Benefits

How You Benefit From The KC Sealing System

KC Multi-Ring® Gasket Design

- Evenly distributes clamping force around entire flange face
- Reduces/eliminates flange distortion
- Requires as little as 50% bolt torque as conventional designs
- Engineered to fit each different pipe/flange style
- Available in these styles:

PVDF Universal	New ANSI
PVDF ring - BCF/IR flange adapters	Old ANSI
PVDF ring - socket fusion flange adapters	FRP Ducting
Schedule 10	Polypro & others contact factory

- Only one torque value required for same size flange in PVDF, Schedule 10, and New ANSI styles in like material
- Gasket styles can be cut and molded from any material:
  - Expanded PTFE
  - Expanded PTFE (densified)
  - KRYSTLE-CLEAR
  - FPM (Fluorine Rubber)
  - EPDM
  - FKM
  - Other sheet or roll material

AC Backing Flanges

- Engineered to direct the clamping force towards the pipe ID, not the flange adapter OD
- Provides a positive seal at the inner ring on a KC Multi-Ring® gasket or any other gasket
- Minimizes gasket surface area contacted by medium
  (Contamination from gasket is proportional to gasket surface area)
- Reduces the cavity at flanged joints
- Available for plastic piping
- Thermoplastic coating is more resilient and less brittle than PVDF
  When an AC flange is dropped, the coating dents rather than shatters
  Dents can be "smoothed out" in the field with a heat gun
- Independent Finite Element Analysis confirms KC Multi-Ring, Inc.'s lab results

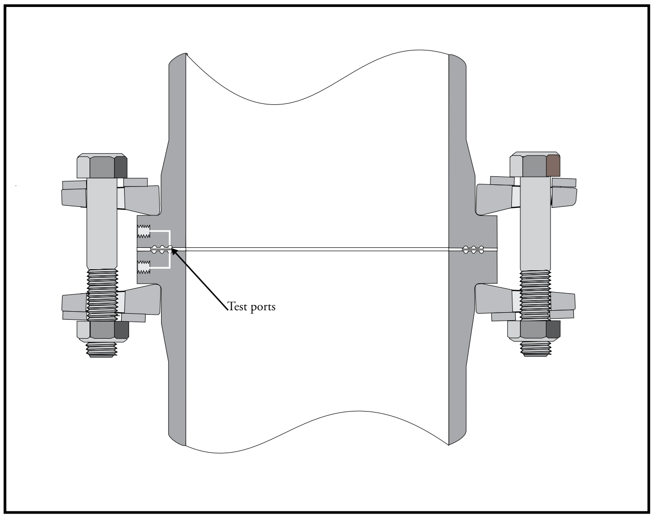
A NEW DEFINITION OF "LEAKY" FLANGED JOINTS

For some, the test of whether a flanged joint is leaking is as simple as whether you are tripping over a bucket on the floor. If not, everything is OK, you can forget about the joint and move on to the next one. (We call this the "bucket" test). On the surface, one might think that the bucket test is fine for all applications. However, the bucket test looks only at what is happening at the flange OD and ignores what is happening between the pipe ID and flange OD.

At a minimum, the bucket test is not appropriate for ultrapure water applications. A number of problems can arise if the joint is sealed at the flange OD and not the pipe ID:

1. The flange adapters are dished. Over time, thermoplastic pipe takes on a thermal set, even at ambient temperatures. This effect is accelerated at elevated temperatures.
2. Both sides of the gasket are exposed to the water. It is widely held that contamination is directly proportional to the surface area of the gasket exposed to the water.
3. Both flange faces are wetted. Water is "trapped" in this "dead" spot, providing an ideal breeding ground for "bugs" to grow. This "trapped" water and any "bugs" it contains may be flushed into the system when valves close abruptly and water hammer occurs.
4. The pipe run is unevenly stressed at each flanged joint.
5. The hydraulic forces, which the joints must overcome, greatly increase.
6. It may be difficult to re-seal the joint once it is taken apart.

The figure below shows the flange which KC Multi-Ring Products, Inc. uses to evaluate its designs. We drill through the first annular groove (measuring from the ID) to a depth of about 1/2 of the flange thickness. We then cross-drill through the flange wall so that we create a path from the flange face to the outside.



Cross-section of a flanged joint with test holes drilled into the first annular grooves of serrated face PVDF flange adapters.

Note that we drilled test ports in both flange adapters to ensure that the gasket did not act like a shuttle valve.

Finally, we defined a joint as "leaky" if any water came out of the test ports, rather than whether any water dripped from the joint OD.

You may be wondering whether we still needed our bucket right at our test fixture to catch what was leaking through these test ports?

No, but only for KC Multi-Ring Products, Inc.'s patented reduced surface area low-torque gaskets installed between KC Multi-Ring Products, Inc.'s patented AC backing flanges!

Yes, for all other combinations of gaskets and backing flanges we tested for UPW applications.

4

COMPARISON OF FLANGED JOINT AFTER BOLT-UP

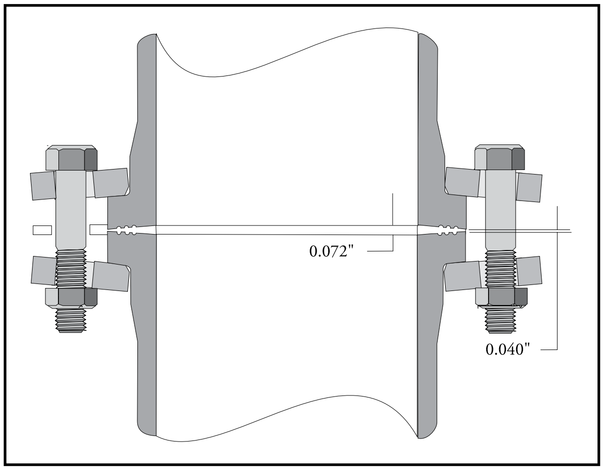


Figure 1 - 80 ft-lbs of torque on conventional "flat" backing ring and 1/8" expanded PTFE 100% contact full face gasket. 225mm SYGEF pipe.

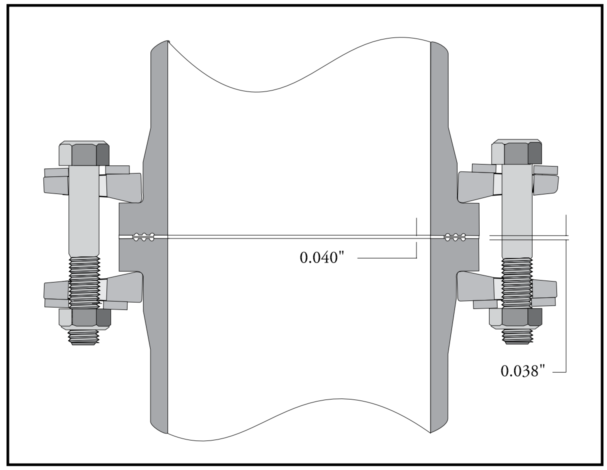


Figure 2 - 56 ft-lbs of torque on AC backing flange and 1/8" expanded PTFE KC Multi-Ring® low-torque gasket. 225mm SYGEF pipe.

The benefits of KC Multi-Ring Products, Inc.'s patented **AC** flange rings are clearly demonstrated in the two figures above. In figure 1, the flat backing rings rotate approximately 2° thereby single-point loading the outside edge of the flange adapter. At the outside edge, the gasket is compressed to 0.040"; at the pipe ID, the gasket is only compressed to 0.072". Contrast this with the relatively even gasket compression between the pipe ID and outside edge of the flange adapter with the **AC** flange ring, at only **70**% of the torque as used with the flat backing ring.

