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Both spiral-wound and kammprofile gaskets are used extensively in refineries and petrochemical plants for applications subject to thermal cycling, pressure variations, flange rotation, stress relaxation and creep. In recent years, however, there has been a discernable shift away from the use of spiral-wound gaskets in favor of kammprofiles, which tend to provide better sealing performance and longer service life.

Spiral-wound gaskets were developed to improve performance in high-pressure applications ranging from flanged pipe connections to heat exchangers. Consisting of alternating plies of compressible filler material and thin-gauge metallic strip wrapped phonographically, spiral-wound gaskets provide the requisite pressure resistance in these applications (Fig. 1). In the 1980s, alternative materials such as flexible-graphite replaced asbestos as the filler in these gaskets, yet their basic design has remained unchanged since they were invented in the early 1900s.

Initially, these gaskets were centered using a length of wire looped over two opposing studs in the flange, commonly referred to as a loop winding (Fig. 2). Today, the most common method for centering a spiral-wound gasket is a metal outer ring. This outer guide ring serves to center the gasket in the flange and limit its compression. If the sealing surfaces are compressed against this centering ring (and no inner ring is present) a metal-to-metal seal may be formed. This is acceptable provided the flanges remain at a steady temperature. However, when gasket assembly stress cannot be adjusted to accommodate upset conditions or thermal cycling, the seal may be subject to premature failure. This is especially true when graphite fillers are used without inner rings. In addition to its performance-related functions, the outer guide ring also serves to identify the size, pressure class and material composition of the gasket.

Spiral-wound gasket dimensions for ASME B16.5 and B16.47 flanges are delineated in ASME B16.20 (Metallic Gaskets for Pipe Flanges). The outer guide ring is dimensioned to center the gasket in the flange off the inner edge of the bolts, allowing it 1/16 in. of radial movement in the flange. The ASME B16.20 specification also provides generally accepted sealing-element dimensions.

Functionality and troubleshooting. During gasket installation the filler material extrudes from between the alternate metallic plies to create a seal against the flange surfaces, including any imperfections. Gasket failures can result from either gasket under- or over-compression.

Vulnerabilities. Increasingly, spiral-wound gaskets are being supplied with inner rings as well. If not, there is a greater risk...
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that the gasket windings will buckle inward, limiting the load that can be applied and maintained on them (Fig. 3). The damaged inner windings can contaminate the system or damage downstream components. Even if the windings are properly loaded, the graphite can move and the gasket relax as the bolted connection heats. As a result, the gasket can lose the stress required for the seal integrity. In some cases, highly loaded windings can also cause buckling of the inner ring itself if it is not wide enough.

In addition to density and compression, ease of handling can be an important factor in selecting the proper gasket for a particular application. For example, installing a gasket in a confined space or 20 feet in the air can pose a number of challenges. Spiral-wound gasket windings are particularly susceptible to damage, “springing” when bumped, dropped or otherwise mishandled. Large spiral-wound gaskets can be especially difficult to handle since the windings have a tendency to pop out. In addition, they are sometimes hard to seal since the initial winding density can be so low that the guide rings are contacted before the windings are properly loaded. If the gasket is unloaded, the windings can come apart like a spring (Fig. 4).

Kammprofile gaskets. Kammprofile gaskets were developed in Europe, where the original grooved cross-section was developed in Germany and standardized in DIN 2697 nearly 40 years ago. Designed as an alternative to both traditional metal-jacketed and spiral-wound gaskets, kammprofiles have seen increased use in the US for the past decade and are displacing spiral-wound gaskets in many systems. Although the original design has been modified over the years, it is relatively simple:

FIG. 3 Spiral-wound gaskets without inner rings can buckle, limiting the load that can be applied and maintained on them.

FIG. 4 Improperly or unloaded spiral-wound gaskets can come apart like a spring.

FIG. 5 Kammprofile gaskets feature a serrated metallic core with soft, conformable materials bonded to both sides.

FIG. 5A Kammprofile gaskets feature a serrated metallic core with soft, conformable materials bonded to both sides.
a solid metal core with concentric serrations and faced with a nonmetallic material such as flexible graphite or various grades of PTFE (Figs. 5 and 5A). When the gaskets are installed, the soft facing material is forced into the metal core serrated grooves. The compressive stress increases the facing material density within the grooves and multiple, concentric high-pressure seals are created across the gasket face. These gaskets can be configured simply as a profiled and faced ring, or they can incorporate an outer ring, much like a standard spiral-wound gasket. This outer ring can be integral to the core metal or a separate, floating ring.

