortunately, gaskets are all too often simply accepted per se, that is, "just another gasket." The irony of this is that one of the most costly and serious industrial problems today is leaky joints resulting in explosions, fires, loss of production and soaring maintenance costs. Much of this is due to insufficient attention to the proper application and design of closures and the gaskets that are used to effect the seal.

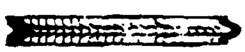
The FLEXITALLIC gasket is not "just another gasket." It is a specifically engineered product in the FLEXITALLIC program of continuous research and development in gasket design and production control to give you assurance of quality and safety.

It is our objective in the preparation of this bulletin to help prevent, through greater knowledge of the FLEXITALLIC gasket, the serious and costly waste of time, money and resources resulting from joint leakage. We trust the information contained herein will prove worthwhile and will benefit the equipment manufacturer, design engineer, and the user in sealing closures, whether high or low pressure, high or low temperature, and regardless of the nature of the corrosive media to be sealed.

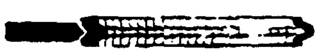
HOW FLEXITALLIC GASKETS ARE MANUFACTURED

A FLEXITALLIC gasket is manufactured by spirally winding a preformed metal strip and a filler on the outer periphery of metal winding mandrels. The winding mandrel outside diameter forms the inner diameter of the gasket and the laminations are continually wound until the required outer diameter is attained. Normal practice is to reinforce the inner and outer diameters with several plies of metal with no soft fillers being introduced. Our method of manufacture includes custom designed devices which provide control of gasket density that permit compression to the operating thickness under a specified load. This engineered product is thus "tailor made" to be compatible with the flanged closure in which it is to be used. For example, a closure designed for vacuum service may require a gasket of exactly the same dimensions as a closure designed for 1500 psi service. The closure designed for the vacuum service would have relatively light bolting indicating the necessity for a soft gasket, while the 1500 psi application would have heavy bolting indicating a relatively dense gasket. It is usually within our capability to satisfy both requirements. Refer to paragraph on "Flange Design for Flexitallic Gaskets."

AVAILABLE STYLES OF FLEXITALLIC GASKETS

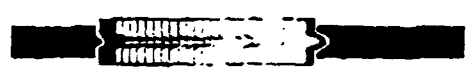


1. **Style R** — This designates a round spiral-wound gasket with no accessory devices added. The notations, R1, R3, and R4 in our catalog, apply to our standard gaskets only, so indicated for use on standard flanges. If a Style R gasket is to be used on a special flange design (other than ANSI or BS flange specification), the gasket is usually termed a **Special Style R**.



2. **Style RIR** — This is a round spiral-wound gasket fitted with an inner metal ring used to provide inner confinement to the gasket, to act as a compression stop if of the proper thickness, and to be used to fill the annular space between the flange bore and the gasket I.D. to minimize turbulence of process fluids and erosion of flange faces.

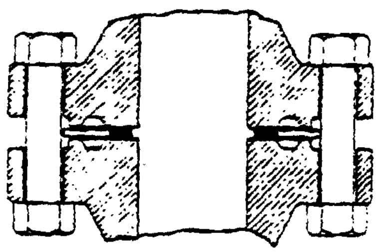
3. **Style CG** — A Style CG gasket is a round spiral-wound gasket with a solid metal or spiral-wound outer ring forming a complete assembly. A solid metal outer ring serves as a compression stop, anti-blowout device, and to properly center the gasket on the flange. A spiral-wound outer ring serves mainly as a centering device, and is normally specified where there is insufficient room for a solid ring.



4. **Style CGI** — This designates a CG gasket as above with the addition of an inner metal ring. The inner ring thickness is normally the same as the outer ring and serves to prevent material build-up between the flange bore and the gasket I.D., as a protection against excessive

heat, to reduce process fluid turbulence and to minimize erosion of flange facings. Style CGI gaskets are frequently used on vacuum service and for PTFE gaskets. This style eliminates costly machining in one of the flange faces if a totally contained gasket is required. A Style CGI gasket will effectively provide a totally contained gasket without the additional costly machining.

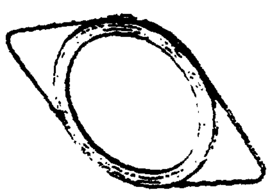
5. **Style CG-RJ** — This style designates a Special CG gasket sized to be used on standard ring joint flanges as noted in our catalog. The outer ring is dimensioned to cover the ring joint grooves and to prevent the spiral-wound portion from entering the groove. The spiral-wound portion of the gasket is sized to fit between the flange bore and the ring joint groove. This type of gasket should be used only as a maintenance repair item. If FLEXITALLIC gaskets are to be used in new construction, it is advisable to use standard raised face flanges and our Style CG gaskets.



6. **Style D** — This consists of a spiral-wound gasket with loops (usually 2) added to the O.D. of the gasket and dimensioned to fit over two diametrically opposite flange bolts for centering purposes. Style D gaskets are not generally recommended for use in applications where pressures are in excess of 600 psi. It is not as widely used or as popular as the Style CG gasket, with its outer metal ring functioning as a centering, anti-blowout device as well as a compression stop. The Style D gasket does lend itself to ease of assembly in areas of congested piping plus the fact that the standard Style D's are less expensive than the CG for the equivalent size and pressure rating.

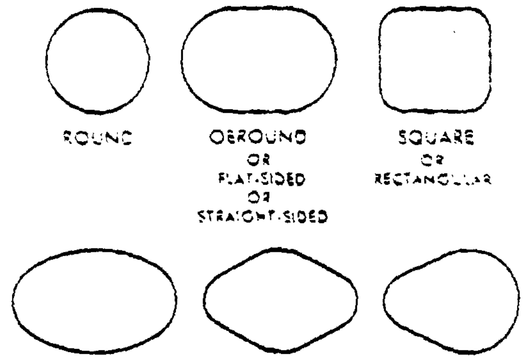
When Style D gaskets are required and are not standard catalog items, special winding mandrels must be purchased.

It should be noted, the spiral-wound portion of the Style D gasket is identical to the spiral-wound portion of a Style CG gasket in the same size and pressure series.

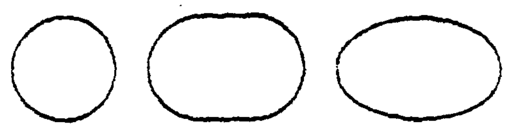


7. **Style T** — This designates gaskets for boiler handhole and tube cap assemblies. They are available in round, oval, obround, square, pear and diamond shapes. Refer to our general catalog for standard Style T gaskets.

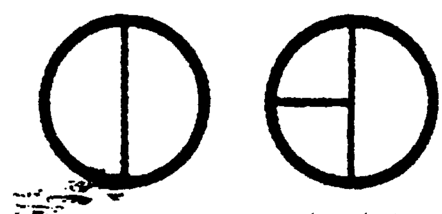
Please note Style T gaskets rely on internal pressure in the boiler to properly seat the gasket. This means, when a hydrostatic test is performed on the gasket, the pressure exerted against the plate will further compress the gasket — and it is necessary to tighten each nut to compensate for the additional compression of the gasket under load.



8. **Style M & MC** — These styles are designed for boiler manhole cover assemblies. They are usually of round, obround or oval shape, depending, of course, upon the manhole plate configuration. Style MC gaskets have a preformed spiral-wound centering ring snapped into the inner groove of the gasket proper. This centering guide permits the gasket to assume its correct position and to compensate for inequalities in plate contours and fillets in cold-pressed plates as well as to prevent shouldering and pinching caused by radial misplacement.



9. **Style HE** — Style HE gaskets are for heat exchangers where pass ribs are required. The outer portion is of standard spiral-wound construction, whereas the rib portion is normally of single or double-jacketed style, securely fastened to the I.D. of the spiral-wound portion.



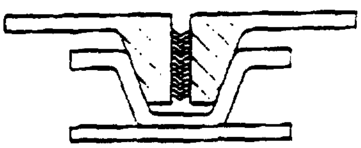
10. **Style HE-CG** — This style is identical to the Style HE above, except that it is fitted with an outer ring on the O.D.

Note — Style HE and Style HE-CG gaskets have a primary seal of spiral-wound construction with its inherent resiliency and excellent sealing quality. It is necessary that dimensional drawings locating the pass ribs and the configurations be submitted for all inquiries and orders for these style gaskets.

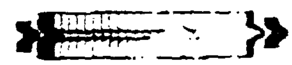
11. **Style HX*** — Style HX gaskets are suitable for standard heat exchanger flanges designed in accordance with BS 3274 and TEMA standards. The primary seal is a spiral-wound gasket construction which is fitted with a stainless steel outer wound guide so as to correctly locate the gasket in the flange recess. An inner compression stop ring is fitted and for the tubeplate to channel connection, a compressed asbestos fiber insert with pass partition bars is incorporated. Where working conditions demand it, the compressed asbestos fiber insert can be dispensed with and the pass partition bars can be supplied in metal asbestos or solid metal as part of the inner compression stop ring.

*Note — Submit application to Engineering Department

12. **Style 625** — Similar to Style R gaskets, except original thickness is .0625". Limited to small diameters and narrow flange widths. Most frequently used on clamp-type closures where an extremely thin gasket is required.



13. **Miscellaneous** — On rare occasions, applications for FLEXITALLIC gaskets arise where it is necessary to utilize a spiral-wound inner and/or outer ring. The spiral-wound inner or outer rings are used primarily as centering devices and are chosen in lieu of a solid metal ring, because of lower cost or because of limited space when the use of a solid metal ring would be prohibited because of the difficulty in fabrication.



Refer to our General Catalog for FLEXITALLIC gaskets available for standard flanges and common boiler handhole and manhole fittings.

CRITERIA FOR MATERIALS USED IN GASKET CONSTRUCTION

The selection of materials of construction for FLEXITALLIC gaskets requires consideration of the following aspects:

1. The corrosive nature and concentration of the fluid to be confined.
2. The operating temperature.
3. The expected life of the installation.
4. The relative cost of alternative materials.

Specific recommendations for materials of construction are beyond the scope of this paper. The resistance to corrosive attack by the various materials used in FLEXITALLIC gaskets fluctuates widely, depending upon the concentration of the corrosive agent, presence of other contaminates and the operating variables of temperature and pressure. Lacking specific experience with the corrosive nature of any particular agent and those materials that would have sufficient corrosion resistance to the media, designers are recommended to contact the manufacturers of alloyed materials, who have available extensive information on the chemical resistivity of their products to various corrosive media. Another excellent source of corrosion resistance is contained in "Corrosion Data Survey" published by the Association of Corrosion Engineers, Houston, Texas. It is frequently necessary to conduct laboratory corrosive tests and or pilot plant operations in order to obtain factual and reliable information.

When considering the choice of materials for FLEXITALLIC gaskets, designers should be guided by the following general comments:

1. Stress Corrosion — FLEXITALLIC gaskets, when installed, are highly stressed, particularly in the area of the engineered wire formation, and adjacent to the flange seating surfaces. The 18-8 stainless steels are particularly subject to stress corrosion or stress corrosion cracking when exposed to certain media. In such cases, alternative materials must be selected that are less susceptible to stress corrosion cracking.

2. Intergranular Corrosion — When austenitic stainless steels are subjected to temperatures in the range of 800° to 1500° F carbides are precipitated along the grain boundaries. When exposed to certain chemicals, intergranular corrosion will occur. A list of corrosives which induce intergranular corrosion are included in Appendix A. When handling these media, special attention to material selection is necessary.