Conventional flat backing ring

1. Seals at the outside edge of the flange adapter.
2. Creates a concave flange adapter face after bolt-up and during subsequent system operation.
3. Over time, thermoplastic flange adapters take on a concave thermal set, even at ambient temperatures. Effect is accelerated by elevated temperatures. Difficult to re-seal if the joint is ever taken apart.
4. Both flange faces and both sides of gasket exposed to medium, providing an excellent breeding ground for contamination.
5. Independent Finite Element Analysis confirms higher stress on pipe when joints are installed with conventional flat backing rings.
6. As additional torque is applied to the fasteners, the sealing point does not change since the backing rings rotate around the outside edge of the flange adapter.

KC Multi-Ring® AC backing flange

1. Seals closer to the pipe ID.
2. Flange adapter face is square after bolt-up and during subsequent system operation.
3. No concave flange adapters. KC Multi-Ring Products, Inc.'s flange ring design can even bring a concave flange adapter back square.
4. Flange face and gasket area exposed to medium are substantially reduced.
5. Independent Finite Element Analysis confirms lower stress on pipe when joints are installed with KC Multi-Ring® AC flange backing rings.
6. As additional torque is applied to the fasteners, the rotation of the flange ring swings the center line of force toward the ID of the pipe to obtain a better seal.

JOINING DISSIMILAR FLANGE ADAPTER TYPES

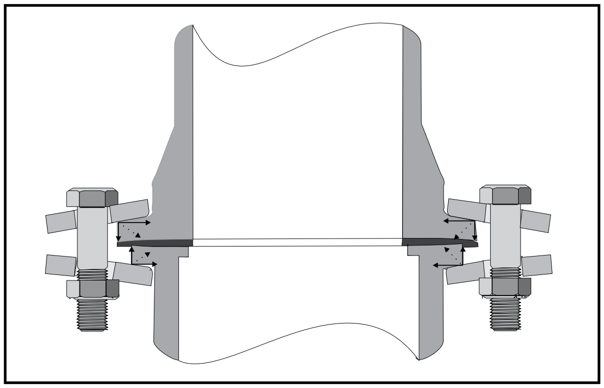


Figure 3 - Butt-weld mated to socket fusion flange adapter; joined with conventional "flat" backing rings.

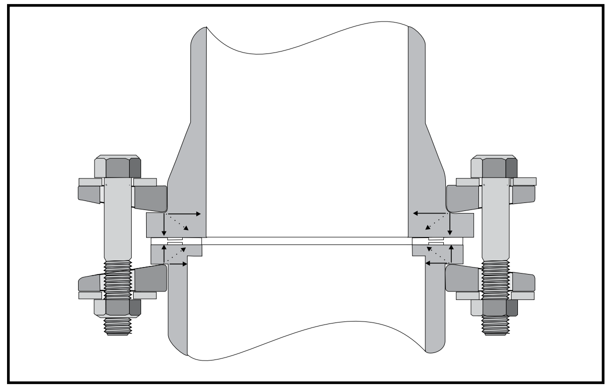


Figure 4 - Butt-weld mated to socket fusion flange adapter; joined with KC Multi-Ring® AC backing flanges.

Illustrated above are the effects of joining dissimilar OD flange adapter types. In both cases, a larger OD butt-weld flange adapter is joined to a smaller OD socket fusion flange adapter. Figure 3 shows a joint installed with conventional "flat" backing rings. Figure 4 shows a joint installed with KC Multi-Ring® **AC** flange rings.

As torque is applied to the fasteners of conventional flat backing rings, the backing rings rotate approximately 2° and the bolts "move" to the outside of the bolt holes, thereby single-point loading the outside edge of each flange adapter. The outside edge of the smaller OD socket fusion flange adapter acts as a knife edge as the larger OD butt-weld flange adapter is "bent" over. Both flange adapters become concave, with the bulk of the sealing taking place only at the outside edge of the smaller flange.

Both flange faces and both sides of the gasket are exposed to the medium, providing an ideal breeding ground for contamination.

The same effects can be observed when pipe spools are joined to valves and pumps. It is quite common for the OD of the flange face on the valve or pump body to differ from the OD of the flange adapter.

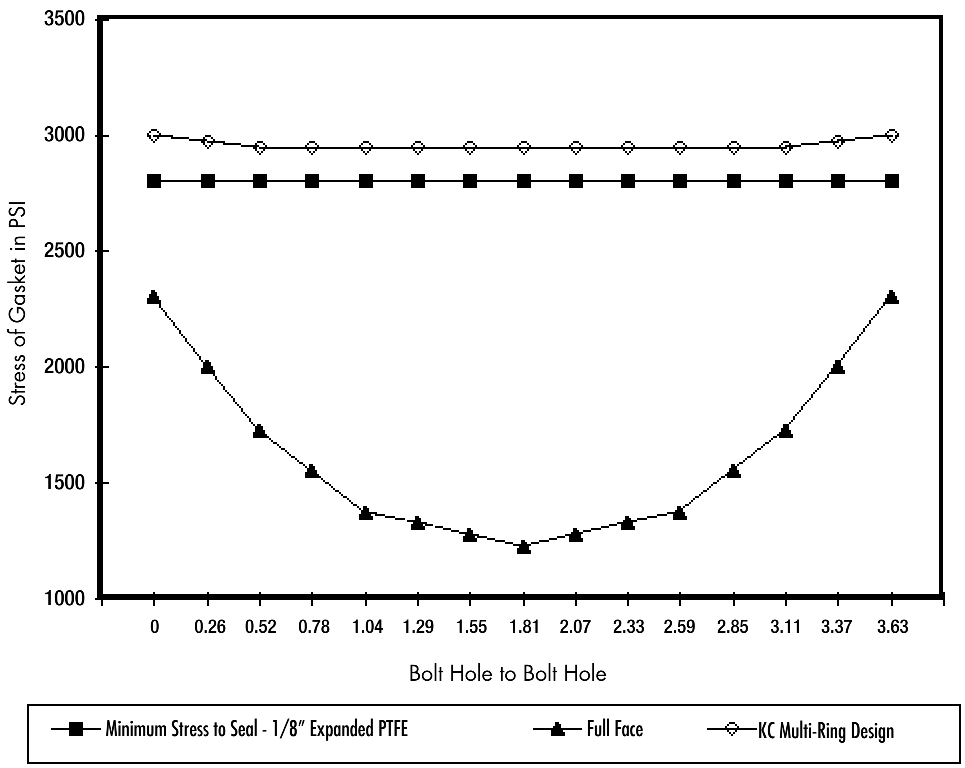
The performance of flanges joined with the KC Multi-Ring® backing flanges is clearly superior. The contact points on flange adapters are the inner radius of the backing flanges, not on the outside edge as with the flat rings. This center line of the force applied to the joint is practically parallel to the pipe. Any rotation resulting from greater bolt load swings the force towards the pipe ID, resulting in a better seal. Flange faces are kept square, not concave, and sealing takes place near the pipe ID.

Wetted surfaces and breeding ground for contamination are minimized. Finally, medium impurities resulting from flanged joints are minimized and gasket wetted surfaces are reduced using the KC Multi-Ring® low-torque design.

4

GASKET STRESS ACROSS FLANGE

6″ 150# Fiberglass Reinforced Plastic



In order to seal a flanged joint, the gasket installed must be adequately stressed by the joint. The chart above presents the dramatic difference in gasket stress on a full face gasket and a KC Multi-Ring® gasket installed in a 6″ 150# fiberglass reinforced plastic flange. Gasket stress was measured at the centerline of two adjacent bolt holes and 13 equal points between bolt hole centerlines.

The top line shows the relatively even stress on a 1/8″ expanded PTFE KC Multi-Ring® gasket as one moves between bolt holes. Note the minor drop in gasket stress at approximately 0.52″ away from each bolt hole centerline, with constant gasket stress at other measurement points.

The middle line shows the minimum stress required to seal 1/8″ expanded PTFE, the material from which both subject gaskets were cut.

