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Engineered Hygienic Clamps – How Lubrication-Free clamps can ensure consistent hygienic union performance

Introducing foreign substances, like thread lubricants, to production suites can be challenging for end users and original equipment manufacturers (OEM's) supplying equipment to them. While some lubricant manufacturers have tested and advised their product is approved, such as FSA approved, food grade, or even sanitary grade, users have the option of using one of the tested or approved materials, using simple, metal-free liquids, like glycerin, or possibly nothing. With the continual development of new products and processes, the interaction of, or potential contamination from, a new lubricant can be too much of a risk to take, so the lubrication may be omitted. This scenario will be the basis for our article.

We will first review how uniform gasket compression is paramount to successful sealing and longevity of hygienic unions. At the core of our discussion, will be a review of common clamp component materials with their applications, and then common customer practices, including some of which that had previously proven to be detrimental to their success of a given process. In "Engineered hygienic clamps — how precision gauging leads to hygienic union reliability and product quality", *Processing Magazine*, March 2021, the discussion is more detailed than the review below, but at that time, stopped short of discussing torque in detail. In this article, we will review various clamp choices, installation, tightening, proper torque techniques, and special materials that had previously been considered overkill for common applications, but are now more cost-effective than ever.

The industry and standards organizations, like ASME BPE[(1)], have standardized geometry for hygienic ferrules and have categorized gasket intrusion. Clamps, however, are not standardized, so the user of the equipment is left to determine what type of clamp to use, as well as how to use it. Truthfully, with the variation in customer application requirements and different levels of tolerance for process variability, or in other words, the degree of process repeatability required, customers will always have a role in clamp application, installation, maintenance, and replacement frequency. In the end, the goal is to define performance and its level of predictability, so the user can be confident that they are meeting the goals of their system, and in doing so, will maximize both their efficiency and their output.

One attempt at standardization came in the form of pre-defined torque values. Here, we immediately stumble getting out of the starting gate because of the perception that achieving a specified torque means achieving your sealing goals. Unfortunately, "Torque ≠ Tight" , but we will forge forward using torque, since it is one thing that can easily be measured. Let us review why using torque presents a challenge. The issue with torque values comes from the assumption that all conditions leading up to the application of torque are consistent. The assumption includes materials of construction for the ferrules (or clamp connections), the gasket, and the clamp are consistent with those used by the manufacturer when defining the torque value. See Figure 1.

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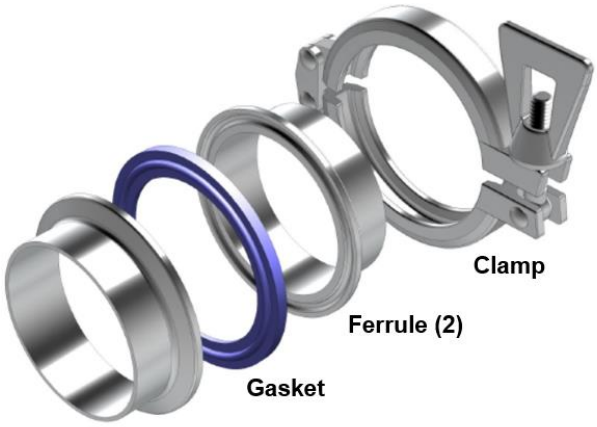

Figure 1: Typical Hygienic Union

The next assumption is that the parts, if not the same, are also designed the same way as the parts used in testing by the manufacturer. This includes key elements of the clamp that contribute to how the force transfers from the nut to the clamp, and ultimately to the seal. For argument's sake, let's say that everything above is exactly the same. The next variable is thread lubrication. Thread lubrication is used because it reduces friction. Friction is important because it decreases the force transferred to seal the gasket in the union at a given torque. Lubrication is introduced by the customer. Some environments limit the lubrication used, limit the amount of lubrication used, and then others prohibit the use of lubrication entirely. Then, if that were not enough, some clamps are cleaned with various CIP solutions, or tossed into a sterilizing process, which can leave a residue or very small particulate on the parts, including the threads. This can then impact the friction within the threads. At every turn, a variation in lubrication has an impact on the net force on the seal.

Now that we are acquainted with the challenges presented by process, product, and customer requirements, we can address ways to mitigate their impact and maximize performance predictability.

Figure 2: Block "A" Profile

Physical design features can decrease the impact of differing system geometries and alignment variations. The GRQ Engineered Hygienic Clamp's design features an open Block-A profile and abbreviated internal angular segment, shown in Figure 2, which seak a higher gauging point on the

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clamped surfaces while helping to align the components in the hygienic union. In Figure 3, we highlight the multiple pivot points of the GRQ's cast double-pin hinge that enables the clamp to encompass the union and pull the two halves together evenly to obtain ***uniform gasket compression***, minimizing variations in gasket load and potential intrusion.

Figure 3: Double-Pin Hinge (Wing Nut)

By aligning and then compressing the union evenly, the GRQ clamp transfers the maximum amount of force to the entire gasket evenly, creating a seal with as little force as possible. The next step is to transfer the force from the nut to the clamp. The GRQ clamp's flat-bottomed nut engages the clamp's flat-bottomed recess in the fork, or arm, while sitting in the flat top surface to ensure proper alignment and evenly distributed load transfer to the fork of the clamp. This feature eliminates any wasted, angular force that could pry the clamp arms apart, and increase the amount of torque needed for a given gasket force.