3. Expected Life of the Installation — The trend in industry today is to lengthen the time between overhauls and consequently, the best possible material, regardless of initial cost, is frequently the most economical. Gaskets are relatively low cost items when compared to labor costs to install, downtime on equipment and loss of productivity, should premature failure occur. Hence, for "permanent" installations, the cost of special gasketing materials should be equated against increased productivity and reliability. The FLEXITALLIC GASKET COMPANY maintains a substantial inventory of a wide variety of metals and filler materials to meet specific operating conditions and requirements.

METAL WINDINGS

The following materials are normally inventoried to insure prompt delivery:

Type 304 Stainless Steel — This 18-8 Chromium-Nickel Steel is the most common metal used in the fabrication of FLEXITALLIC gaskets. It has excellent corrosion resistance to a wide variety of chemicals. It is, however, subject to stress corrosion cracking when exposed to certain media, and to intergranular corrosion at temperatures between 800° F and 1500° F in the presence of certain media. Under these conditions, alternative materials should be selected. Due to the precipitation of carbides along grain boundaries, its use is normally limited to a maximum continuous temperature of 800° F if any danger of the materials that would cause intergranular corrosion are expected to be present.

Type 347 Stainless Steel — The addition of columbium to this 18-10 Chromium-Nickel serves to keep carbides in solution, and hence, inhibits carbide precipitation along the grain boundaries. Type 347 Stainless Steel has corrosion resistant qualities comparable to Type 304 Stainless Steel. It is not as subject to intergranular corrosion as is Type 304 Stainless Steel, and can be used at continuous temperatures up to the 1400 — 1500° F range. Type 347 is subject to stress corrosion cracking, however, as is Type 304.

Type 316L Stainless Steel — The 2% molybdenum added to this 18-12 Chromium-Nickel alloy increases its creep strength at elevated temperatures. Carbon content is held at a maximum of .03% which inhibits the tendency toward carbide precipitation. Type 316L is subject to stress corrosion cracking and also to intergranular corrosion, but to a lesser degree than Type 304 Stainless Steel. Its continuous maximum temperature exposure would be in the range of 1400 — 1500° F.

Type 321 Stainless Steel — This austenitic Chrome-Nickel Steel is stabilized by the addition of Titanium, thereby eliminating carbide precipitation and consequently intergranular corrosion. The higher chromium content of this grade gives ~~improved oxidation~~ resistance and so it can be used at temperatures up to 1400 — 1500° F.

Type 304L Stainless Steel — This 18-8 stainless steel alloy has the same excellent corrosion resistance as does Type 304, but its carbon content is maintained at a maximum of .03%, which tends to reduce the precipitation of carbides along grain boundaries, and as a consequence, would be less subject to intergranular corrosion than is the Type 304 stainless steel. It is, however, subject to stress corrosion cracking.

Plated Low Carbon Steel — In FLEXITALLIC gasket construction, the use of this metal is normally limited to low pressure steam applications at maximum temperatures in the range of 500° F.

Monel Metal — This Nickel base alloy contains 67% Nickel and 30% Copper. It is widely used as a gasketing material due to its excellent resistance to most acids and alkalis, except the strong oxidizing acids. In combination with PTFE, it is widely used in FLEXITALLIC gaskets for hydrofluoric acid service. Maximum upper temperature limit for Monel metal is in the range of 1500° F. Monel metal is subject to stress corrosion cracking when exposed to fluorosilic acid, mercuric-chloride and mercury, and should not be used with these media.

Inconel 600 — This metal is a Nickel base alloy containing 77% Nickel, 15% chromium and 7% iron. It has excellent high temperature strength and can be used at temperatures up to the 2000° F range. Inconel 600 has little tendency toward stress corrosion cracking and is frequently used as a gasketing material to overcome this problem.

OTHER METALS AVAILABLE

MATERIAL	MAX. TEMPERATURE*
430 S.S.	1400, 1500° F
Carpenter 20	1400, 1500° F
Phosphor Bronze	500° F
Nickel	1400° F
Titanium	2000° F
Hastelloy C-276 & B	2000° F
Inconel X	2000° F
Copper	500° F
310 S.S.	1900° F

On special order, gaskets can be fabricated from gold, zirconium, platinum and tantalum.

*Maximum temperature ratings are based upon hot air at constant temperatures. The presence of contaminating fluids and cyclic conditions may drastically affect the maximum temperature range.

FILLER MATERIALS

1. **FLEXITE™** — A new, non-asbestos, chlorite mineral paper especially developed for use in FLEXITALLIC spiral-wound gaskets. The chlorites are a group of minerals with a layered structure, in many respects resembling the micas. The nominal composition of FLEXITE Filler (Patent Applied For) is: 90% minimum chlorite mineral, 2% — 5% nitrile latex binder, less than 1% green dye for identification, with balance cellulose pulp. In addition, the paper is coated with acrylic latex and a paraffinic wax. FLEXITE can be used at temperatures from cryogenic to +1050° F in steam, hydrocarbons, heat transfer fluids, alkaline solutions, solvents, aqueous and salt solutions, fuel oil, hydraulic oil, halogens, and general service in mild acids. It is available in all sizes, styles and pressure ratings, with compressibility and recovery being equivalent to asbestos filled spiral-wound gaskets.

FLEXITE Filler is tested for leachable chlorides and meets the 200 parts per million requirements for total soluble chlorides.

2. **Canadian Asbestos Paper** (Chrysotile) — Canadian Asbestos Paper is the most common filler material used in the fabrication of FLEXITALLIC gaskets. Canadian Asbestos is a hydrated magnesium-silicate. The form, as we use it, is composed of approximately 90% Canadian Chrysotile Asbestos, 7% vegetable rubber latex binder and 3% water-proofing binder. This material has poor acid resistance and strong mineral acids dissolve out all magnesia, leaving a residue of nearly pure insoluble silica. It does, however, show excellent resistance against alkaline solutions, such as sodium-hydroxide or caustic soda and can be used against solvents, aqueous and salt solutions, and gases (except oxygen). Canadian Asbestos has a very high melting point fusing at approximately 2770° F. However, it loses 11% by weight of water at 1100° F and about 13.5% at 1400° F. From this point to the fusion temperature, it has turned to a powder with very little tensile strength left. In spite of this, it can continue to produce a satisfactory seal since it is com-

pletely confined between the metal windings of the gasket and the seating surfaces of the flange.

Our standard Canadian Asbestos Paper contains .1% blue vegetable dye for identification purposes. This material is available without the dye added if the possibility of color contamination is a problem.

Note: All asbestos paper used by FLEXITALLIC GASKET COMPANY is tested for leachable chlorides and meets the 200 parts per million requirements for total soluble chlorides.

3. **Compressed Asbestos Fiber Type Special** — This is a grade of compressed asbestos fiber specially developed for use in spiral-wound gaskets. The homogeneous structure of the material allows it to more readily conform to the spiral-wound steel profile than conventional compressed asbestos fiber materials. The material contains an asbestos content of 70% and a binder content of 12%, this being a blend of NR and SBR. The material shows good performance in steam and hydrocarbon service at high temperatures.

4. **Polytetrafluoroethylene (PTFE)** — PTFE is used as a filler material in FLEXITALLIC gaskets where extreme chemical inertness is required for temperatures ranging from cryogenic to 500°F. PTFE is unaffected by any known chemicals except molten alkali metals and fluorine precursors. Because of its low permeability, PTFE is also frequently used as a filler material on FLEXITALLIC gaskets in vacuum applications. Gaskets wound with PTFE should be fully confined either by fitting in a groove or providing both an external and internal ring.

5. **Ceramic Fiber Paper** — Consists of aluminum silicate fiber with an organic binder. This material has excellent high temperature stability to 2300°F. It resists attack from most corrosive agents (except hydrofluoric and phosphoric acids) as well as concentrated alkalies.

6. **Flexicarb** — This material is a pure pyrolytic graphite with no binder which exhibits excellent resistance to a wide variety of chemicals. Flexicarb can be used in the temperature range from -350°F to 900°F in an oxidizing atmosphere and up to 6000°F in a reducing or neutral atmosphere*. Its unique combination of low permeability, inherent lubricity, and compressibility make Flexicarb suitable for critical gas services.

*Note — We suggest applications for oxidizing atmospheres be submitted to Engineering Department.

7. **Other Materials** — FLEXITALLIC gaskets are also available with various compressed asbestos sheet packings utilizing Buna S, Neoprene, or Buna N as a binder for special applications.

AVAILABLE GASKET SIZES AND MANUFACTURING TOLERANCES

TABLE I

Gasket Thickness	Maximum Inside Dimension	Maximum Flange Width	Recommended Compressed Thickness**
0.0625"	**Up to 6"**	**3/8"**	**0.050"/0.055"**
0.0625"	6" to 9"	1/4"	0.050"/0.055"
0.100"	**10"**	**1/2"**	**0.075"/0.080"**
0.125"	**Up to 20"**	**1"**	**0.090"/0.100"**
0.125"*	20" to 40"	3/4"	0.090"/0.100"
0.175"	**Up to 40"**	**1"**	**0.125"/0.135"**
0.175"*	40" to 60"	1"	0.125"/0.135"
0.175"*	60" to 70"	7/8"	0.125"/0.135"
0.175"*	70" to 75"	3/4"	0.125"/0.135"
0.250"	**90"**	**1"**	**0.180"/0.200"**
0.285"	**185"**	**1"**	**0.200"/0.220"**

Note 1 — Preferred size range in relation to thickness shown in bold type.

Note 2 — *PTFE filled FLEXITALLIC gaskets in this size range are unstable and are subject to "springing apart" in shipping and handling. Specify next gasket thickness up.

Note 3 — **The recommended compressed thickness is what experience has indicated to be the optimum range in order to achieve maximum resiliency of the gasket. An additional spread of .010" in either direction may be tolerated on all gasket thicknesses with the exception of the .0625 and the .100" thick gasket. This is on the assumption that the flange surface finishes are relatively smooth. Refer to "Flange Surface Finish" on page 10. When attempting to contain hard to hold fluids, or pressures above 1000 psi, it is suggested that compression be maintained at the lower range of the recommended compressed thickness.

FLEXITALLIC gaskets are available in sizes from 3/8" I.D. to approximately 185" I.D. depending upon gasket thickness. Table I indicates size ranges available in various thicknesses, maximum flange widths and the recommended compressed thickness.

FLEXITALLIC gaskets are subject to standard manufacturing tolerances listed in Table II. If tighter tolerances are required, consult our Engineering Department.

TABLE II

Gasket Diameter	Inside Diameter	Outside Diameter
Up to 10"	± 1/64"	± 1/32"
10" to 24"	± 1/32"	± 1/16"
24" to 60"	± 3/64"	± 1/16"
60" & Above	± 1/16"	± 1/16"

Tolerance on gasket thickness is plus 0.010", minus 0.005" (measured across metal winding) on all thicknesses.

SIZING SPIRAL-WOUND COMPONENTS FOR FLEXITALLIC GASKETS

Regardless of the type of flange facing in use. FLEXITALLIC gaskets must be sized to insure the spiral-wound element is seated against a flat surface. This is of utmost importance. If the spiral-wound element protrudes into the flange bore or extends beyond a raised face, mechanical damage will occur to the gasket during initial compression, and ultimate failure will result. In addition, should the gasket protrude into the flange bore, the windings can possibly enter the process stream with severe damage to other equipment resulting. With recessed flange facings, limiting dimensions of the gasket are established by dimensions of the groove. On flat or raised face flanges, considerable leeway is available. Note that due to radial growth and clearance requirements, spiral-wound gaskets are normally sized differently than other types of gaskets. The following rules will be generally applicable for limiting dimensions of spiral-wound components.