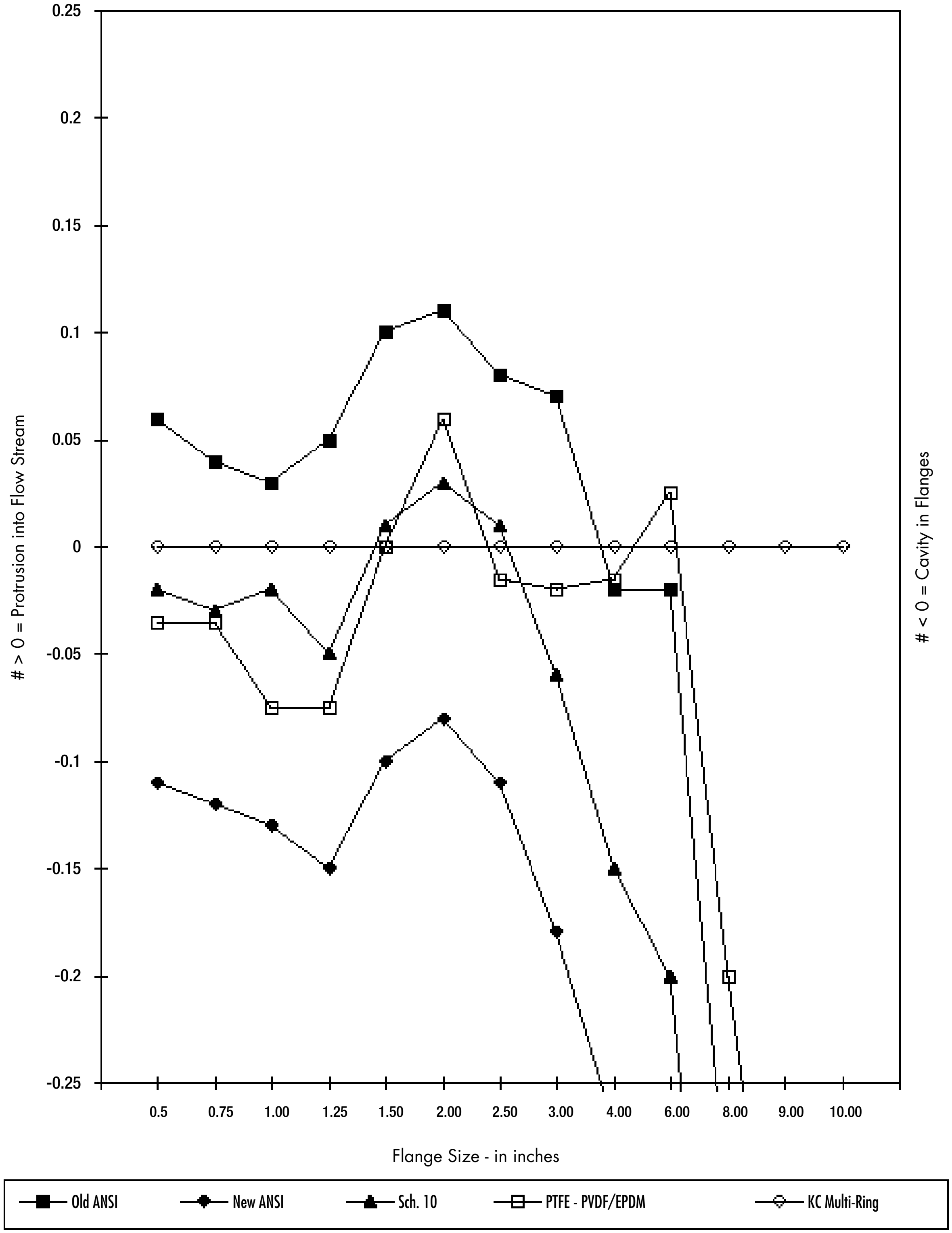
The bottom line shows the gasket stress on a 1/8″ expanded PTFE full face gasket.

Note that the stress decreases symmetrically, reaching the minimum stress halfway between bolt holes. At the midway point, gasket stress has diminished to approximately 1/2 of the stress as measured at each bolt hole.

Please note that the torque required to stress the full face gasket equal to the stress on the KC Multi-Ring® gasket would have caused flange fatigue and failure.

COMPARISON OF GASKET FIT TO HIGH PURITY PVDF FLANGES

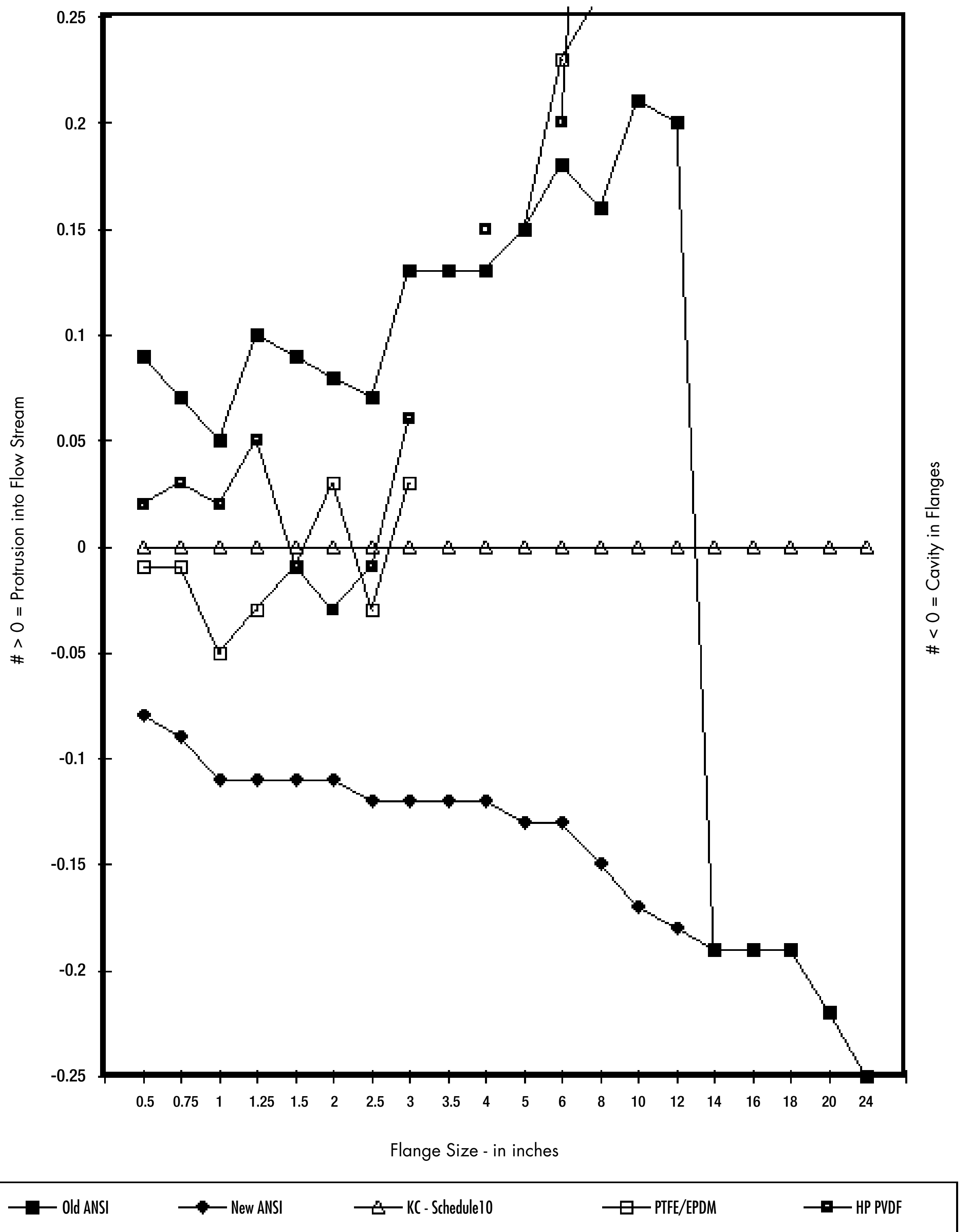
(plotted points reflect radial protrusion or cavity)



Note that the KC Multi-Ring® gasket is designed so that the gasket ID matches the flange ID. All other gaskets either act as installed orifice plates (when the gasket protrudes into the flow stream), or create cavities at the joint. Both conditions create "dead" spots, an ideal breeding ground for micro-contamination. Missing data points for a given style/size combination mean that either that size is not available, or the radial difference in gasket ID to flange ID exceeds +/- 0.25".