Kammprofile gaskets offer the advantage of sealing at a relatively low seating stresses. Radial shear tightness (RAST) testing at TTRL in Canada showed these gaskets to seal reliably down to 4,000 psi seating stress, but some users consider 6,000 psi as an absolute minimum. Suggested gasket stress is generally in the range of 10,000 psi to 40,000 psi. Kammprofile gaskets can also maintain a seal under extremely high seating stresses. In Europe these gaskets are replacing jacketed and clad gaskets in pressure vessels and heat exchangers, where it is difficult to achieve and maintain sufficient gasket seating stresses due to differential thermal expansion between sealing surfaces.

**Kammprofile vs. spiral-wound gaskets.** Kammprofile pipe flange gaskets compress significantly less than spiral-wound gaskets, on the order of 0.022 in. compared with 0.030 in. to 0.075 in. for a spiral wound. This means kammprofile gaskets load more quickly with less risk of nonparallel flanges. One disadvantage is that the graphite facing is more susceptible to mechanical damage if not properly handled. Since the graphite is not protected by the windings as it is in spiral-wound gaskets, it also can be damaged by oxidation at temperatures between 600°F and 800°F depending on the grade of graphite. (Higher temperatures may be possible by including a mica-based layer around the OD to protect the graphite.) It is, therefore, recommended to specify good-quality, inhibited graphite when using these type gaskets.

In the case of ASME/ANSI flanges, the faced portion of the kammprofile ring is the same for any given flange size regardless of pipe class. However torque values for different pressure classes must be adjusted to obtain consistent gasket stresses since stud number and size will vary (Table 1). Unlike a spiral-wound gasket, all of the compressive force is transmitted directly onto the kammprofile graphite facing, resulting in a very tight seal. Since the kammprofile is solid metal as opposed to alternating plies of metal and filler, it is extremely stable and easy to handle even in large diameters.

Kammprofile gaskets are significantly more expensive than spiral-wound gaskets, but can help avert costly, unscheduled outages and downtime. When properly manufactured, both gasket types provide reliable seals. Spiral-wound gaskets may have a slight advantage if the flanges are extremely close together, and the gasket might be susceptible to mechanical damage during installation. Likewise, they may be more resistant to oxidation since the windings hold the graphite in place and protect it. Kamm-profiles can be more tolerant of sealing surface defects and seal more effectively in fugitive emissions services. While the choice of which gasket to use is sometimes based on properties that are specific to one or the other, often the choice comes down to personal preference. **HP**

### TABLE 1. Causes of over-and-under gasket compression

<table>
<thead>
<tr>
<th>Cause</th>
<th>Effect</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insufficient torque</td>
<td>Filler not conformed to sealing surfaces</td>
<td>Increase torque to increase gasket stress or reduce winding cross-sectional area</td>
</tr>
<tr>
<td>Insufficient available bolt force</td>
<td>Filler not conformed to sealing surfaces</td>
<td>Reduce cross-sectional area or use a kammprofile</td>
</tr>
<tr>
<td>Filler density too high</td>
<td>Problems sealing at low stud loads</td>
<td>Address gasket design with manufacturer</td>
</tr>
<tr>
<td></td>
<td>Leaks can develop if windings take the initial load and the graphite is under-loaded</td>
<td></td>
</tr>
<tr>
<td>Excessive torque/available bolt force</td>
<td>Radial buckling (especially with gaskets with no inner rings) of the windings and/or inner ring</td>
<td>Reduce torque (see gasket manufacturer)</td>
</tr>
<tr>
<td>Low-density winding-flanges contact outer guide ring</td>
<td>Reduced stress within the windings</td>
<td>Address gasket design with manufacturer</td>
</tr>
<tr>
<td></td>
<td>Leakage because gasket cannot be loaded properly</td>
<td></td>
</tr>
<tr>
<td>Filler density too high</td>
<td>Gasket will seal if compressed sufficiently</td>
<td>Address gasket design with manufacturer</td>
</tr>
<tr>
<td></td>
<td>Outer guide ring cups, warps or tilts</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Can cause inner ring to buckle and excessive guide ring roll</td>
<td></td>
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