1. **Gasket confined on both I.D. & O.D.** — This is the type facing encountered in tongue and groove joints, and groove to flat joints. Standard practice is to allow 1/16" nominal diametrical clearance between the I.D. of the groove and the I.D. of the gasket and 1/16" nominal diametrical clearance between the O.D. of the gasket and the O.D. of the groove.*

2. **Gasket confined on the O.D. only** — This is the type of facing encountered with male and female facings and female to flat facings. Standard practice is to allow 1/16" nominal diametrical clearance between the O.D. of the gasket and the O.D. of the groove.* If possible, allow a **minimum** 1/4" diametrical clearance between the I.D. of the seating surface and the I.D. of the gasket.

*Note — 1/16" nominal O.D. clearance for gaskets up to 60" O.D.; from 60" O.D. to 80" O.D., allow 5/64", above 80" O.D., allow 3/32" nominal O.D. clearance.

3. **Gasket unconfined on both the I.D. & O.D.** — Allow a minimum 1/4" diametrical clearance between the gasket I.D. and the I.D. of the seating surface. The O.D. should be kept as close as possible to the bolt circle to minimize flange bending moments. If the gasket is used with raised face flanges, allow a minimum 1/4" diametrical clearance between the gasket O.D. and the raised face O.D. and determine the I.D. on the basis of the desired flange width. **Important** — Please note the above rules establish general limits for sizing FLEXITALLIC gaskets. It is frequently necessary to adjust dimensions in order to achieve a proper balance between gasket area and bolt area to maintain a reasonable compressive force on the gasket and a minimum gasket factor "m" of three. Please refer to section covering ASME Boiler and Pressure Vessel Code.

4. **Metal Gauge Rings** — When Flexitallic gaskets are required to be equipped with outer metal rings or with inner metal rings, limitations on the minimum flange widths of the solid metal ring are necessary due to the availability of machining facilities and rigidity of completed assemblies. Table III indicates the minimum flange width for solid metal rings based on the ring I.D.

TABLE III

Diameter of Ring	Minimum Flange Width*
Up to 10" Inside Diameter	3/8"
10" to 24" Inside Diameter	7/16"
24" to 50" Inside Diameter	1/2"
50" to 70" Inside Diameter	5/8"
70" and Larger	3/4"

*Note — Where space is limited and narrower flange widths are necessary, it may be possible to supply inner and outer spacer rings of metal spiral-wound construction. Consult our Engineering Department for advice.

Standard practice is to size outer rings with the outside diameter equal to the diameter of the bolt circle less the diameter of one bolt for rings up to 60" O.D. Above 60" O.D., rings are sized to the diameter of the bolt circle less the diameter of one bolt **hole**. Inner rings are normally sized with an outside diameter equal to the flange bore plus 1/8".

5. **Non-Circular Gaskets** — FLEXITALLIC gaskets can be fabricated in non-circular shapes within limitations. As a general rule, if the ratio of the long I.D. to the short I.D. exceeds 3 to 1 and should any of these sides approach a straight line, it may not be possible to manufacture a FLEXITALLIC gasket that would be suitable. Our product requires a definite radius or curvature to give it inherent strength and stability and to prevent it from springing apart. Any application requiring a non-circular gasket should be submitted to our Engineering Department for review to determine the feasibility of producing a satisfactory gasket as early as possible in the design stage.

The comments above relating to availability of sizes and recommended clearances for proper sizing of FLEXITALLIC gaskets are general in nature. Many applications will arise where the recommended clearances are impractical due to space limitation on the flange. Frequently, clearances between gasket sealing member and grooves must be reduced in order to effectively maintain a seal under operating conditions, particularly when the higher pressures are encountered. Under such circumstances, FLEXITALLIC GASKET COMPANY engineers should be consulted prior to finalizing designs.

BASIC GASKET DESIGN FACTORS

The same basic fundamentals of FLEXITALLIC spiral-wound gasket design and construction that have been used successfully for ANSI flanges have been extended to cover a wide range of applications in installations for which there were no industry-wide equipment standards. When special joint assemblies are designed in which spiral-wound gaskets can be applied, FLEXITALLIC'S variable compression characteristics and wide range of materials embodied in gasket construction can usually be adapted to solve all problems related to achieving a satisfactory joint assembly.

The designing of a spiral-wound gasket can be compared to the design problem of a heavy-duty spring supporting a compressive force. Both are structures engineered to withstand calculated loads and shock. In the design of any gasket, the gasket engineer must consider three factors: type of joint, bolting load and operating conditions.

Type of Joint. The joint design is the basis for determining the gasket thickness as well as the inside and outside dimensions. The gasket is dimensioned so that it is totally confined between two flat faces without any overhang and is proportioned to the joint in which a safe seal is to be made.

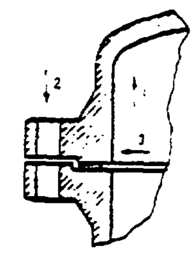
Bolting Load. The available compressive force is the basis for calculating the density of the gasket structure to support specific bolt loading.

Operating Conditions. As the basis for specifying gasket materials, consideration is given to the nature of the confined fluid, temperature and pressure of the fluid, thermal shocks, vibration, abrasion, erosion and corrosion.

Selection of a suitable joint assembly is the function of the piping or pressure vessel designer. FLEXITALLIC gasket design is coordinated closely with a wide range of joint assemblies. Whether a joint assembly is designed originally for soft sheet packings or for high load values requiring harder gaskets, the proper FLEXITALLIC construction can usually be selected to meet the requirements.

When a joint assembly is placed in service, three basic forces become active and affect its sealing qualities.

1. **End Force** — which originates with the pressure of confined gases or liquids and tends to separate the flange faces.
2. **Gasket Load** — the function of bolting or other means which applies force upon the flange faces to compress the gasket.
3. **Internal Pressure** — which tends to move, permeate or bypass the gasket.



Because these forces are operating variables in any joint assembly, a gasket of resilient construction, such as the FLEXITALLIC construction, is more suitable for the variable conditions than is a gasket of solid construction which cannot adjust to the varying conditions.

The chart below illustrates an interesting study in gasket design. A FLEXITALLIC Style CG Gasket for use with a 6" raised face flange assembly is described. For each series considered, the gasket contact area is the same, but the bolting varies with each series. With bolting calculated at a constant stress of 30,000* lbs. per sq. in., the resulting unit gasket loads vary. A constant terminal thickness is retained within the elastic limits of the gasket body by designing a specific construction for each case. This is determined by FLEXITALLIC engineers. This procedure is of the utmost necessity.

It is imperative that FLEXITALLIC engineers be furnished complete and accurate flange design data to ensure that the gasket construction is correct.

This chart below illustrates the variable compression characteristics FLEXITALLIC can design into their spiral-wound gaskets with identical I.D. and O.D. dimensions. Similar variable constructions can be provided for most sizes and materials.

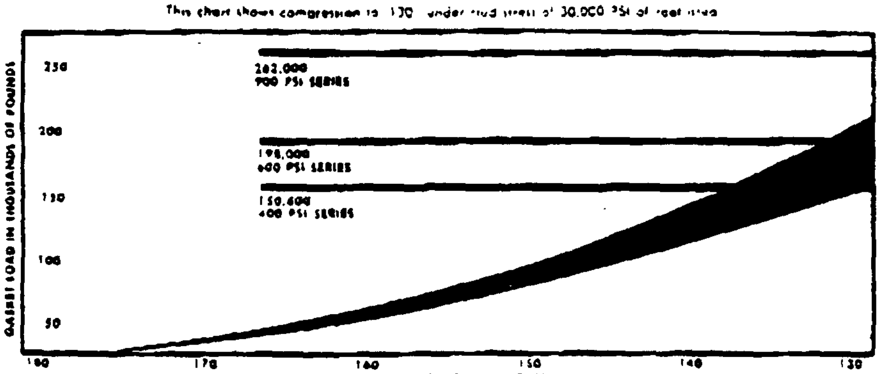
*Stress of 30,000 psi is well within the yield point of low alloy bolting but is sometimes equal to or above the yield points of 18-8 Cr. Ni and other austenitic steels. When low yield point metal is employed either for flanges or bolts, special gasket construction may be necessary, for which reason, when such metal is used, FLEXITALLIC engineers should be consulted.

CHART NO. 1
GASKET COMPRESSION CHARACTERISTICS

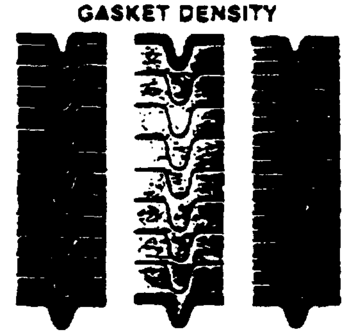
Based on Construction Designs Developed to Meet API Bolting Standards

6" Style CG Gasket
Contact Area 14.7 Square Inches
Original Gasket Thickness .0175

This chart shows compression to .130" under stud stress of 30,000 PSI of root area



GASKET DENSITY



The service conditions under which a FLEXITALLIC spiral-wound gasket is expected to hold its seal dictate the density of the gasket. Gaskets that have identical inside and outside diameters can be either hard or soft as shown above. The available compressive force is the basis for calculating the density of the gasket structure to support specific bolting loads.

FLANGE SURFACE FINISH

FLEXITALLIC gaskets rely on the combined reaction of the metal and filler material to effect a seal. When the gasket is compressed, the filler material flows into minute imperfections and the metal serves to completely trap the filler material and provide the necessary strength and resilience to the gasket assembly. Obviously, the deeper the serrations, or the rougher the flange surface finish, the higher the force required to flow the gasket into the imperfections. Although FLEXITALLIC gaskets may seal against virtually any commercial flange surface finish, abnormally high bolt loads may be required to obtain a seal against rough flange finishes, while exceptionally smooth surfaces may destroy the inherent resiliency of the gasket. Surface finish is one of the major factors to consider when attempting to seal a joint with a FLEXITALLIC spiral-wound gasket! Surface finish as specified in ANSI B16.5 (1981) has proven satisfactory under a wide range of service conditions. ANSI B16.5 specifies a circular lay (either concentric or phonographic) produced by a .06 minimum radius round nose tool. The resultant surface finish shall be 125 to 500 AARH. For difficult service conditions dictated by low specified leak rates, light gas sealing, narrow gaskets or minimal available bolt load, FLEXITALLIC recommends tighter limits be considered. Optimum results have been obtained with a finish as described in ANSI B16.5, with the resultant surface limited to the 125 to 250 AARH range. Surface finishes significantly smoother than 125 AARH can present a sealing problem. A spiral-wound gasket may creep or slide radially on a smooth finish if unconfined by a groove or inner and outer rings.

Important — Under no circumstances should flange sealing surfaces be machined in a manner that tool marks would extend radially across the sealing surface. Such tool marks are practically impossible to seal regardless of the type of gasketing material used.

ASME BOILER AND PRESSURE VESSEL CODE CALCULATIONS

Section VIII, of the ASME Boiler & Pressure Vessel Code, establishes criteria for flange design and suggests values of "m" (gasket factor) and "y" (minimum gasket seating stress) as applied to spiral-wound gaskets. For the most part, the defined values have proven successful in actual applications. However, much confusion exists regarding these values, primarily due to a misunderstanding of the definitions of the terms and their significance in practical applications.

Mandatory Appendix II, in Section VIII of the Boiler Code, requires in the design of a bolted flange connection, complete calculations shall be made for two separate and independent sets of conditions.

1. Operating Conditions

Condition one (1) requires a minimum load be determined in accordance with the following equation:

$$(1)\quad W_{m1} = \frac{3.14G^2P}{4} + 2b\ 3.14GmP$$

This equation states the minimum required bolt load for operating conditions is the sum of the hydrostatic end force plus a residual gasket load on the contact area of the gasket times a factor times internal pressure. Stated another way, this equation requires the minimum bolt load be such that it will maintain a residual unit compressive load on the gasket area that is greater than internal pressure when the total load is reduced by the hydrostatic end force.