COMPARISON OF GASKET FIT TO SCHEDULE 10 FLANGES

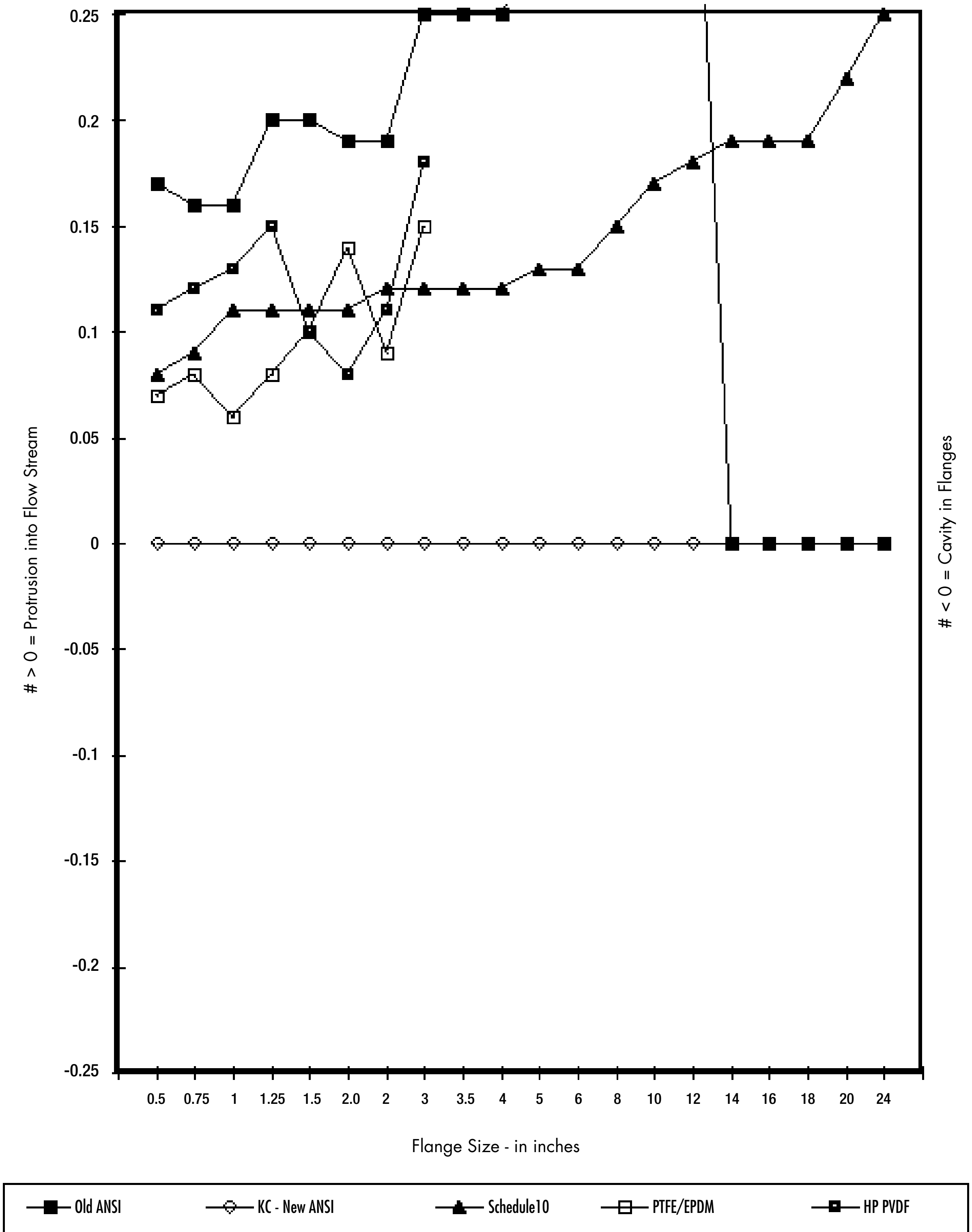
(plotted points reflect radial protrusion or cavity)



Note that the KC Multi-Ring® gasket is designed so that the gasket ID matches the flange ID. All other gaskets either act as installed orifice plates (when the gasket protrudes into the flow stream), or create cavities at the joint. Missing data points for a given style/size combination mean that either that size is not available, or the radial difference in gasket ID to flange ID exceeds +/- 0.25".

COMPARISON OF GASKET FIT TO NEW ANSI FLANGES

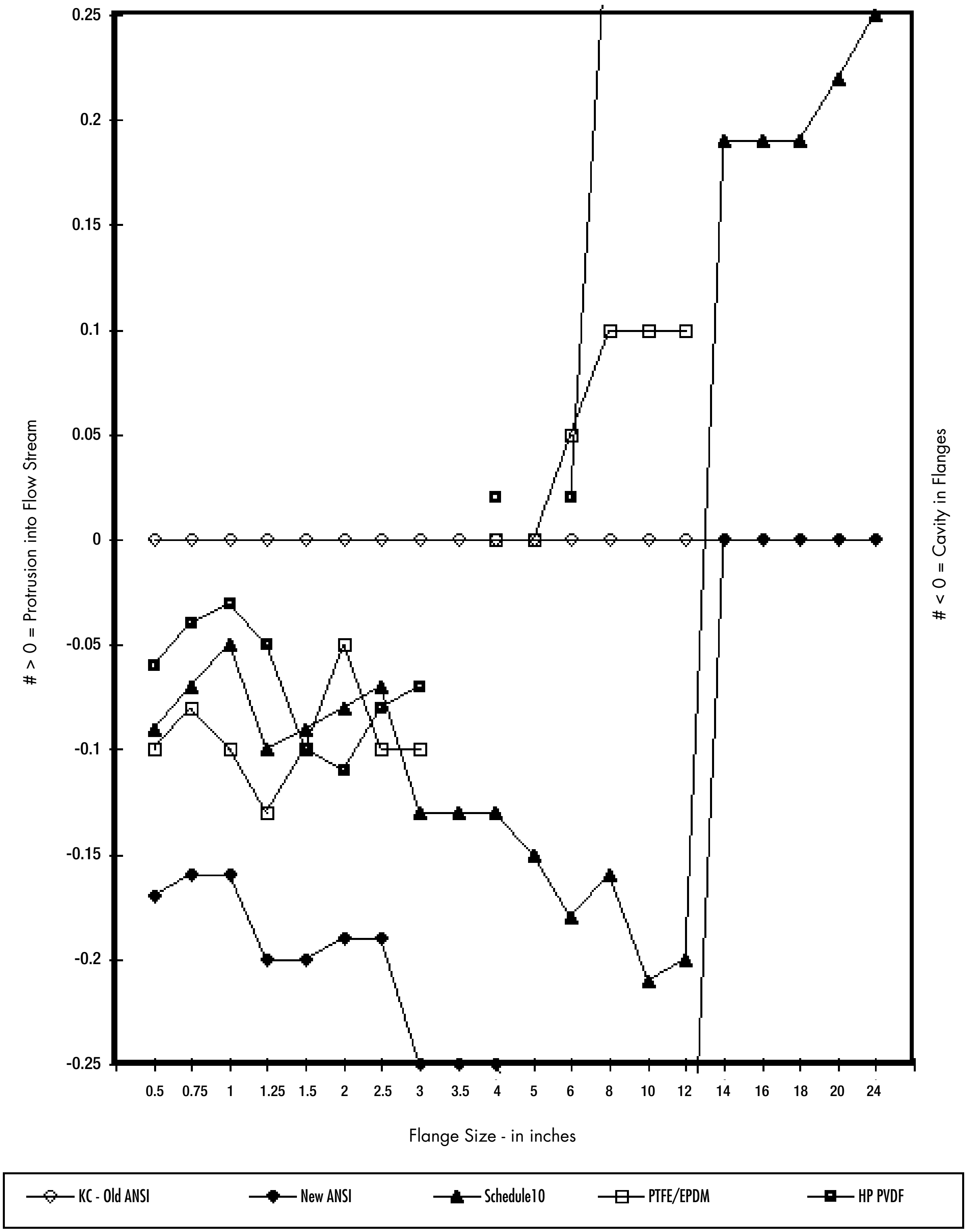
(plotted points reflect radial protrusion or cavity)



Note that the KC Multi-Ring® gasket is designed so that the gasket ID matches the flange ID. All other gaskets either act as installed orifice plates (when the gasket protrudes into the flow stream), or create cavities at the joint. Missing data points for a given style/size combination mean that either that size is not available, or the radial difference in gasket ID to flange ID exceeds +/- 0.25".

