Engineered Elastomers for Use in Demanding Applications

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1 ABSTRACT

Recent advances in elastomer technology are empowering users to increase productivity, reduce downtime and, reduce total maintenance costs. To ensure that the appropriate and most technically advanced elastomer is being used, a basic understanding of elastomer properties is required. This basic elastomer understanding will allow the users to set an achievable safety factor by upgrading the elastomer. This report is a first step approach to educate original equipment manufacturers and end users on recent elastomer advances. Armed with this knowledge, users are encouraged to work with seal manufacturers to appropriately match new elastomer technologies with application needs.

2 INTRODUCTION

Sealing technology has continued to advance in recent years, changing from off-the-shelf consumable commodities to highly engineered products. As asset uptime and environmental requirements become more and more demanding, the need for high performance sealing materials increases. To support these evermore-demanding requirements, the formulation of seal materials becomes increasingly important.

3 ENGINEERED ELASTOMERS

The main goals during elastomer engineering are enhancing chemical compatibility, increasing temperature resistance and improving abrasion resistance. Together, these properties will create a solid foundation for a superior sealing solution that will increase seal life, productivity, and lower total maintenance costs. Thus, the realizable value received from the sealing solution increases significantly, which empowers users to increase productivity, reduce downtime, and reduce total maintenance costs.

For industrial sealing applications, three elastomers are commonly used; Mill-Right® N (NBR), Mill-Right® ES (HNBR) and Mill-Right® V (FKM). These elastomers were engineered for a broad range of conditions, from benign to extremely harsh environments, all while focusing on mechanical and chemical performance. Hereafter, Mill-Right N will be expressed simply as elastomer N, Mill-Right ES as elastomer ES and Mill-Right V as elastomer V.

3.1 Mechanical Properties

Throughout the engineering process extensive and often reiterative testing, using predefined protocols and methods, occurs. Some of the mechanical properties measured during the elastomer testing are as follows:

- Coefficient of friction (kinetic) – the resistive force that prevents two objects from freely sliding on one another. Kinetic coefficient of friction excludes the starting breakaway force; only the resistance once an object has become dynamic is measured.
- Compression Set (ASTM D395, Method B) – the materials ability to recover from a constant applied load, which causes both elastic and permanent deformation.
- Elongation change – the increase of length, measured as a percent, from a natural state to fracture.
- Hardness – the materials ability to resist puncture by means of indentation. Typically hardness is quantified by the Shore A & D scales.
- Tear resistance – the material's ability to prevent tearing while under load.
- Tensile strength – the amount of stress the material can withstand prior to a fracture.
- Wear Index (Taber (ASTM 4060)) – the amount of material abraded during dynamic interaction of the elastomer and the test surface.
- Wear resistance – the materials ability to prevent wear on contacting surfaces.

3.2 Chemical Testing

Once the physical properties of the elastomer are achieved, initial chemical testing follows. Similar to the physical testing, the chemical testing follows predefined protocols. Examples of the chemical tests are as follows:

- ASTM 903 Oil Immersion (ASTM D471) – an accelerated test that determines the change of tensile, elongation, durometer and swell of an elastomer if immersed in a 903 oil bath for extended periods of time.
- Heat Aging (ASTM D865) – an accelerated test that determines the change of tensile, elongation and durometer of an elastomer if exposed to severe temperature for extended periods of time.

3.3 Evaluation of the Data

The testing phase of elastomer engineering yields a tremendous amount of raw data. This data is used in comparative benchmarking of the new elastomer to other high-performance elastomers. The new elastomer properties are benchmarked to a set of guidelines, which were developed using historical data and practical application experience. Essentially, the guidelines are used as "go/no go" gauges. The following are the guidelines most commonly used throughout the testing routine:

- Compression set of the material equal to or less than 25% of the original value
- Heat aging and ASTM 903 oil immersion testing
  - Point change of -10 to +10 durometer
  - Maximum tensile strength and elongation loss of -25%
  - Volume change of -5 to +15%
- Wear index improvement (no definitive value, but the closer to zero results in less wear)

Throughout the benchmarking, it is important to remember that all the properties of elastomers must be evaluated collectively and not just singularly.

4 ELASTOMER ENGINEERING RESULTS – THE DATA!

Application challenges and seal performance requirements are typically grouped into three categories; everyday normal applications, challenging applications, and harsh environments and applications. Generally speaking, the three most commonly used elastomers are paired with each category based on overall performance of the elastomer; elastomer N for everyday applications, elastomer ES for challenging applications and elastomer V for harsh conditions. It must be noted that all three elastomers are outstanding in their appropriate application. For all three, the objective was to engineer an elastomer that would experience a very limited change in performance when subjected to harsh and varying environments. Since the exact formulation of the elastomers is proprietary, the following data will be the performance advances in the elastomers rather than the actual composition changes.