It should be noted that Table UA-49.1 suggests a gasket factor "m" for a spiral-wound gasket of 2.5 for carbon steel and 3.0 for stainless or monel. It is important to note the gasket factor "m" is suggested and is not mandatory.

Note — See paragraph on gasket factor "m" on page 11 for a more detailed discussion.

2. Gasket Seating

Condition two (2) requires a minimum bolt load be determined to seat the gasket regardless of internal pressure and utilizes a formula:

$$(2)\quad W_{m2} = 3.14bGy^*$$

The "b" in this formula is defined as the effective gasket width and "y" is defined as the minimum seating stress in psi that depends upon the type of gasket material. Table UA-49.1, Section VIII of the Boiler Code suggests a minimum "y" value for a spiral-wound gasket of 10,000 psi (Winter 1976 Addenda). These design values are suggested and not mandatory.

The term "b" is defined as:

$$b = b_0 \text{ when } b_0 \leq 1/4" \qquad b = \sqrt{\frac{b_0}{2}} \text{ when } b_0 > 1/4"$$

In the case of a spiral-wound gasket, $b_0 = \frac{N}{2}$ in all cases where N is the radial flange width of the spiral-wound portion of the gasket.

*Note — In applications where W_{m2} exceeds W_{m1}, we suggest that the actual gasket seating stress be determined as calculated in equation (3). If S_g is less than 6000 psi, we suggest contacting our technical service department.

After W_{m1} and W_{m2} are determined, the minimum required bolt area, A_m is determined as follows:

$A_{m1} = \frac{W_{m1}}{S_b}$ where S_b is the allowable bolt stress at operating temperature, and $A_{m2} = \frac{W_{m2}}{S_a}$ where S_a is the allowable bolt stress at atmospheric temperature.

Then A_m is equal to the greater of A_{m1} or A_{m2}. Bolts are then selected so the actual bolt area, A_b, is equal to or greater than A_m.

At this point, it is important to realize the gasket must be capable of carrying the entire compressive force applied by the bolts when prestressed unless provisions are made to utilize a compression stop in the flange design or by the use of a compression gauge ring. For this [illegible] the gasket [illegible] optimum operating [illegible]

[illegible] ... the value [illegible] within the [illegible] range indicated in Ta[illegible]. If the values determined are greater than those listed, either a wider gasket is required or [illegible] must be utilized.

*NOTE — If a prestress greater than S_g is to be used (as is normal practice in order to successfully pass a hydrostatic test) the actual prestress value will be used in lieu of S_g in equation (3).

GASKET SEATING STRESS — "y"

FLEXITALLIC'S past position regarding the unrealistic low value of "y", as defined in Table UA-49.1 has been recognized by the Winter 1976 Addenda change to [illegible],000 psi minimum (formerly "y" = 2500 psi for [illegible] steel and "y" = 4500 psi for stainless steel). Our [illegible] value is [illegible] designs utilizing FLEXITALLIC gaskets. Table IV can be used as a guide to "y" (minimum seating stress) and S_g (actual stress).

The actual seating stress is a function of flange surface finish, gasket material, density, thickness, fluid to be sealed and allowable leak rate.

Rough or irregular flange finish, difficult to contain fluids and specified low allowable [illegible] will indicate the need for different "y" values. [illegible] work to determine the effect of these variables is indicated and is presently being sponsored by a sub-group of the Pressure Vessel Research Committee, Welding Research Council.

Work is also being done to this end by ASTM Committee F-3 and Flexitallic Gasket Company. S_g and "y" are normally considered to be the unit load required

GASKET FACTOR "m"

Appendix [illegible] Section VIII of the Boiler Code under paragraph UA-49 makes the statement "the m factor is a function of the gasket material and construction." We do not agree entirely with this interpretation of "m". Actually, the gasket does not create any forces and can only react to external forces. We believe a more realistic interpretation of "m" would be "the residual compressive force exerted against the gasket contact area must be greater than internal pressure when the compressive force has been relieved by the hydrostatic end force." It is the ratio of residual gasket contact pressure to internal pressure that must be greater than unity otherwise leakage would occur. It follows then, the use of a higher [illegible] result in a closure design with a greater factor of safety. Experience has indicated a value of 3 for "m" is satisfactory for flanged designs utilizing FLEXITALLIC gaskets regardless of the materials of construction.

In order to maintain a satisfactory ratio of gasket contact pressure to internal pressure, two points must be considered. First, the flanges must be sufficiently rigid to prevent unloading the gasket due to flange rotation when internal pressure is introduced. Secondly, the bolts must be adequately prestressed.

The Boiler Code recognizes the importance of prestressing bolts sufficiently to withstand hydrostatic test pressure. Appendix S, in the Code, discusses this problem in detail.

NOTATIONS

- A_b = Actual total cross-sectional root area of bolts or section of least diameter under stress; square inches.
- A_m = Total required cross-sectional area of bolts, taken as greater of A_{m1}, or A_{m2}; square inches.
- A_{m1} = Total required cross-sectional area of bolts required for operating conditions; square inches.
- A_{m2} = Total required cross-sectional area of bolts required for gasket seating; square inches
- b = Effective sealing width; inches.
- $2b$ = Joint-contact-surface pressure width; inches
- b_o = Basic gasket seating width; inches.
- G = Diameter of location of gasket load reaction; inches
- m = Gasket factor.
- N = Radial flange width of spiral-wound component; inches.
- P = Design pressure; psi.
- S_a = Allowable bolt stress at atmospheric temperature; psi
- S_b = Allowable bolt stress at design temperature; psi
- W = Flange design bolt load, pounds.
- W_{m1} = Minimum required bolt load for operating conditions, pounds.
- W_{m2} = Minimum required bolt load for gasket seating; pounds
- y = Minimum gasket seating stress; psi
- S_g = Actual unit stress at gasket bearing surface; psi
- d_o = Outside diameter of gasket, inches.
- d_i = Inside diameter of gasket, inches

FLANGE DESIGN FOR FLEXITALLIC GASKETS

1. Determine the required bolt load for operating conditions W_{m1}, Equation (1). (Approximate gasket size by referring to Table I, and use an "m" value equal to three.)
2. Determine the required bolt load to effect a seal (W_{m2}) by solving Equation (2). Use a minimum seating stress "y" per Table IV.
3. Determine the minimum bolt area by dividing W_{m1} by the allowable bolt stress at operating temperature and by dividing W_{m2} by the allowable bolt stress at atmospheric temperature. The greater of these two values becomes Am, the minimum bolt area. Select the number and size of bolts that will give an actual total cross-sectional area equal to or greater than Am.
4. Substitute the larger W_{m1} and W_{m2} into the numerator of Equation (3) and solve for "S_g". If "S_g" falls within the ranges shown on Table IV, a FLEXITALLIC gasket can be designed to [illegible]. If the resulting S_g is greater than the maximum [illegible] in Table IV, it is necessary to provide a compression stop either by utilizing a ring on the inside or the outside of the gasket or by designing into the flange, a compression stop that would bring the flanges metal to metal.
5. If W_{m2} is substantially greater than W_{m1} resulting in a greater bolt load than required for operating conditions, it is possible to reduce W_{m2} by reducing the flange width of the gasket. If this is the case, we suggest you contact FLEXITALLIC engineers for recommendations as to minimum flange widths for the diameter and pressure temperature conditions.
6. Proceed strictly to the flange design procedures in Appendix II of the Boiler Code.
7. After all flange dimensions have been determined, determine flange rotation at the gasket interface at test conditions. If the flange rotation is excessive, extraordinary precautions must be taken to insure a satisfactory hydrostatic test. (Refer [illegible] covering "Bolting Up Procedures.")

[illegible]

ORDERING FLEXITALLIC GASKETS FOR SPECIAL FLANGE DESIGNS

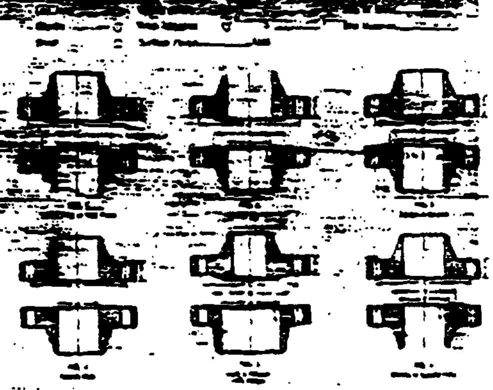
In order for the FLEXITALLIC GASKET COM-[illegible]

[illegible]

6. Hydrostatic Test pressure
7. Initial bolt pre-stress
8. Customer preference on gasket materials

FLEXITALLIC supplies engineering [illegible] at no cost on which this information may be submitted.

As a gasket manufacturer, it is impossible for us to review every flange design to ascertain that flange rotation and flange stresses are within allowable limits defined in the Code. We proceed on the assumption the design engineer has followed the design criteria established by the ASME Boiler Code and that the flanges are sufficiently rigid under the most severe condition to preclude the possibility the gasket could become unloaded either during operating conditions or hydrostatic test conditions. We are aware that most flange designers do not take into consideration flange rotation at test conditions. This is a very important aspect that is not normally considered and we urge every flange designer to check out flange rotation at test conditions prior to finalizing his design. We also, of a practical necessity, must assume the bolt material being used is adequate for all conditions including operating pressure at operating temperature and hydrostatic test pressure at ambient temperature. The use of the optimum material for bolts is a very complex subject and we suggest ASME paper, number 52-PET-7 entitled "Modern Steel Bolting for Piping & Pressure Vessels", authored by C. M. Vogrin, Frank S. G. Williams and John S. Worth, be consulted for guidance in the proper selection of bolting material for piping and pressure vessel applications.



BOLTING-UP PROCEDURES

FLEXITALLIC GASKET COMPANY supplies thousands of different gaskets for special flange designs [illegible] that must successfully pass a hydrostatic test and maintain a satisfactory seal under operating co[illegible]s. Our experience has indicated that virtually every time a leaky joint is encountered, the actual cause [illegible] relates to something other than the gasket design. Some of these causes are itemized below:

1. On low pressure applications, flange designers have followed the Code suggestions for a minimum [illegible] stress (y value) that we know from experience are impractical and hence, neither the bolting nor the [illegible] of the flanges are adequate to initially seat the [illegible] obtain a seal.
2. Flange designers do not take into consideration [illegible] rotation of the flanges, and the necessity for the flanges and the bolting to maintain a sufficiently high residual unit load on the gasket contact surface to contain internal pressure.
3. The insistence of some inspection personnel that hydrostatic test conditions must be carried out at stress values for initial pretensioning of bolts at the allowable design stresses specified in the Code. Appendix S, in the Code, specifically covers this area and must be taken into consideration anytime a hydrostatic test is to be performed. From a practical standpoint, when a flange is designed for pressure conditions of 600 psi and the hydrostatic test pressure is to be performed at 900 psi, it is obvious that a higher prestress must be applied to the bolts if a satisfactory test is to be achieved.
4. The use of low yield bolting material, such as the austenitic stainless steels or ordinary carbon steel machine bolts. With both of these materials, it is relatively easy to stress the bolts beyond their yield point with eventual failure occuring using a standard wrench for the nominal bolt diameter. In order to successfully pass a hydrostatic test, it is often desirable and permissible to utilize a high strength alloy bolt for hydrostatic testing purposes. When this procedure is followed, the following steps are recommended:
   a. For hydrostatic testing, use ASTM B 193, Grade B 7 bolting material, or equivalent, to initially seat the gasket and perform the hydrostatic test.
   a. After achieving a successful hydrostatic test, relieve the tension on the bolts to approximately 50% of the allowable bolt stress and replace the bolts one at a time with the required bolting material.
   c. When replacement is made, the bolts should be stressed to the allowable stress for operating conditions.
5. On high temperature applications, considerable relaxation of bolt stress can occur due to creep of the bolt material. The level of relaxation depends upon the bolt material and the temperature to which the bolt is subjected. In applications where a bolt is operating near the upper extremity of its recommended temperature range, it is highly feasible that the relaxation will be so great that leakage will occur after a period of time on a flange that has successfully passed the hydrostatic test. It is therefore essential to prestress a bolt to a degree that will guarantee maintenance of a stress level at operating conditions that will ensure a leak-tight joint.
6. As previously discussed under the heading of "Flange Surface Finish", the ability of a gasket to seal depends, to [illegible] degree, on the condition of the flange face. [illegible]ar attention should be given to the recommendations detailed under this heading.

