TECHNICAL ARTICLES

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Gasket Design and Development Guide

I have been asked to create a Design Guide and have given the creation of such much thought. I have concluded that every gasket application is a unique solution to a complex set of variables which I will go into later. In light of this reality, I have decided to present not a cookbook approach, but an approach based on the parameters which must be considered in each gasket design. I will separate these sets of considerations which may be unique for new applications and reverse engineered parts. To sum it up, a gasket can be simple and service a large number of applications, but there is no simple gasket that can seal the myriad of all gasket applications.

Much of the material has already been described separately and in detail. What I will attempt to do is to fit these factors and tools into a strategy for design.

A gasket may seem like a very simple element in any application. A simple credo is that you want to use the thinnest gasket which will seal and survive in the environment. In reality, it is an element which is placed in a unique set of conditions. A simple list of these environmental conditions is as follows:

- **Fluid compatibility** is by far the most important consideration in selecting a gasket design or material. Without being compatible, the gasket will experience a breakdown of its structure, and will ultimately experience leakage and even possible catastrophic failure. There may be more than one fluid involved, as in the case of an automotive or diesel engine: coolant, engine oil (which may be contaminated) and product of combustion. For some of the more obscure fluids you will find compatibility data furnished by most O-ring suppliers, who are a good source of information. It usually lists the preferred binder to be used for a particular fluid. It is the binder in gaskets whose properties degrade in the fluid.
- **Mating elements (flanges)** which may be sturdy, such as: heavy machined flanges, cast flanges or sheet metal stampings. In terms of materials, they may range from cast iron to plastic. This element introduces the variable of joint stiffness. The stiffer these structures are, the simpler, thinner and stiffer the gasket can be. If the structures are flimsy, materials or a design with more compressibility is required.
- **Internal pressure**, whether static or dynamic, must be contained throughout the life of the joint. If internal pressures are very high, the gasket may require the use of a metal core to add radial strength or other elements such as metal grommets or eyelets to aid in containment.
- **Available initial clamp load** is generated usually by torque being applied to threaded fasteners about the periphery of the joint. In one of my previous articles for GFA, I said that "it really takes load to seal any application." This is where the selection of the proper gasket type or material is important.

Any gasket material has a set of basic properties: thickness, density, fluid compatibility (usually determined by the type of binder), stress relaxation, compressibility and recovery.

The environment of your application (i.e. heat, fluid attack, vibrations, and dynamic pressures) will tend to reduce the initial clamping load. If reduced sufficiently, the gasket will leak because when the contained pressure is at its peak (highest pressure), there must be greater residual clamping pressure. If not, at the peak pressure, the joint will separate and completely unload the gasket resulting in a leak.

It is here I want to point out some of the choices the designer has to help maintain the clamping load:

- Select the thinnest gasket which will seal the application when the initial clamp load is applied. To help determine this, a variety of tools can be used, including the use of pressure sensitive films.

- Generally speaking, the thicker the gasket is, the greater the settling of the gasket, resulting in greater loss in fastener load.
- The higher the temperature of the application, the higher the loss in clamp load. The effect of internal pressure fluctuations will tend to induce settling.

I have found that the published specification sheets that gasket material suppliers provide are generally vague and with very broad ranges in values. As a designer, I have found that they will provide "typical values" or some statistical values which are more useful.

DESIGN PROCESS:

There are several levels of detail to each of several scenarios:

- Established customer with experience with gaskets. These customers already have their applications designed and determined the gasket they want. This is commonly a partnership where you cooperatively supply sample and participate in the development. If there are problems along the way, it is best if

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you have alternatives in mind and a tool box of enhancements at you disposal to use if necessary. Those might include coatings, screen-printing, eyeleting, etc. But, keep the design as simple as possible. Enhancements should only be used as an overall cost effective solution. Enhancements cost money.

- New customer with no gasket experience but has application. This type of customer will require you to do most of the work. If it is a relatively simple application, little work on your part may be involved. If ample spaced fasteners were designed and stiff flanges are involved, you should be able to provide a solution which will suit the customer's purpose perfectly. If, however, he provided you with an imperfect application (i.e. few fasteners, short fasteners, poor spacing, low available clamp load, flimsy flanges, and his design is fixed, etc.) you will have to do some developing of the gasket. I would try to obtain hardware from the customer so that you can develop your gasket on his production parts. Use the various investigative tools available to you (i.e. pressure sensitive films, air pressure or nitrogen pressure checks) on assembled joints. This will show you the weakness in the initial gasket choice. Whenever possible, give the assembly a heat cycle (if that will occur in the final application) and check residual clamp load. These will indicate the weak points in the design and help provide direction to the final solution, perhaps using different materials, enhancements, etc.
- Reverse engineering parts, particularly for aftermarket applications. A lot of gasket fabricators now see a market for gaskets for applications out of production. The original manufacturer's replacement parts are expensive or unavailable, but there is still a sizable market for these parts.

From my own experience I want to caution you; don't try to develop your own "cheap" home-grown design for these parts, particularly when those parts might by cylinder head gaskets. Your best approach is to analyze the OEM part (preferably unused) and those of experienced major gasket manufacturers who specialize in after-market applications. Take them apart, measure thicknesses, analyze materials, etc. These parts have been successfully used for years and have history. Usually every element of the gasket was there as a solution to a particular problem and any radical deviation could be a disaster.

Also, be very skeptical of off-shore sources for replacement gaskets, as many are simply "Chinese copies" sometimes using elements totally different from the original. Consult an expert with extensive experience in the design of the particular types of gaskets.

Why Does A Joint Leak?

(Based on a passage by John H. Bickford with editing and amplification by Larry Pyle)

A joint leaks when the material being contained escapes through pores or gaps in the gasket material, or escapes around the gasket or across the surface. Persistent leaks through a gasket can often be reduced by a change in gasket material or type. Often it helps to coat the gasket with a gasket compound or coating of some type. Frequently, where very little seepage can be tolerated, such in a gasket sealing Freon, the gasket may be soaked in a liquid such as mineral oil to close off the internal pores.

Eliminating leaks around the gasket is a more difficult job. It is not just a question of eliminating major openings or gaps between gasket and flange surfaces. This would be relatively simple to do in most cases with the use of coatings. Otherwise, we must maintain sufficient contact pressure, usually called gasket stress, between the flange and gasket surfaces. Also, we must maintain this stress as bolts or gaskets relax, and as the temperature and pressure of the contained fluid or gas change.

We generate the contact pressure by tightening the bolt or studs that hold the joint together, tightening them enough to create intimate contact between gasket and joint surfaces. Non-uniform tightening can distort the joint members and/or the gasket, opening leakage paths. Rough or damaged flange surfaces will also cause problems. Small leaks allowed by these conditions will often erode and/or corrode the leak path, ultimately increasing the leak rate.

Remember: **Every gasket leaks, it's only a matter of degree**. Some industries measure leakage rates with various liquids (relatively huge molecules) and their seal/no seal criteria is visible leakage. Other industries where even tiny leakage is tolerated (i.e. Nuclear and Petroleum industries) leakage is measured with helium (a very tiny molecule).

If you have technical questions you would like to see answered in future issues, please send them by e-mail to lfptech@gmail.com.