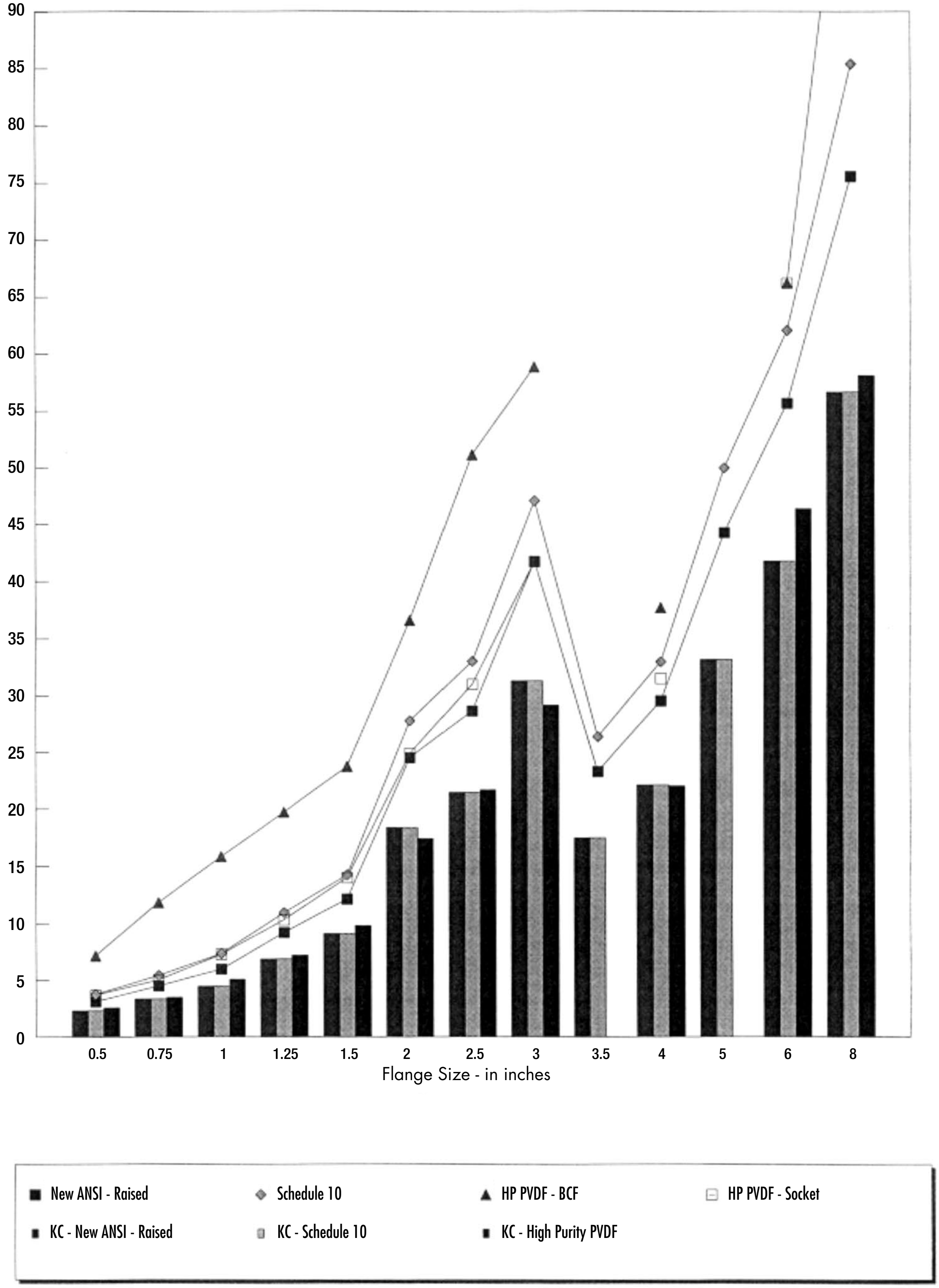
COMPARISON OF GASKET FIT TO OLD ANSI FLANGES

(plotted points reflect radial protrusion or cavity)

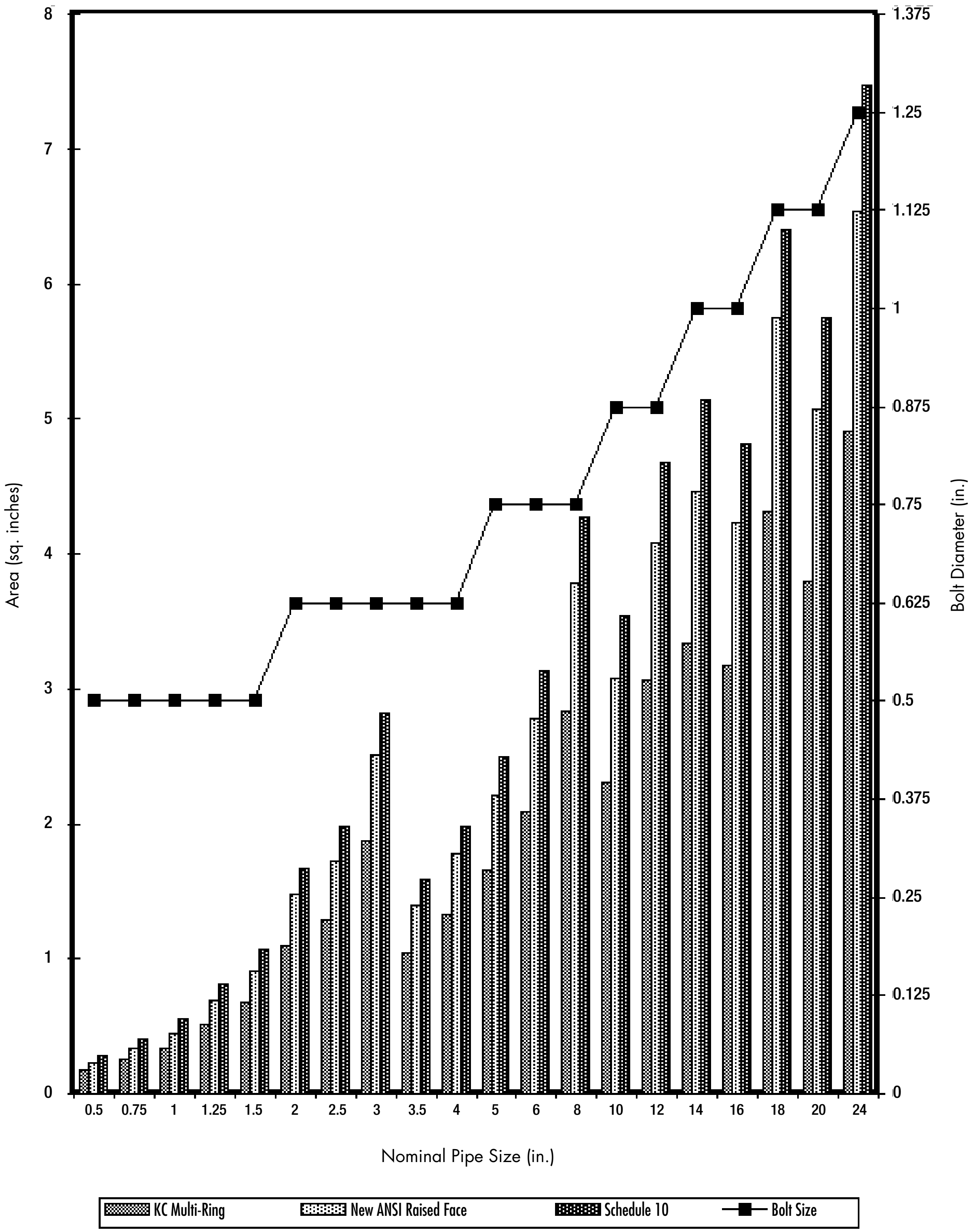


Note that the KC Multi-Ring® gasket is designed so that the gasket ID matches the flange ID. All other gaskets either act as installed orifice plates (when the gasket protrudes into the flow stream), or create cavities at the joint. Missing data points for a given style/size combination mean that either that size is not available, or the radial difference in gasket ID to flange ID exceeds +/- 0.25".