THERMAL EXPANSION

[illegible]lts are initially prestressed, consideration [illegible]n to stresses induced by thermal expansion [illegible]ating conditions. In extreme cases, when [illegible]pansion is a serious problem and excessive bolt stresses or gasket loading can result, it may be practical for the gasket to be compressed only to a point that will permit further compression of the gasket as the loading due to thermal expansion is applied. **This is not a recommendation by FLEXITALLIC, but rather a suggestion to be considered in extreme cases by the designer.**

DEVELOPING PRESTRESSES IN BOLTING

In order to achieve and maintain a seal on a flange connection, it is extremely important to provide adequate bolt stress to meet both operating and hydrostatic test conditions. Although the correct level of bolt stress can be determined as detailed under the section headed "ASME Boiler and Pressure Vessel Code Calculations" and with due consideration to the comments already made in this section, it is the inability to adequately achieve the correct level of stress that is another common cause of joint leakage.

The most frequent method of stressing bolts is by utilizing torque wrenches. The use of torque wrenches, however, introduces many variables, and are not normally reliable methods of determining the actual bolt stress developed. Some of the factors that enter into the actual developed bolt stress are:

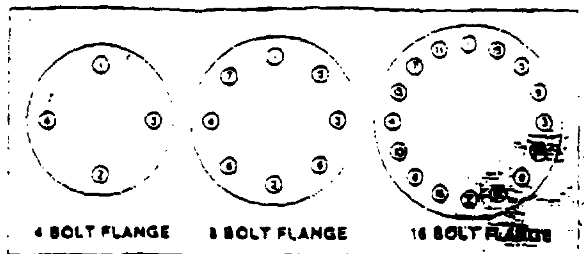
1. The class of fit of the bolt and nut
2. Presence of burrs
3. The degree of lubrication achieved
4. The presence of grit, chips and dirt in the threads in the bolt and nut
5. Nicks
6. The relative condition of the seating surface on the flange against which the nut is rotated

All of these variables have a marked effect on the amount of torque required to produce a given stress. When conditions are fairly constant and reasonably controlled, it is possible to give nuts a certain torque value and obtain stresses that are constant within reasonable limits. The tables on page 15 reflect the results of many tests to determine the relationship between torque and bolt stress and the values are based on steel bolting well lubricated with a heavy graphite and oil mixture. It is important to realize, however, that any deviation in lubrication will have a considerable effect on the [illegible] bolt stress. For example, if the given torque values are applied to a [illegible] lubricated bolt, the resultant bolt stress [illegible] by as much as 30% of that given in the table. [illegible] lubricated with a [illegible] molybdenum disulphide grease may be stressed to higher levels than those indicated on applications of the recommended torques.

In order to effect a seal, it is a requirement of any gasketed joint to apply an even compressive force. From a practical standpoint, in order to achieve this, a very definite bolt-up procedure must be followed when tightening a flange using torque methods. This procedure is detailed as follows.

1. Install the gasket on the gasket seating surface and [illegible] the cover flange into contact with the gasket.
2. Install all bolts, making sure they are free of dirt and grit, and are well lubricated.
3. Run-up all nuts finger tight.
4. Develop the required bolt stress in a minimum of four stages following a tightening up procedure as recommended in Sketch I. It is important to make certain that no more than 30% of the required bolt stress is achieved on the initial set. Should this occur serious damage can be done to the FLEXITALLIC gasket and subsequent [illegible] cannot offset the damage. After following this [illegible] final tightening should be performed in a clo[illegible] bolt-to-bolt seque[illegible] all bolts ha[illegible] evenly stressed.

[illegible] following the above seq[illegible] compressive force can be exerted [illegible] of the varying frictional co[illegible] bolts and the fluctu[illegible] in s[illegible] of [illegible] which occur as the bo[illegible] indivi[illegible] tightened around a flange, the final level of stress in all bolts around



SKETCH I - BOLTING-UP SEQUENCE

the flange can vary considerably. Even under ideal conditions where all bolts have been lubricated to the same degree and the recommended bolting-up sequence is followed using controlled torques, tests have shown that the final stress levels in bolts around a flange can vary as much as plus or minus 20% from the average. If the bolts are stressed by an uncontrolled method, e.g., hammer watches, etc., then the final stress levels in bolts around the flange will vary enormously.

BOLT TENSIONING

In view of these inaccuracies associated with torque wrenches, it may be pertinent to consider a more accurate method of prestressing bolts on flanges which continually suffer from leakage problems or flanges where it is critical to maintain a seal from a safety standpoint. One method of stressing bolts, which is independent of varying frictional [illegible] conditions, is the use of hydraulic bolt tensioning equipment. In addition to prov[illegible] developing indiv[illegible] equipment [illegible] all or ma[illegible] simultaneou[illegible] urate levels that an[illegible] on the gasket, there[illegible] enhancing the joint's ability to withstand [illegible]. Details of [illegible] equipment [illegible] Park, Texas, plant.

A FLEXITALLIC spiral-wound gasket will provide a reliable seal if properly installed in the application for which it was designed. Please remember that the performance of FLEXITALLIC spiral-wound gaskets is not solely dependent on the gasket itself but on a combination of variables, many of which are outside the control of FLEXITALLIC. If joint leakage or failure occur during test or subsequent use, it is most often due to something other than failure of the gasket. If leakage does occur, the following items should be checked:

1. Is the correct new gasket being used?
2. Are flanges clean and true, and free of surface damage?
3. Do flanges have the correct surface finish?
4. Are nuts and bolts of the correct material, and well lubricated?
5. Has a proper bolt-up procedure been followed and sufficient preload applied?

If you have any problems, contact our technical service department — they are there to assist you! Please have the following information available when calling:

a. style, dimensions, and materials of gasket
b. flange details, i.e., dimensions, bolting data, etc.
c. application details, i.e., pressure, temperature, medium being sealed

The information contained in this bulletin is not to be taken as a warranty or representation for which we assume legal responsibility. It is offered solely for your consideration, investigation, and verification.

Comments, criticisms, and discussion on its contents are cordially invited. Please write Flexitallic Gasket Company Inc., P.O. Box 848, Bellmawr, New Jersey 08031, U.S.A., or Flexitallic Gaskets Ltd., Station Lane, Heckmondwike, Yorkshire, England.

The authors are appreciative of the assistance freely given by their co-workers and others outside the company in preparing this bulletin and the extremely helpful suggestions and criticisms offered.

CAUTION — We shall be under no liability for loss, damage or injury incurred by any person and resulting directly or indirectly from incorrect processing or use of asbestos based products sold by us.
In drawing your attention to the dangers to health from exposure to asbestos dust or fibers, we would point out that most of our products containing asbestos fibers are produced with bonding agents, coatings or binders that render them safe for normal handling and usage.

CHART NO. 2

TORQUE DATA FOR USE WITH MACHINE BOLTS AND COLD ROLLED STEEL STUD BOLTS

Load in Pounds on Bolts and Stud Bolts when Torque Loads are Applied

NOMINAL DIAMETER OF BOLT	NUMBER OF THREADS	DIAMETER AT ROOT OF THREAD	AREA AT ROOT OF THREAD	STRESS					
				7,500 PSI		15,000 PSI		30,000 PSI	
(Inches)	(Per Inch)	(Inches)	Sq. Inch	Torque Ft/Lbs.	Compression Lbs.	Torque Ft/Lbs.	Compression Lbs.	Torque Ft/Lbs.	Compression Lbs.
1/4	20	185	027	1	203	2	405	4	810
5/16	18	240	045	2	338	4	675	8	1350
3/8	16	294	068	3	510	6	1020	12	2040
7/16	14	345	.093	5	698	10	1395	20	2790
1/2	13	400	126	8	945	15	1890	30	3780
9/16	12	454	182	12	1215	23	2430	45	4860
5/8	11	507	202	15	1515	30	3030	60	6060
3/4	10	620	302	25	2265	50	4530	100	9060
7/8	9	731	419	40	3143	80	6285	160	12570
1	8	838	551	62	4133	123	8265	245	16530
1-1/8	7	.939	693	98	5190	195	10380	390	20760
1-1/4	7	1.064	.890	137	6675	273	13350	545	26700
1-3/8	6	1.158	1.054	183	7905	365	15810	730	31620
1-1/2	6	1.283	1.294	219	9705	437	19410	875	38820
1-5/8	5-1/2	1.389	1.515	300	11363	600	22725	1200	45450
1-3/4	5	1.490	1.744	390	13080	775	26160	1550	52320
1-7/8	5	1.615	2.049	525	15368	1050	30735	2100	61470
2	4-1/2	1.711	2.300	563	17250	1125	34500	2250	69000

TORQUE DATA FOR USE WITH ALLOY STEEL STUD BOLTS

Loads in Pounds on Stud Bolts when Torque Loads are Applied

NOMINAL DIAMETER OF BOLT	NUMBER OF THREADS	DIAMETER AT ROOT OF THREAD	AREA AT ROOT OF THREAD	STRESS					
				30,000 PSI		45,000 PSI		60,000 PSI	
(Inches)	(Per Inch)	(Inches)	Sq. Inch	Torque Ft/Lbs	Compression Lbs.	Torque Ft/Lbs	Compression Lbs.	Torque Ft/Lbs	Compression Lbs
1/4	20	.185	.027	4	810	6	1215	8	1620
5/16	18	240	045	8	1350	12	2025	16	2700
3/8	16	.294	068	12	2040	18	3060	24	4080
7/16	14	.345	093	20	2790	30	4185	40	5580
1/2	13	400	126	30	3780	45	5670	60	7560
9/16	12	.454	182	45	4860	68	7290	90	9720
5/8	11	.507	.202	60	6060	90	9090	120	12120
3/4	10	.620	302	100	9060	150	13590	200	18120
7/8	9	.731	419	160	12570	240	18855	320	25140
1	8	838	.551	245	16530	368	24795	490	33060
1-1/8	8	963	728	355	21840	533	32760	710	43680
1-1/4	8	1.088	.929	500	27870	750	41805	1000	55740
1-3/8	8	1.213	1.155	680	34650	1020	51975	1360	69300
1-1/2	8	1.338	1.405	800	42150	1200	63225	1600	84300
1-5/8	8	1.463	1.680	1100	50400	1650	75600	2200	100800
1-3/4	8	1.588	1.980	1500	59400	2250	89100	3000	118800
1-7/8	8	1.713	2.304	2000	69120	3000	103680	4000	138240
2	8	1.838	2.652	2200	79560	3300	119340	4400	159120
2-1/4	8	2.088	3.423	3180	102690	4770	154035	6360	205380
2-1/2	8	2.338	4.292	4400	128760	6600	193140	8800	257520
2-3/4	8	2.588	5.259	5920	157770	8880	236655	11840	315540
3	8	2.838	6.324	7720	189720	11580	284580	15440	379440

