GASKET STANDARDIZATION:
IT’S NOW BECOMING A REALITY IN
THE CHEMICAL PROCESSING INDUSTRY

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Abstract
A recent survey of leading North American chemical processors indicated that 80% of those surveyed feel that gasket standardization is a highly important objective. To them, standardization means one gasket that can be used anywhere, and is suitable for almost all flange sealing applications.

This white paper addresses trends in gasket standardization in chemical plants. The potential savings in cost, inventory reduction, easier installation procedures and safety factors are covered. Also examined are the technical issues that have hindered gasket simplification and standardization up until now. These include understanding pipe gasket needs versus equipment gasket needs, the inability to quantify the cost savings, plus the fact that no single gasketing material has met all or most performance criteria. Statistical data from the PVRC (Pressure Vessel Research Council) and other sources is included for illustration.

Finally, this paper outlines the steps chemical processors can take to achieve success in standardization. In fact, with the right gasketing material, standardization for the three main types of chemical process piping systems – steel, glass-lined and FRP – is achievable.
Introduction

Responding to global economic pressures, U.S. industries are continually looking for different ways to become more competitive. For manufacturers in the CPI, this means finding new methods to economize and streamline production processes and costs. This has brought about the adoption of new technologies and simplified procurement processes, leading in turn to standardization of the raw materials used in a process. Manufacturing and maintenance simplification, as well as inventory reduction, are goals for manufacturers.

As process optimization trickles down from the more expensive items, it is reaching into all corners of processing plants that handle chemicals and other aggressive media. We are seeing a definite trend in the CPI towards standardizing on materials. Higher-cost items such as pumps and piping systems have seen the rapid advance of standardization. Now the ball is moving towards standardization of smaller process components, such as mechanical seals, bearings, O-rings, gaskets, and even nuts & bolts. Every one of these categories has unique standardization challenges. The remainder of this paper will focus on gasket products.

Gasket Standardization in the CPI

Gasket standardization is one of the challenges now being addressed by chemical plants and process units. From market research conducted by W. L. Gore & Associates, Inc. among leading North American chemical processors, it was found that approximately three-fourths of the companies interviewed have a gasket standardization effort in place. In most cases, the processors have standardized on a specific gasketing material for each of the three main CPI piping categories – steel, glass-lined, and FRP – while also allowing for some exceptions due to abnormal application requirements. Among the gasketing experts interviewed, 80% view gasket standardization is a top-level or highly important activity.
What does gasket standardization mean in terms of an “ideal world” to these practitioners? It means this: a single gasket that can be used anywhere, and is suitable for practically all applications.

Unfortunately, the world today is not ideal. Thus, the efforts have generally been to *reduce* the number of materials rather than to *standardize* on a single gasket material. Several gasket materials available today may be categorized as one material for a pipe class (e.g., for FRP, for glass-lined steel, or for steel piping) but a single material that meets the needs across classes has been difficult to identify.

**Attempts to Standardize**

Gasket standardization is more easily achieved with process piping as opposed to process equipment. The reason for more difficulty in standardizing with process equipment is that many of the equipment vessels in use today have been in place for 15 years or more. The equipment applications themselves are less standardized. Also, with equipment flanges, “trouble-mode” applications are encountered more often. In these cases, an engineer on the scene must make a quick decision on what kind of gasket will solve the problem. With equipment flanges, standard sizes are not often encountered. There can be many different flange sizes – varying from several inches in diameter up to 84 inches. In addition to non-standard sizes, complex shapes and specialty flanges are often found.

On the other hand, piping system flanges are typically standard sizes (most being 1 to 24 inches). Furthermore, there are generally far fewer problems experienced in pipe sealing, since piping is more frequently and easily replaced. The concept of standardizing gaskets for piping systems – while recognizing that gasket specialization will continue for equipment flanges – is commonly accepted as the “real world” scenario by plant operations and maintenance personnel.
Cross-Purposes?

Even while the industry is focused on streamlining and standardizing, there has actually been a proliferation of gasket material offerings. Each of these choices comes with its own chemical compatibility and pressure/temperature limits. Considering the complexity and potential confusion that accompanies proliferation, this can cause extra costs for operators. There are procurement and inventory costs for multiple materials ... technical testing and evaluation costs ... management costs ... and, of course, failure costs.

Despite process safety measures, a leakage resulting from installation of the wrong gasket is still all too common. With the many colors of gaskets, remembering which color to choose for each service is also an issue. Today’s millwrights and maintenance crews must keep all of this straight, in order to avoid major leak incidents and unexpected plant shutdowns.

Simplifying Processes with Gasket Standardization

Because piping comprises 75% of all gasketing needs, if piping gaskets can be standardized, surely the economic incentive is there. Through simplification and standardization, there would be sizable inventory savings, fewer ordering mix-ups, less time spent in specification development and material testing, and a smaller number of failures due to installation of the wrong gasket.