TORQUE USED TO SEAL COMMON FLANGE STYLES

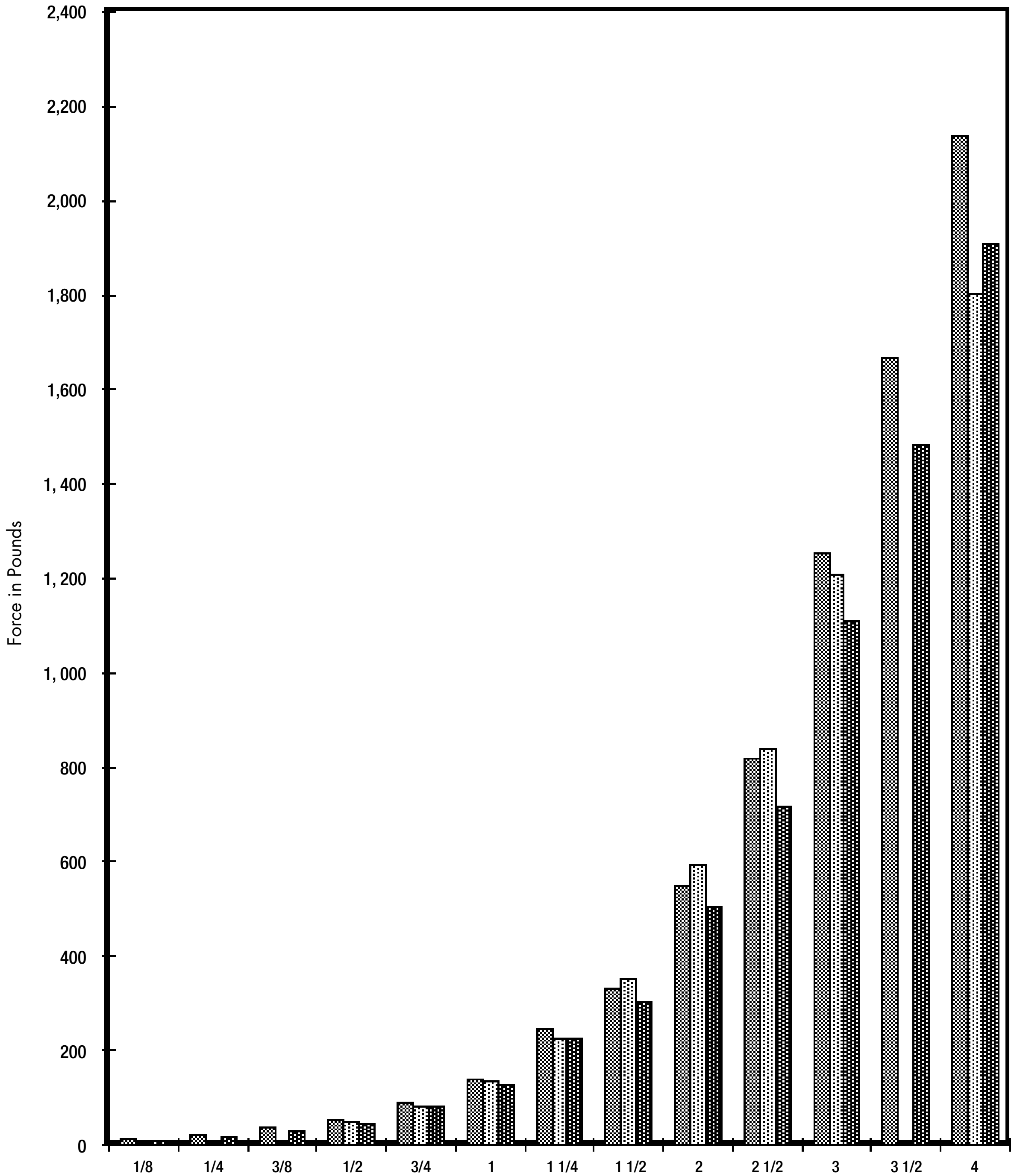


BOLT STRAIN VS. GASKET AREA



This chart shows the total gasket surface area divided by the number of bolts in ANSI 150# bolt pattern. The data helps explain why 3″ and 8″ flanges are the toughest to seal with conventional flanges, and how sealing is improved with the reduced surface area KC Mult-Ring® gasket design.