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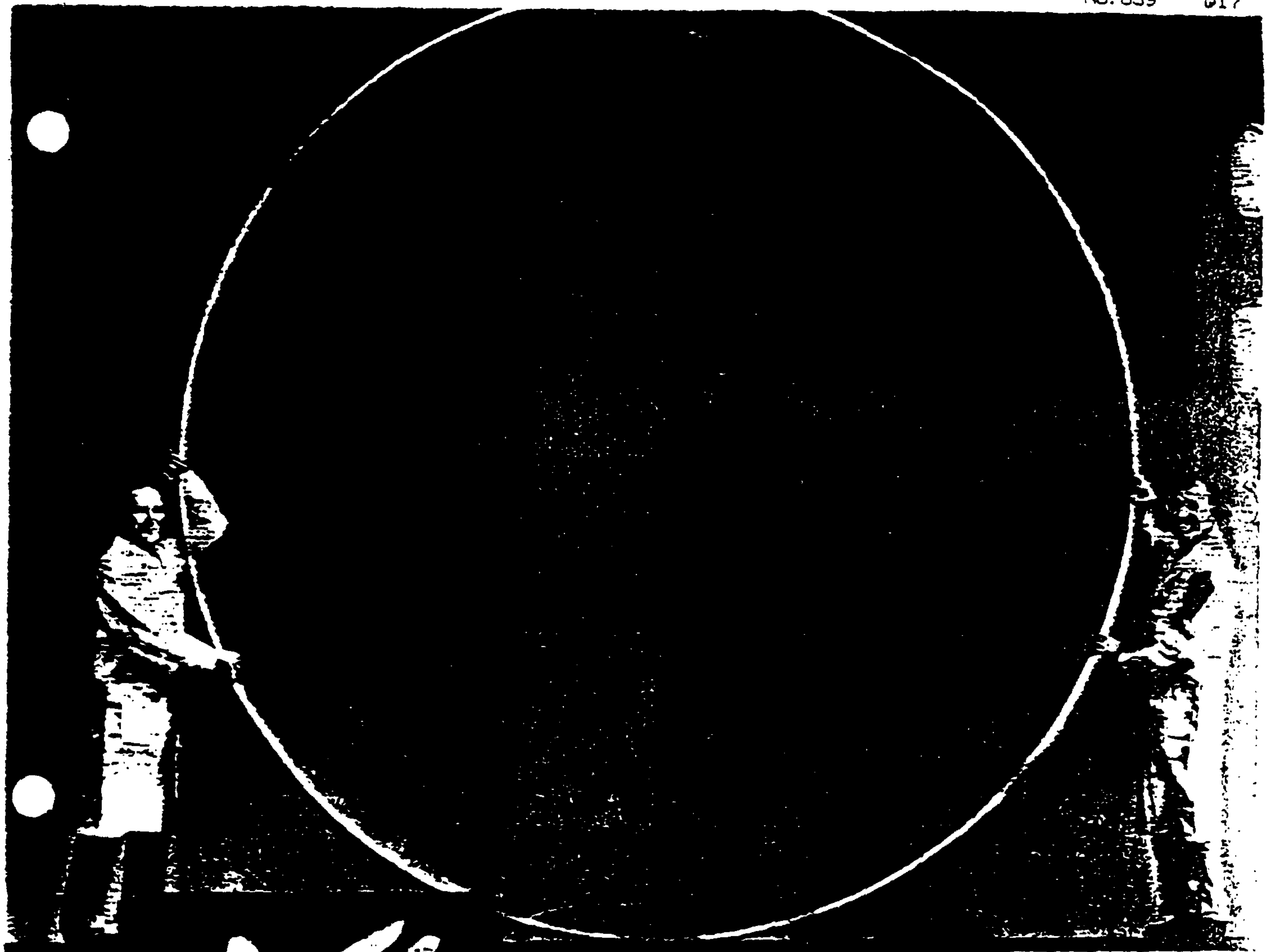
APPENDIX A

Reprinted from 1967 Corrosion Data Survey, NACE, 2400 W. Loop S., Houston, Tx 77027

CORROSIVES WHICH INDUCE INTERGRANULAR CORROSION IN AUSTENITIC STAINLESS STEEL

Acetic Acid ■ Acetic Acid + Salicylic Acid ■ Ammonium Nitrate ■ Ammonium Sulfate ■ Ammonium Sulfate + H_2SO_4 ■ Beet Juice ■ Calcium Nitrate ■ Chromic Acid ■ Chromium Chloride ■ Copper Sulfate ■ Crude Oil ■ Fatty Acids ■ Ferric Chloride ■ Ferric Sulfate ■ Formic Acid ■ Hydrocyanic Acid ■ Hydrocyanic Acid + Sulfur Dioxide ■ Hydrofluoric Acid + Ferric Sulfate ■ Lactic Acid ■ Lactic Acid + Nitric Acid ■ Maleic Acid ■ Nitric Acid ■ Nitric Acid + Hydrochloric Acid ■ Nitric Acid + Hydrofluoric Acid ■ Oxalic Acid ■ Phenol + Naphthenic Acid ■ Phosphoric Acid ■ Phthalic Acid ■ Salt Spray ■ Sea Water ■ Silver Nitrate + Acetic Acid ■ Sodium Bisulfate ■ Sodium Hydroxide + Sodium Sulfide ■ Sodium Hypochlorite ■ Sulfite Cooking Liquor ■ Sulfite Solution ■ Sulfite Digester Acid (Calcium Bisulfite + Sulfur Dioxide) ■ Sulfamic Acid ■ Sulfur Dioxide (Wet) ■ Sulfuric Acid ■ Sulfuric Acid + Acetic Acid ■ Sulfuric Acid — Copper Sulfate ■ Sulfuric Acid + Ferrous Sulfate ■ Sulfuric Acid + Methanol ■ Sulfuric Acid + Nitric Acid ■ Sulfurous Acid ■ Water + Starch + Sulfur Dioxide ■ Water + Aluminum Sulfate



Flexitallic

manufacturer of the largest spiral-wound gasket in the world and the smallest.

Find it fast in the "Yellow Pages" under gaskets. There's a listing for your nearest Master Flexitallic Stocking Distributor in the Yellow Page Telephone Directory in more than 120 strategically located cities across the nation.

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Main Office & Factory:
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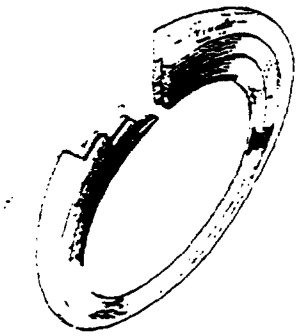
Phone (609) 931-2500 • Telex 834660 • TWX 7106390125
Houston Plant:
P.O. Box 760, Deer Park, TX 77536
Phone (713) 479-3491
Los Angeles Plant:
802 Spruce Lake Drive, Harbor City, CA 90710
Phone [illegible]
Main European Office & Factory:
Flexitallic Gaskets Limited
Heckmondwike, Yorkshire, England. Telex 557485
OTHER AFFILIATED COMPANIES in Australia, Mexico, New Zealand, Scotland, South Africa, Venezuela, West Germany

SL-835-5M Printed in U.S.A.



Flexitallic
SPIRAL-WOUND GASKETS

The nuclear navy

...where gaskets must not fail

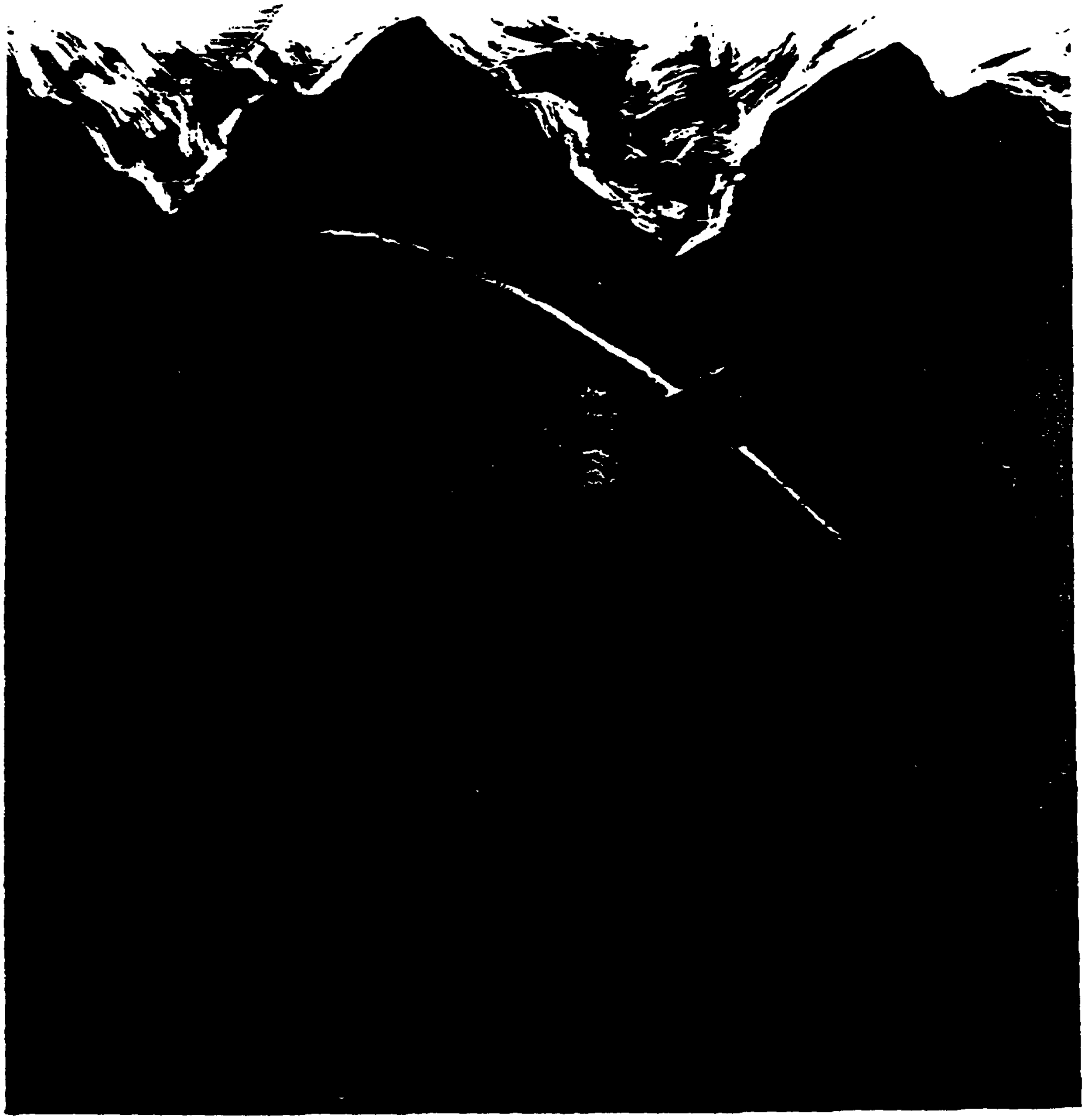
For critical sealing applications in the Nuclear Navy, engineers depend on Flexitallic Gaskets.

In Flexitallic Spiral-Wound Gasket construction, type of metal, type of filler, relationship of metal to filler — all are variables in the hands of the Flexitallic engineer.