Standardization can also allow for more efficient procurement procedures, such as centralized purchasing and the enabling of more competitive cost bidding practices.

Indeed, the American Production & Inventory Control Society (APICS) has estimated that the cost of administering a single purchase order runs from $75 to $150. Coupled with other costs, total inventory carrying charges can range from 20% to 36% of total annual gasket expenditures. Published data and counsel from some of Gore’s own customers has shown that gasket standardization could reduce inventories by as much as 60%. Inventory carrying
costs could be reduced significantly, and ongoing order frequency reductions could produce additional savings of up to 3%.

Based on this data, we estimate that if a plant were to standardize on one gasket for all non-metallic gasketing needs, it could manage with an average inventory of 15% to 20% of annual usage. This is much lower than the current gasket inventory levels at most plants today.

**Part of a Larger Strategy**

Beyond the numbers, the strategic benefits of standardization are significant. Today, cost-effectiveness is integral to the strategic plans of all plants in the chemical process industry. Gasket standardization can help unlock the long-term strategic value that plants are seeking. Not only will the lowest procurement cost to seal a flange be achieved, but also the total “lifetime cost” of sealing will be optimized and will produce continuous annual cost savings.

Gasket simplification of the type envisioned here would facilitate system-wide standardization across piping classes – metal, plastic and glass-lined – while reliability and safety would be increased. A PVRC (Pressure Vessel Research Council) study from the mid-1980s showed that the average plant experienced 180 leaks per year, with 2% being serious enough to cause a process shutdown or worse. Knowing that the primary causes of leaks are improper installation of gaskets and use of the wrong gasket for the service, it’s not hard to conclude that installation effectiveness would be positively impacted with a standard gasket. In the final analysis, gasket standardization is a “win” for every function that is now involved with gasket selection, acquisition and use.

**Technical Hurdles**

While technical advances continue to be made in gasket technology, there is still no single material available that meets all of the criteria necessary for gasket standardization. Such a gasket material would need to have the largest possible operating window (handling the ranges of process pressure and temperature).
Approximately 95% of all process piping systems operate at less than 450°F and 1,000 psi internal pressure. Thus, to enable standardization, the gasketing material must withstand as close to 100% of these operating parameters as possible. This gasket material must achieve a bolt load retention that emulates graphite, perhaps the best material in this regard. It must also have the tightest sealing and lowest emissions, as well as the greatest safety against blowout.

In other words, it should be the most reliable gasket! It must work effectively and deliver this performance across all three piping classes. It must meet the needs of glass-lined, FRP and steel pipes, as well as supporting the full range of 0-14 pH service and low stress-to-seal systems.

Now, add to these performance qualities the issue of economics. With cost reduction being a primary driver of standardization, this gasket material must be cost-competitive at time of initial purchase if it is has any hope of becoming a standardization “flag bearer.” Gasket experts who value standardization and desire one gasket material to work in all applications qualify their opinion with this statement: “Whatever meets all of these criteria must also be reasonably priced and cost-effective to use.”

What they’re essentially saying is, “Give me the most advanced technology on which to standardize, and give it to me at the price I currently pay for gasketing.” This is a tall order, and goes against the grain of normal practices associated with technology improvements.

There are yet other factors affecting the drive to standardize. For one thing, it’s often difficult to quantify strategic cost savings. It may be easy to see the procurement cost savings, but what about the savings that result from reductions in inventory bins? Reduced testing and specification development? Reduced management oversight? Once companies get a better handle on these costs, they can more effectively judge the total benefits of standardization.

In addition, most chemical processing plants have already gone through the arduous (and costly) process of developing pipe gasket specifications for
each piping class or individual process units. Naturally, they view changing specifications as a challenging initiative (the technical personnel needed for the activity typically already stretched thin). Plus, from a practical standpoint, changing material specifications can be problematic and costly.

**Techno-Economic Challenges**

What gasket standardization really boils down to is this: finding a technically advanced material that will fit virtually all piping classes under all application parameters, at a competitive price. In addition to affording the largest operating zone – as defined by temperature, pressure, and type of fluid – any technically advanced gasket material must have the largest “safe installation window.”

When various gasket materials on the market today are examined in terms of the gasket stress required to achieve a gas-tight seal (T-3 seal), each material has such a window. That window is defined as the minimum stress needed to obtain the seal and the maximum stress, above which further torquing will not improve the seal. This is the gasket’s “safe installation window.” CSF and ceramic-filled PTFE have the narrowest safe installation windows, while expanded PTFE has the widest window. However, for any gasket material to be considered for piping system standardization, its safe installation window needs to be even wider.