FORCE PULLING JOINT APART @ 150 PSI

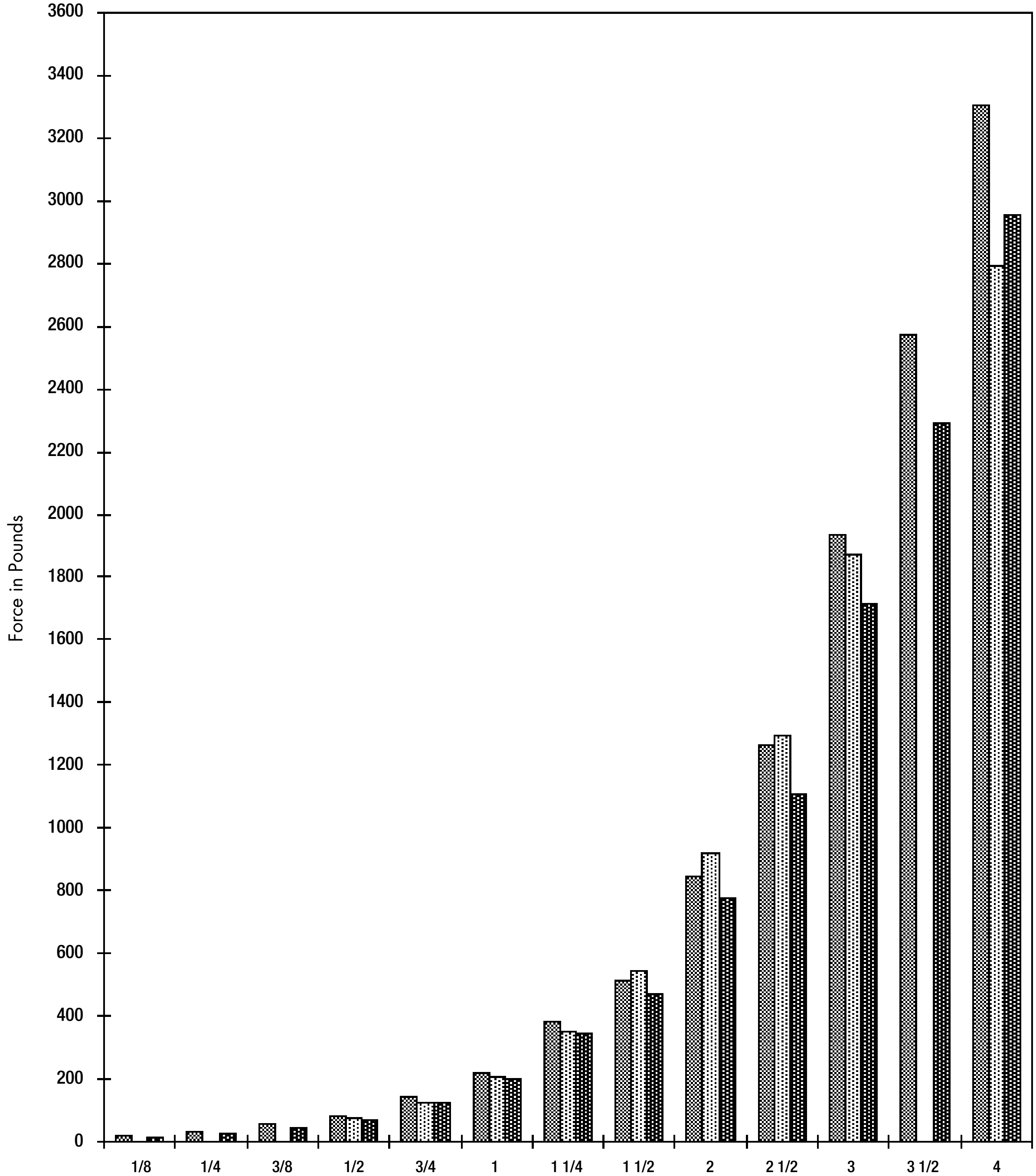


Schedule 10	11	20	35	54	92	140	245	333	548	818	1252	1666	2138
SYGEF HP				48	82	135	226	354	593	839	1210		1804
Schedule 40	9	16	29	46	80	128	224	305	503	718	1109	1483	1910

Nominal Pipe Size

This chart shows the hydraulic forces that joint bolts must overcome to seal, assuming that sealing occurs at the pipe ID. Since conventional backing flanges seal near the flange OD, "effective" hydraulic forces (calculated at the actual sealing point) are greater than shown. Force is calculated as pressure x flange ID radius x pi ^{2}.

FORCE PULLING JOINT APART @ 232 PSI

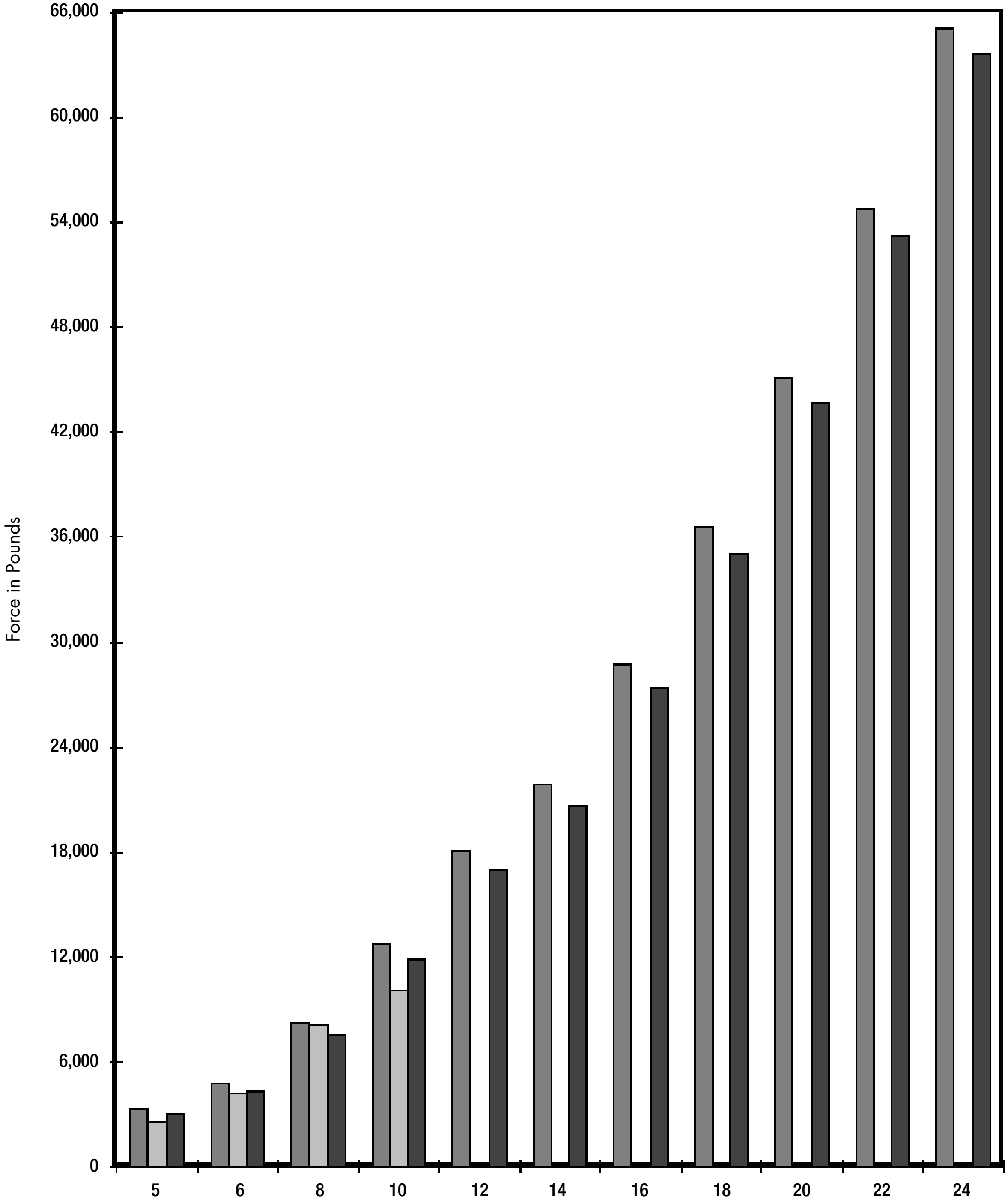


	1/8	1/4	3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	3 1/2	4
Schedule 10	17	31	54	83	142	217	379	516	848	1265	1936	2576	3307
SYGEF HP				74	127	209	350	547	918	1298	1871		2790
Schedule 40	13	24	44	70	124	199	347	472	779	1111	1715	2294	2953

Nominal Pipe Size

This chart shows the hydraulic forces that joint bolts must overcome to seal, assuming that sealing occurs at the pipe ID. Since conventional backing flanges seal near the flange OD, "effective" hydraulic forces (calculated at the actual sealing point) are greater than shown. Force is calculated as pressure x flange ID radius x pi^2.