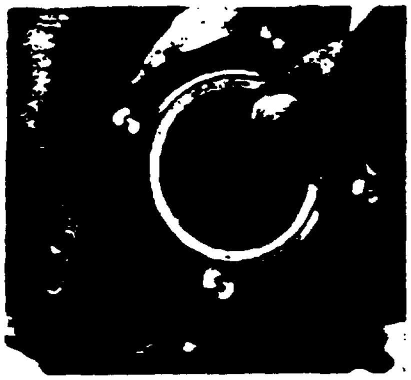
Every Flexitallic Gasket is designed for the specific job it has to do, based on the flange geometry, temperature and pressure of the confined fluid, bolt load, corrosion, vibration, unusual joint stress. Style CG Gasket, illustrated, has Flexite Finish to inhibit corrosion.

Give us the facts about your most serious sealing requirement — in chemical processing, petroleum, power, marine, aircraft and missiles, diesel, or any other field. There's a Flexitallic Gasket to meet your needs — or Flexitallic will design one.

Flexitallic Gasket Company, Camden 2, New Jersey. Stocking Distributors for Standard Flexitallic Gaskets in principal cities.



WE BUILD "PEACE OF MIND" INTO EVERY GASKET WE MAKE



This valve uses a FLEXITALLIC Spiral-Wound Gasket which adjusts automatically to changes in temperature/pressure cycles.

It's a big plus in valves, pumps, compressors, heat exchangers, engines, and fluid processing lines when you know that the gaskets you used are not going to let you down. A FLEXITALLIC Spiral-Wound Gasket will not fail when used in the application for which it was designed. The engineers at FLEXITALLIC help you select the proper metal, the proper filler, and the gasket density so that the gasket will have an extra margin of safety to compensate for emergency loads.

Not every spiral-wound gasket, of course, is a FLEXITALLIC. But every FLEXITALLIC Spiral-Wound Gasket is engineered to provide a leak-proof seal even under severe sealing conditions in all practical pressure/temperature ranges from vacuum to 15,000 psi and higher; and from cryogenic temperatures to 1900° F. and higher. How can FLEXITALLIC be so sure? Because we've constructed more spiral-wound gaskets than anyone else in the world and we provide the engineering skill required to assure a safe seal. We'll be glad to share that engineering know-how with you on your design problems.

We are ready to serve you at any of three plant locations or from any authorized FLEXITALLIC distributor — consult Yellow Pages.

Send for a General Catalog or Bulletin 171 on Design Criteria today.

Flexitallic SPIRAL-WOUND GASKETS

FLEXITALLIC GASKET COMPANY
P.O. Box 680, Camden, N. J. 08101
HOUSTON: 6915 LaPorte Rd., Deer Park, TX 77536
LOS ANGELES: 802 Spruce Lake Dr., Harbor City, CA 90710

End corrosion in gasket inventory

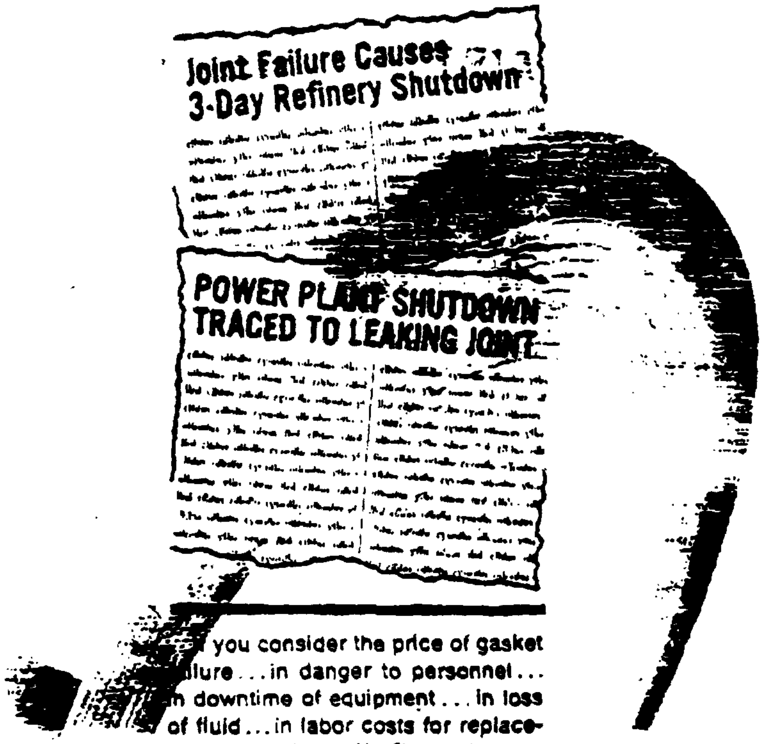
The gold Flexite Finish* for the metal gauge rings in Flexitallic Compression-Gauge Gaskets is new. It is highly corrosion resistant when exposed to severest weathering in open construction projects or in stock. The Flexite Finish provides for ease of identification and a clean, long-lived installation. Write for samples.

FLEXITALLIC GASKET CO., 8th & Bailey Sts., Camden 2, N. J.
Representatives in Principal Cities

TRADE *Flexitallic* MARK
SPIRAL-WOUND GASKETS
WITH *Flexite* FINISH

*The gold Flexite Finish is a development of the Flexitallic Gasket Co. (Originators of Spiral Wound Construction) — Register applied for on both name and color. Flexitallic Blue is our exclusive blue-dyed Canadian asbestos filler. Look for the blue and gold color combination as the mark of Flexitallic quality.

CONSIDER THE PRICE OF GASKET FAILURE!



If you consider the price of gasket failure . . . in danger to personnel . . . in downtime of equipment . . . in loss of fluid . . . in labor costs for replacements, you'll specify Flexitallic.

Flexitallic Spiral-Wound Gaskets are constructed with an extra margin of safety. That's why engineers specify Flexitallic where gaskets must not fail. Available in almost any pressure/temperature combination — limited only by the materials used in their construction.

The application engineering provided by Flexitallic and the extra care we take in manufacturing results in the right gasket, for the right flange, to make the right seal. We have 3 manufacturing plants and authorized distributors in principal cities — see your local yellow pages.

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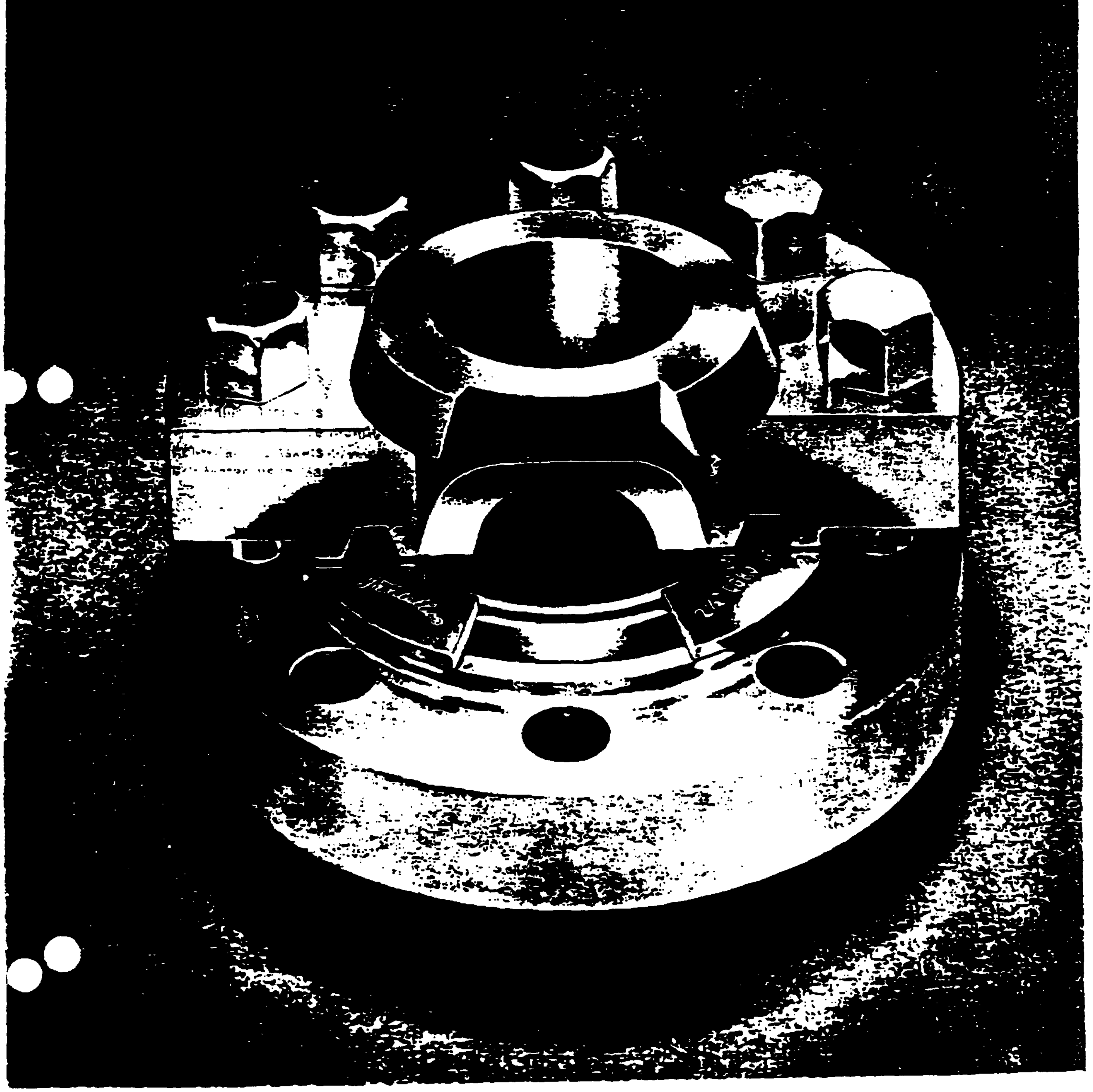
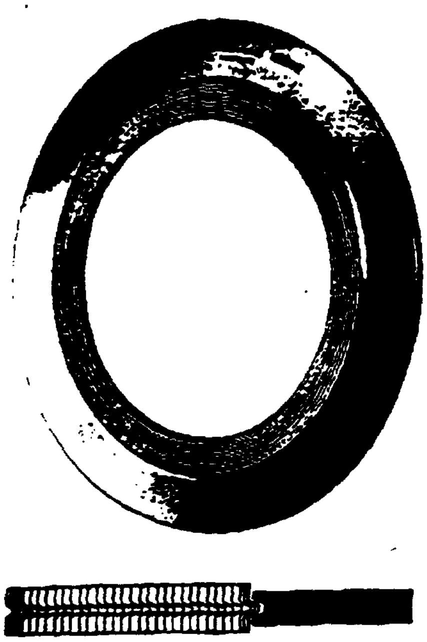
Flexitallic

SPIRAL-WOUND GASKETS
STYLE CG-RJ

"Compression-Gauge" Gaskets
for Ring-Type Joints





Flexitallic Style CG-RJ Compression-Gauge Gasket with outer ring. The compression-gauge confines the gasket on the outside.

Flexitallic
STYLE CG-RJ

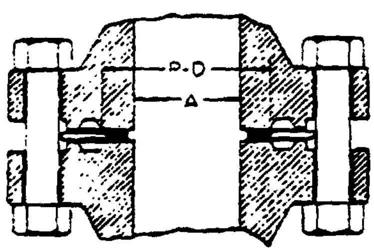
"Compression-Gauge" Gaskets for Ring-Type Joints

The Flexitallic Style CG-RJ Gasket in effect converts a ring-type joint into a male-and-female type joint, with the outer ring of solid steel providing a compression stop and centering device.

When the groove in a ring-type joint is worn or scored, more bolt stress is a temporary solution, but there is a danger of overstressing the bolts. Eventually, the flange has to be cut out of the line, and then welded back after the groove has been re-machined. Style CG-RJ Gaskets prevent this costly maintenance expense.