What users are looking for in a gasket material worthy of piping system standardization is one that fits all of the above criteria, plus has the greatest resistance to creep, the lowest emissions, and the strongest blowout resistance. It needs to be the world’s most reliable and safest chemical service gasket. Adding competitive price to this product package, you achieve the third leg of the stool: standardization.
Meeting the Challenge

W. L. Gore & Associates, Inc. has developed a new ePTFE processing technology that has produced a new gasket material. This product has greatly improved creep relaxation properties and high tensile strength, which makes the gaskets resistant to blowout at temperatures above 600°F and internal pressures of 2,900 psi. By combining this new ePTFE technology with GORE™ TriGuard® gasket construction, Gore has created a low stress-to-seal 100% PTFE gasket that is the most creep and blowout resistant of its kind. The name of the product is the GORE™ Universal Pipe Gasket, and it is now on the market. In fact, numerous chemical processing plants in North America and Europe have been using these gaskets with very good success over the past 18 to 24 months.

Moreover, technical testing by Gore and by third party laboratories demonstrates how this new gasket is breaking down barriers of performance:

Bolt Load Retention Test

The Bolt Load Retention test is an internal Gore test method for determining retained gasket stress after a specified dwell time at elevated temperatures. The percent bolt load retention (%BLR) is calculated by dividing the final stress after cool-down by the initial gasket stress. The bar graph (Fig 1.) shows results for this gasket when compared to other available gaskets. Test gaskets were a 2” NPS class 150 ring gasket (1/8” thick). They were subjected to 8,000 psi stress at 100°C for an eight-hour dwell time.
Sealability-ROTT Testing (Room Operating Temperature Testing)

The ROTT (Room Temperature Testing) test method (developed by the PVRC) is intended to characterize the tightness behavior of PTFE-based gasket materials for sealing and operating conditions. The ROTT test will produce the new PVRC gasket constants $G_b$, $a$ and $G_s$ related to a tightness parameter $T_p$, representing the mass leakage rate and internal pressure. (see Fig 2.)
Since the ROTT test procedures were designed for determining leak rates at relatively high gasket stresses, Gore, in conjunction with TTRL (Tightness Testing & Research Laboratory), developed a low-stress version of the ROTT test. This modified version evaluates the tightness behavior of gaskets in fragile flanges such as glass-lined steel and FRP. The new test, named the Low Stress Leak Tightness Test (LSLT), is a modified version of the ROTT test, and it is intended to characterize adequately the gasket tightness behavior in low stress applications. The low stress leakage test is performed with an internal pressure of 100 psig (helium) and measured through a stress range of 250 to 4,500 psi. The modified ROTT test results (LSLT) for the GORE™ Universal Pipe Gasket are displayed. (see Fig 3.)
Blowout Safety

The Hot Blowout Test (HOBT) test method, also developed by the PVRC, is designed to measure PTFE-based gaskets as to their margin of safety against blowout. The HOBT test gauges PTFE gasket tightness performance under extreme relaxation conditions. HOBT1 and HOBT2 procedures have been used. The gasket is loaded to an initial stress of 5,000 psi and then heated to 450°F. Once at this temperature, the internal pressure is ramped up until blowout occurs or until the maximum pressure of 2,900 psi is reached.

When this test was administered, a competing filled PTFE material exhibited blowout when the internal pressure reached 1,900 psi. In contrast, the GORE™ Universal Pipe Gasket did not experience blowout at 450°F and 2,900 psi during the tests, so the temperature was increased and pressure maintained until
blowout did occur – at 682°F. (see Fig 4.) The significantly higher blowout resistance of the gasket is a result of the improved mechanical properties that result from Gore’s new ePTFE technology.

Figure 4

Blowout Resistance (Tensile Strength)

The Blowout Resistance test method covers the determination of tensile strength of certain nonmetallic gasketing materials at room temperature. Organizations such as ASTM do not grant approvals for materials. Instead, they issue standards and guidelines for their selection and use. Gore’s Sealant Technologies Group is experienced in conducting this type of testing. The new GORE™ Universal Pipe Gasket material was tested against other PTFE based products. Comparative results are given in the following chart.

High-Temperature Aged Leakage Relaxation Test (HALR)

The HALR test method (developed by the PVRC) is intended to characterize the creep relaxation and leakage behavior of gasket materials after exposure to elevated temperatures. In this case, only the creep relaxation portion of the test protocol was performed. The gaskets were loaded to an initial stress of 5,000 psi,
and then exposed to 600°F for 96 hours. The residual gasket stress was calculated after the fixture cooled to room temperature. *(See Fig 5.)*

**Figure 5**

![Residual Gasket Stress](image)

The HALR test results demonstrate the improved creep relaxation performance of the GORE™ Universal Pipe Gasket. It retains more of the initially applied gasket stress than any other ePTFE or PTFE-based gasketing, and it performs comparable to that of graphite, even at elevated temperatures.