FORCE PULLING JOINT APART @ 150 PSI

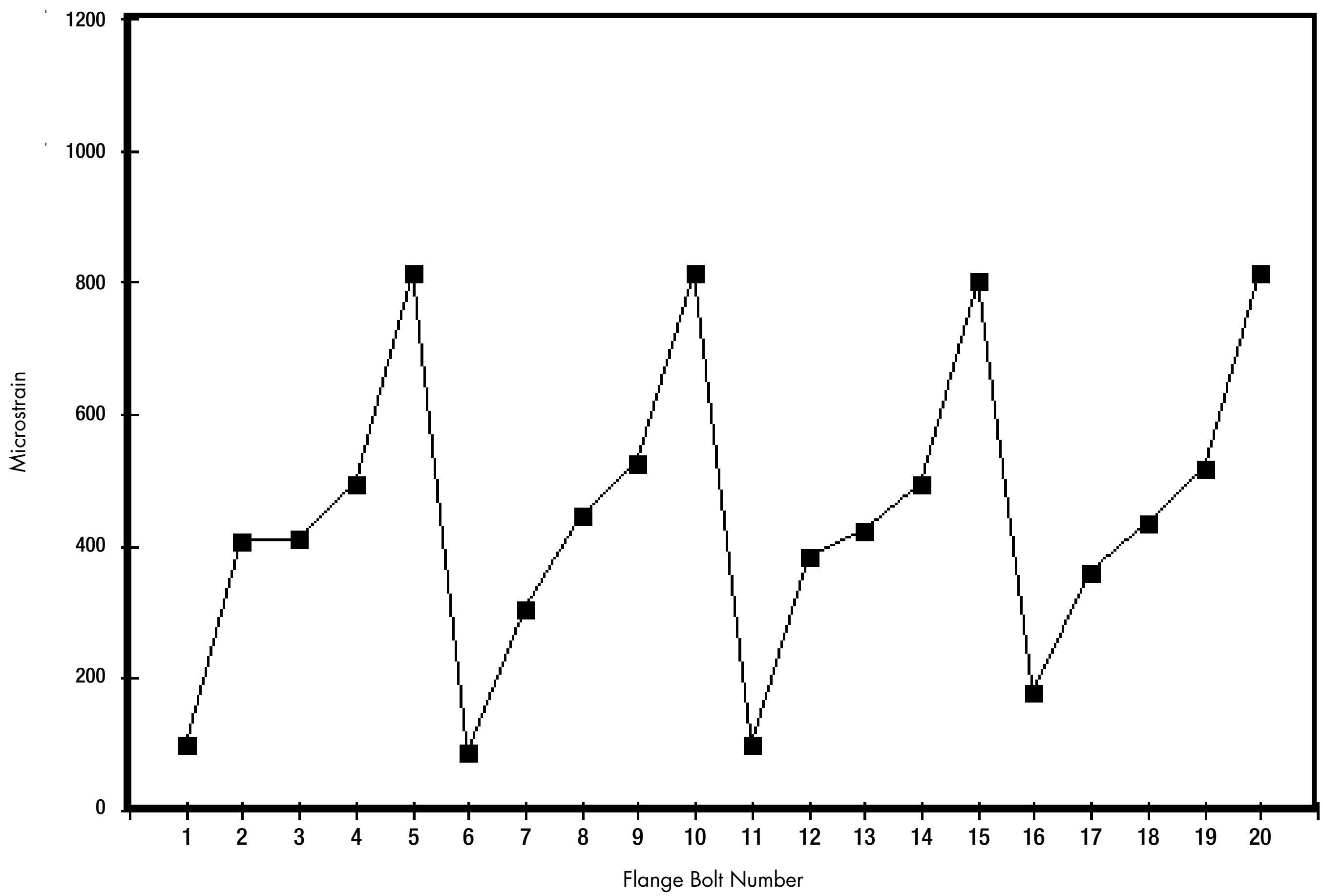


	5	6	8	10	12	14	16	18	20	22	24
Schedule 10	3302	4761	8173	12791	18085	21867	28759	36592	45092	54782	65061
SYGEF HP	2508	4175	8130	10050							
Schedule 40	3000	4334	7504	11858	16965	20683	27398	35056	43656	53199	63684

Nominal Pipe Size

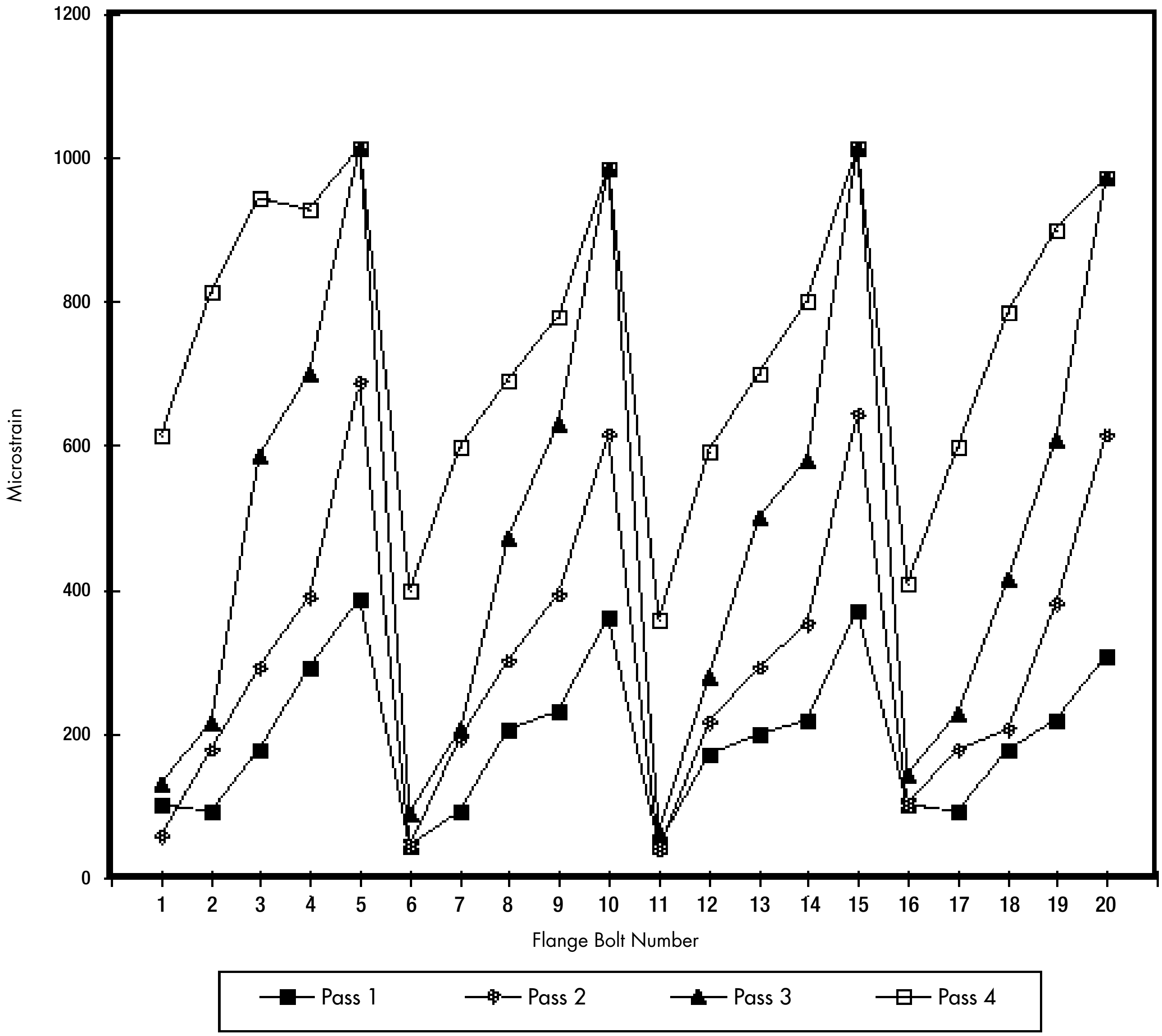
This chart shows the hydraulic forces that joint bolts must overcome to seal, assuming that sealing occurs at the pipe ID. Since conventional backing flanges seal near the flange OD, "effective" hydraulic forces (calculated at the actual sealing point) are greater than shown. Force is calculated as pressure x flange ID radius x pi ^{2}.

THE EFFECTS OF SINGLE PASS TIGHTENING



This chart shows the variability of compressive force for 20 bolts, all of which are tightened to the same torque following a star pattern. Maximum compressive force is applied at bolts 5, 10, 15 and 20. Minimum force is applied at bolts 1, 6, 11 and 16; the average force for these bolts average only about 1/8 of the maximum. All other bolts average about 1/2 of the maximum.

EXAMPLE OF BOLT TALK WHEN TIGHTENING UP FLANGES



This chart shows the variability of compressive force for 20 bolts, all of which are tightened to the same torque following a star pattern. Maximum compressive force is applied at bolts 5, 10, 15 and 20. With single-pass tightening, minimum force is applied at bolts 1, 6, 11 and 16; the average force for these bolts average only about 1/8 of the maximum. All other bolts average about 1/2 of the maximum. It is important to note that with multi-pass tightening, the final value for each bolt is higher than with single pass tightening, and the range between the maximum and minimum values is much narrower. The minimum value is about 2/5 of the maximum, and all other bolts average about 7/10 of the maximum.