Style CG-RJ Gaskets are especially suitable for joints where there is close manifolding of the piping. With the Style CG-RJ Gasket, the making and breaking of ring-type joints is accomplished with minimum delay and maintenance expense. Only 1/16-inch breakaway is required, as compared with ½-inch to ¾-inch with conventional ring gaskets.

It's the spiral winding of the V-crimped metal plies, alternating with plies of filler, that gives Flexitallic Gaskets the spring-action or resiliency which is so valuable where thermal shocks occur. Standard Style CG-RJ Gaskets are manufactured of Type 304 stainless steel with Canadian asbestos filler. Many other metals and fillers are available—check with the factory. Standard gauge rings are of carbon steel. Standard gasket thickness before compression is .175". Standard thickness of the gauge ring is ⅛".



Typical position of Style CG-RJ Gasket. Dimension A and P-D are controlling factors of the application of Style CG-RJ Gasket.

The maximum available gasket seating surface is the area between the flange orifice and the ID of the ring groove. Use of this full space is not always necessary.

Flexitallic STYLE CG-RJ FOR STANDARD A. S. A. RING-JOINT FLANGES

Type 304 Stainless Steel and Flexitallic "Blue" Canadian Asbestos. Original Gasket Thickness .175" ± .005". 3/32" Thick Carbon Steel Outer Ring (1/8" thick carbon steel rings may be substituted at no additional cost.)

150 LB. SERIES

	Nominal Pipe Size (Inches)	Gasket Dimensions I.D. (Inches)	Gasket Dimensions O.D. (Inches)	Ring O.D. (Inches)	Gasket Number
See Note 1	2 1/2	2 3/4	3 5/16	4 7/8	RJ-1H
	3	3 5/16	3 15/16	5 3/8	RJ-1J
	3 1/2	3 13/16	4 1/2	6 3/8	RJ-1K
	4	4 5/16	5 5/16	6 7/8	RJ-1L
	5	5 5/16	6 7/16	7 3/4	RJ-1N
	6	6 5/16	7 3/16	8 3/4	RJ-1P
	8	8 1/4	9 9/16	11	RJ-1Q
	10	10 5/16	11 7/16	13 3/8	RJ-1R
	12	12 9/16	13 9/16	16 1/4	RJ-1S
	14	13 7/16	14 13/16	17 3/4	RJ-1T
	16	15 5/16	16 13/16	20 1/4	RJ-1U
	18	17 1/4	19	21 5/8	RJ-1V
	20	19 1/4	21 1/8	23 7/8	RJ-1W
	24	23	25 1/8	28 1/4	RJ-1X

300 LB. SERIES

	Nominal Pipe Size (Inches)	Gasket Dimensions I.D. (Inches)	Gasket Dimensions O.D. (Inches)	Ring O.D. (Inches)	Gasket Number
See Note 2	2 1/2	2 3/4	3 5/16	5 1/8	RJ-3H
	3	3 5/16	3 15/16	5 7/8	RJ-3J
	3 1/2	3 13/16	4 1/2	6 1/2	RJ-3K
	4	4 5/16	5 5/16	7 1/8	RJ-3L
	5	5 5/16	6 7/16	8 1/2	RJ-3N
	6	6 7/16	7 3/8	9 7/8	RJ-3P
	8	8 1/4	9 13/16	12 1/8	RJ-3Q
	10	10 5/16	12	14 1/4	RJ-3R
See Note 3	12	12 7/8	14 1/2	16 5/8	RJ-3S
	14	14 1/4	15 3/4	19 1/4	RJ-3T
	16	16 1/2	17 3/4	21 1/2	RJ-3U
	18	18 1/2	20 1/2	23 1/2	RJ-3V
	20	20 1/4	22 5/16	25 3/4	RJ-3W
	22	22 1/4	24 1/8	27 3/4	RJ-3WA
	24	24 1/2	26 5/16	30 1/2	RJ-3X

400 LB. SERIES

	Nominal Pipe Size (Inches)	Gasket Dimensions I.D. (Inches)	Gasket Dimensions O.D. (Inches)	Ring O.D. (Inches)	Gasket Number
See Note 2	2 1/2	2 3/4	3 5/16	5 1/8	RJ-4H
	3	3 5/16	3 15/16	5 7/8	RJ-4J
	3 1/2	3 13/16	4 1/2	6 1/2	RJ-4K
	4	4 5/16	5 5/16	7	RJ-4L
	5	5 5/16	6 7/16	8 3/8	RJ-4N
	6	6 7/16	7 3/8	9 3/4	RJ-4P
	8	8 1/4	9 13/16	12	RJ-4Q
	10	10 5/16	12	14 1/8	RJ-4R
See Note 3	12	12 7/8	14 1/2	16 1/2	RJ-4S
	14	14 1/4	15 3/4	19	RJ-4T
	16	16 1/2	17 3/4	21 1/2	RJ-4U
	18	18 1/4	20 1/4	23 3/8	RJ-4V
	20	20 1/4	22 5/16	25 1/2	RJ-4W
	22	22 1/4	24 1/8	27 3/8	RJ-4WA
	24	24 1/2	26 5/16	30 1/2	RJ-4X

600 LB. SERIES

	Nominal Pipe Size (Inches)	Gasket Dimensions I.D. (Inches)	Gasket Dimensions O.D. (Inches)	Ring O.D. (Inches)	Gasket Number
See Note 2	2 1/2	2 3/4	3 5/16	5 1/8	RJ-6H
	3	3 5/16	3 15/16	5 7/8	RJ-6J
	3 1/2	3 13/16	4 1/2	6 3/8	RJ-6K
	4	4 5/16	5 5/16	7 5/8	RJ-6L
	5	5 5/16	6 7/16	9 1/2	RJ-6N
	6	6 7/16	7 3/8	10 1/2	RJ-6P
	8	8 1/4	9 13/16	12 5/8	RJ-6Q
	10	10 5/16	12	15 3/4	RJ-6R
See Note 3	12	12 7/8	14 1/2	18	RJ-6S
	14	14 1/4	15 3/4	19 3/8	RJ-6T
	16	16 1/2	17 3/4	22 1/4	RJ-6U
	18	18 1/2	20 1/4	24 1/8	RJ-6V
	20	20 1/2	22 5/16	26 7/8	RJ-6W
	22	22 1/2	24 1/8	28 3/4	RJ-6WA
	24	24 1/2	26 5/16	31 1/2	RJ-6X

900 LB. SERIES

	Nominal Pipe Size (Inches)	Gasket Dimensions I.D. (Inches)	Gasket Dimensions O.D. (Inches)	Ring O.D. (Inches)	Gasket Number
See Note 4	1/2	[illegible]	1 1/16	2 1/2	RJ-9B
	3/4	3/4	1 1/4	2 3/4	RJ-9C
	1	7/8	1 1/2	3 1/8	RJ-9D
	1 1/4	1 3/16	1 7/8	3 1/2	RJ-9E
	1 1/2	1 3/8	2 5/16	3 7/8	RJ-9F
	2	1 13/16	2 3/4	5 5/8	RJ-9G
See Note 8	1/2	9/16	1 1/16	2 1/2	RJ-9B
	3/4	3/4	1 1/4	2 3/4	RJ-9C
	1	13/16	1 1/2	3 1/8	RJ-9D
	1 1/4	1 1/16	1 13/16	3 1/2	RJ-9E
	1 1/2	1 7/16	2 5/16	3 7/8	RJ-9F
	2	1 13/16	2 3/4	5 5/8	RJ-9G
See Note 4	2 1/2	2 5/16	3 1/8	6 1/2	RJ-9H
	3	3 3/16	4 5/16	6 5/8	RJ-9J
	4	4 1/16	5 5/16	8 1/8	RJ-9L
	5	5 3/16	6 7/16	9 3/4	RJ-9N
	6	6 5/16	7 3/8	11 3/8	RJ-9P
	8	8 1/4	9 13/16	14 1/8	RJ-9Q
See Note 5	10	10 5/16	12	17 1/8	RJ-9R
	12	12 7/8	14 1/2	19 5/8	RJ-9S
	14	13 5/16	15 5/16	20 1/2	RJ-9T
	16	15 5/16	17 5/16	22 5/8	RJ-9U
	18	17 1/4	19 13/16	25 1/2	RJ-9V
	20	19 5/16	21 13/16	27 1/2	RJ-9W
	24	23	25 13/16	33	RJ-9X

1500 LB. SERIES

	Nominal Pipe Size (Inches)	Gasket Dimensions I.D. (Inches)	Gasket Dimensions O.D. (Inches)	Ring O.D. (Inches)	Gasket Number
See Note 6	1/2	5/16	1 1/16	2 1/2	RJ-15B
	3/4	1/2	1 1/4	2 3/4	RJ-15C
	1	3/4	1 1/2	3 1/8	RJ-15D
	1 1/4	1 1/16	1 7/8	3 1/2	RJ-15E
	1 1/2	1 1/4	2 5/16	3 7/8	RJ-15F
	2	1 11/16	2 3/4	5 5/8	RJ-15G
See Note 8	1/2	9/16	1 1/16	2 1/2	RJ-15B
	3/4	3/4	1 1/4	2 3/4	RJ-15C
	1	13/16	1 1/2	3 1/8	RJ-15D
	1 1/4	1 5/16	1 13/16	3 1/2	RJ-15E
	1 1/2	1 7/16	2 5/16	3 7/8	RJ-15F
	2	1 11/16	2 3/4	5 5/8	RJ-15G
See Note 6	2 1/2	2 5/16	3 1/8	6 1/2	RJ-15H
	3	3 5/16	4 5/16	6 7/8	RJ-15J
	4	4 1/16	5 11/16	8 1/4	RJ-15L
	5	5 1/16	6 13/16	10	RJ-15N
	6	6	7 5/16	11 1/8	RJ-15P
	8	7 7/8	9 3/8	13 7/8	RJ-15Q
	10	9 13/16	11 7/8	17 1/8	RJ-15R
See Note 7	12	11 5/8	13 13/16	20 1/2	RJ-15S
	14	12 3/4	15 5/16	22 3/4	RJ-15T
	16	14 5/16	17	25 1/4	RJ-15U
	18	16 3/4	19 1/2	27 3/4	RJ-15V
	20	17 3/4	21 7/16	29 3/4	RJ-15W
	24	22 3/8	25 1/2	35 1/2	RJ-15X

Note 1. For weld neck type flanges having a pipe bore equal to that of schedule 40 pipe but not for slip-on flanges.

Note 2. For weld neck type flanges having a pipe bore equal to that of schedule 40 pipe and heavier, but not for slip-on flanges.

Note 3. Suitable for slip-on and weld neck type flanges.

Note 4. For weld neck type flanges having a pipe bore equal to that of schedule 80 pipe and heavier but not for slip-on flanges.

Note 5. For weld neck type flanges having a pipe bore equal to that of schedule 40 pipe and heavier, but not for slip-on flanges.

Note 6. For weld neck type flanges having a pipe bore equal to that of schedule 80 pipe or heavier, but not for slip-on flanges.

Note 7. For weld neck type flanges having a pipe bore equal to that of schedule 100 pipe or heavier, but not for slip-on flanges.

Note 8. For weld neck type flanges having a pipe bore equal to that of schedule 160 pipe or heavier, but not for slip-on flanges.

INSTRUCTIONS FOR ORDERING

Select the Gasket number from tables above. Add pipe size and pressure series for your application. With this information, Gaskets can be shipped promptly without correspondence. Gasket Engineering Data Forms similar to the one on page 4 furnished separately on request.