**Future Direction**

The practical test, of course, is how well the gaskets perform in “real world” applications. GORE™ Universal Pipe Gaskets are now being adopted in a growing number of chemical processing facilities, with extended field trial results in actual applications becoming available. As these are completed we are planning to share these results with the CPI, so that we can continue to
document the encouraging progress on the road to making gasket standardization no longer a dream, but a reality.

**Sidebar Article:**

O.K., I want to implement gasket standardization. How do I go about it?

Just the idea of going through a gasket standardization effort may seem daunting! The typical chemical processing facility may use from five to as many as a dozen different gasketing materials. Not to worry! In fact, the process can be broken down into several important but relatively simple steps:

**Step 1: What kind of piping do I have?** Conduct a review of all the piping systems in your facility, including FRP, glass-lined steel, and steel. How much of each do you have, and how many flanges are involved? The difference in piping is important. Glass-lined steel is used for aggressive chemicals. Because it is easily damaged if too much torque is applied, it requires a gasket material that can seal at low bolt loads, plus is dimensionally stable in width yet conformable in height. FRP piping is similar to glass-lined steel, but without the macro deviations to the flange. It requires a conformable material – often an elastomer gasket – which can accomplish a gas-tight seal at very low stresses (below 1,500 psi). By contrast, steel flanges can be used with any material, because high stresses can be applied. Standardization within steel allows for uniform stress across all piping systems, but the key is standardizing on a high-performance material to eliminate any “weak links” and improve the overall reliability of your piping system.

**Step 2: What gasketing materials am I using now?** You might be surprised at the number of different materials that are currently being used. You could
identify several gasketing materials being used in each type of pipe flange, such as:

**FRP Piping**
- PTFE envelope elastomer
- Elastomer
- Filled PTFE
- Expanded PTFE

**Glass-Lined Steel Piping**
- PTFE-enveloped compressed synthetic fiber
- Expanded PTFE

**Steel Piping**
- Filled PTFE (silicone, barium sulfate, or glass)
- Graphite
- Compressed synthetic fiber
- Skived PTFE
- Expanded PTFE
- Metallic gaskets (e.g., spiral wound)

Sealing different pipe diameters has no bearing on the gasket materials you use; the key is the right type of gasket material for the type of piping. Don’t neglect special considerations for situations such as highly toxic fluids, slurries, or sanitary processing, where the choice of gasket material really makes a difference in chemical inertness, purity, high tightness, and low stress to seal.

**Step 3: How can I reduce the number of gasketing materials I use?** The goal here is to go from as many as ten, to as few as two. Typically, you’ll want to divide your processes into those that are below 600°F and those that are above, as well as those processes that generate less than 1,500 psi internal pressure versus those that generate more. Another consideration, affecting hydrocarbon processing in particular, is the strict requirement for fire and blowout protection. Make sure you select a gasket that seals properly at low stress levels – gas tight at 100 psi internal pressure at a gasket stress of 250 psi – and can successfully seal all applicable piping gas tight according to the manufacturer’s recommended
torque. This will greatly simplify maintenance based on piping glass, not on the gasket material used.

**Step 4: Ask your gasketing suppliers for guidance.** Gasket suppliers are often a very good source of information about the performance characteristics of the gasketing products they supply. Another source is the manufacturers themselves. The answers to the following questions will help you narrow your gasketing materials down to just a few which will meet all of your sealing needs:

- *For what types of piping is the material suitable?* Many gasketing materials will not be suitable for all the piping that you have in your plant.

- *Can I use this material for all chemicals?* Which ones aren’t acceptable?

- *What is the maximum temperature and pressure the material is good for?* Above 600°F/below 600°F, Above 1,000psig/below 1,000 psig. (All 150# and 300# class flanges.)

- *Is the material Metallic?* (i.e., flammables and high-temp/high-pressure applications ... blowout-safe and fire-safe gaskets.)

- *... or Non-Metallic?* All services except those with criteria above (for non-metallic gaskets capable of above 1,000 psig using 600# and 900# class flanges, you should contact the manufacturer for specific installation instructions).

- *How well does this material seal at low stress levels* (e.g., below 1,500 psi)? What stress is required to achieve a T-3 gas-tight seal? This information is particularly important when considering glass-lined and FRP flanges.

- *What is the leak rate capability of the gasketing relative to alternative materials?* This information will provide the gross leak rate at certain stress levels, which will help you confirm the tightness of the seal that is achievable and can aid in claiming overall emission reduction for pipe flanges once standardization is implemented.

By following the steps above, you’ll likely reduce the number of gasketing materials used in your facility, simplifying your life and reducing complexity and risk – along with streamlining your administrative and inventory control costs.
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