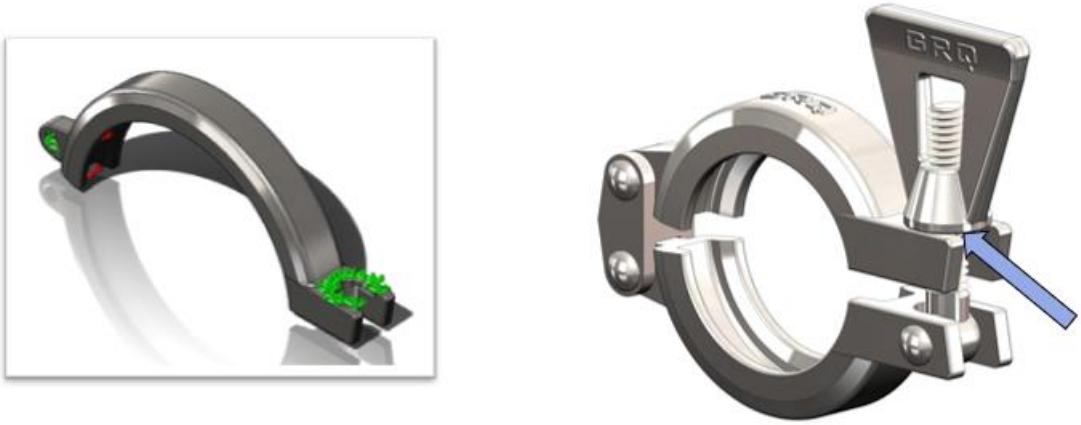

Figure 4: Even stress of flat nut seat/pocket on the clamp segment, and flat bottom wing nut

With the physical attributes of the hygienic union aligned to make them consistent from union to union, the last variable for which to account is force transfer from nut to clamp. This brings us back to

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the greatest variable in our sealing system, the customer's lubrication practices. One fact is undeniable. The omission of an anti-seize material WILL limit the life of a fastener, as will the other elements, such as dust and residue from cleaning solutions, often mitigated by lubricants. However, we must continue to eliminate variables, so lubrication, if not used by all, must be removed from the equation.

We conducted tests with different materials and did not use any lubrication for the threads. The tests included crosses and ferrules from different manufacturers. All gaskets were James Walker® Elast-O-Pure EP75, EPDM. All clamps were GRQ engineered hygienic clamps made of 304SS, including the swing bolt. Hex nuts used were made of two different materials, 316SS and UNS21800 (Nitronic® 60), which we will call "N60". Hex nuts were used instead of wing nuts so a recently calibrated standard industrial torque wrench with inch-pound increments could be used.

Before testing, we reviewed torque recommendations made by different clamp manufacturers. We then compared sealing areas, and based on our experience in the industrial arena, applied sealing practices that we have used for more than 100 years. In doing so, we determined that, to seal properly, the hygienic union must have different torque values for different sizes and not just for different gasket materials. The final table was not available in time for article submission. Details will be published on our website as soon as they are available.

Testing revealed that, as expected, torque values required to achieve desired compression were higher than those recommended by most clamp manufacturers. The torque values required by the 316 SS nut on the 304 SS clamp were 33% higher than the torque of the N60 nut on the 304 SS clamp to achieve the same compression. The comparison was made by measuring the space between the arms of the clamp. Repeated torquing of the 316 SS nut on the 304 SS clamp assembly also began to exhibit metal shaving release on the swing bolt threads within the first 30 cycles, while the GRQ Lubrication-Free Hygienic Clamp with a N60 nut on the 304 SS clamp had not, at over 4 times the cycles and counting.

To verify we were not alone in our observations, and that our data was consistent with others, we sought details from metal manufacturers. Gall resistance was the reason for creating Nitronic 60. Austral Wright Metals[2] recorded test data, from which we created the data below in Figure 5.

Threshold Galling Stress, psi (Mpa)

Grade	Condition	Hardness (RB)	Units	303	304	316	Nitronic 60
303	Annealed	153	psi (Mpa)	2,031 (14)	2,031 (14)	3,046 (21)	+ +
304	Annealed	140	psi (Mpa)	2,031 (14)	2,031 (14)	2,031 (14)	+ +
316	Annealed	150	psi (Mpa)	3,046 (21)	2,031 (14)	2,031 (14)	38,000 (262)
Nitronic 60	Annealed	205	psi (Mpa)	+ +	+ +	38,000 (262)	+ +

+ did not gall at stress highests test data point, 50,000 psi (345 MPa)

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Figure 5: Unlubricated Galling Resistance of Stainless Steel

In the table, no value is shown for Nitronic 60 combined with 304 SS, the materials used in the Lubrication-Free Hygienic Clamp. This is because the testing was stopped prior to finding a value to record, which means galling resistance is maximized when combining Nitronic 60 with 304 SS, even without lubrication.

Applying a specified torque with consistent geometric alignment, the same seals, and under controlled conditions, will result in consistent force applied to achieve the desired seal of the hygienic union. With this, one can achieve predictable performance. It is ***predictability*** and not simply having "no leak", that is our goal in all applications. Along the way, we will continue to work toward achieving predictability in all applications and to maximize expected component life in those applications. For now, we believe the most consistent solution is the GRQ Lubrication-Free Hygienic Clamp with either the wing or hex style nut.

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(1) ASME BPE = American Society of Mechanical Engineers standard for Bioprocessing Equipment
(2) Austral Wright Metals, www.australwright.com.au

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