4.1 Mill-Right® N

Figure 1 represents two different ASTM Nitrile (NBR) elastomer formulations measured against an ideal elastomer (no change). The NBR formulation is an example of a common elastomer used by bonded seal manufacturers. The NBR was used to benchmark the performance of elastomer N, which was engineered for industrial applications, specifically for increased abrasion resistance and chemical compatibility.

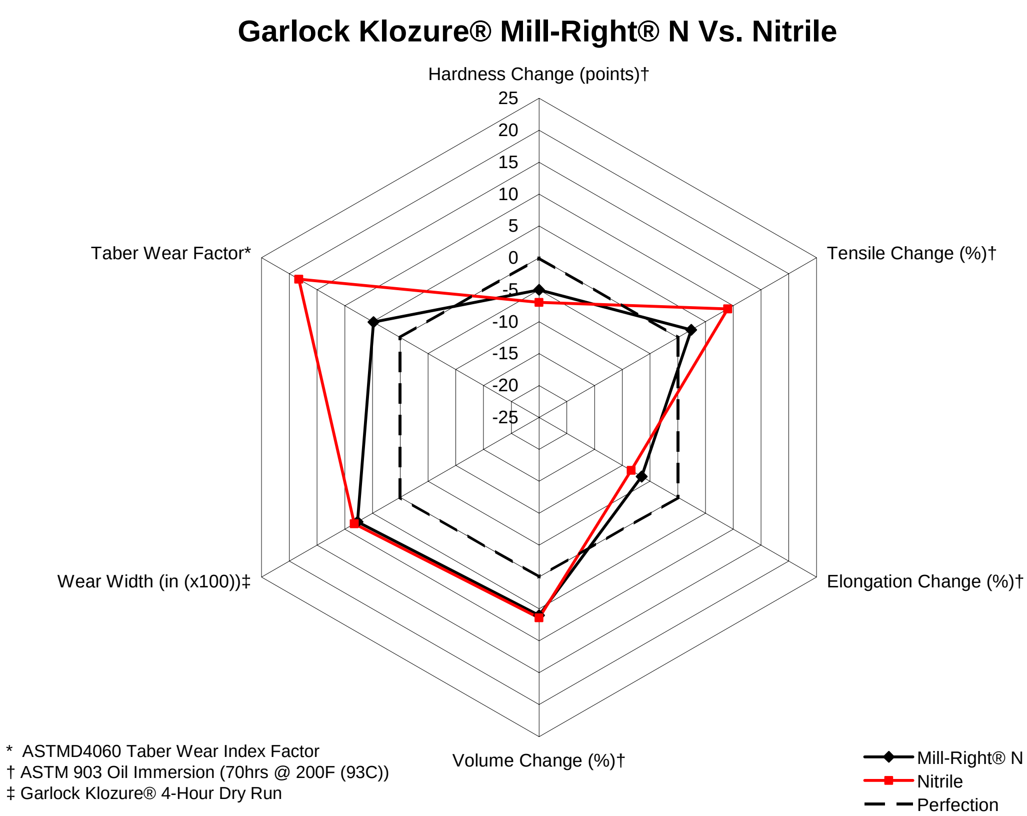

Figure 1 NBR Formulations Radar Chart

The ideal line in Figure 1 represents the most desirable outcome for materials under test; zero change for each property. The ideal line, in effect, is the engineering performance goal for all new elastomers. As Figure 1 shows, the chemical compatibility of elastomer N is much closer to the ideal line than that of NBR formulation. In addition to the enhanced chemical compatibility of elastomer N, the most significant performance increase is that of abrasion resistance. In fact, elastomer N has a seventy-four percent (74%) improvement in abrasion resistance over the NBR formulation! As a result of abrasion resistance improvement, the wear width of elastomer N is reduced at the dynamic interface (as seen in Figure 1). The dramatic improvement in abrasion resistance translates into longer life of the elastomer; the seal will last much longer than the NBR under the same conditions.

4.2 Mill-Right® ES

Similar to the above, Figure 2 represents two different Hydrogenated Nitrile (HNBR) formulations measured against an ideal elastomer, one with no change. The HNBR formulation is an example of a typical elastomer used by bonded seal manufacturers. Although the HNBR formulation performs well, the elastomer ES performs much better. The elastomer ES is an example of an elastomer designed for superior abrasion resistance and chemical compatibility. Although both elastomers fall within the ASTM HNBR classification for elastomers, the performance of both is drastically different. The elastomer classification is also true for the aforementioned ASTM NBR and the ASTM FKM below.

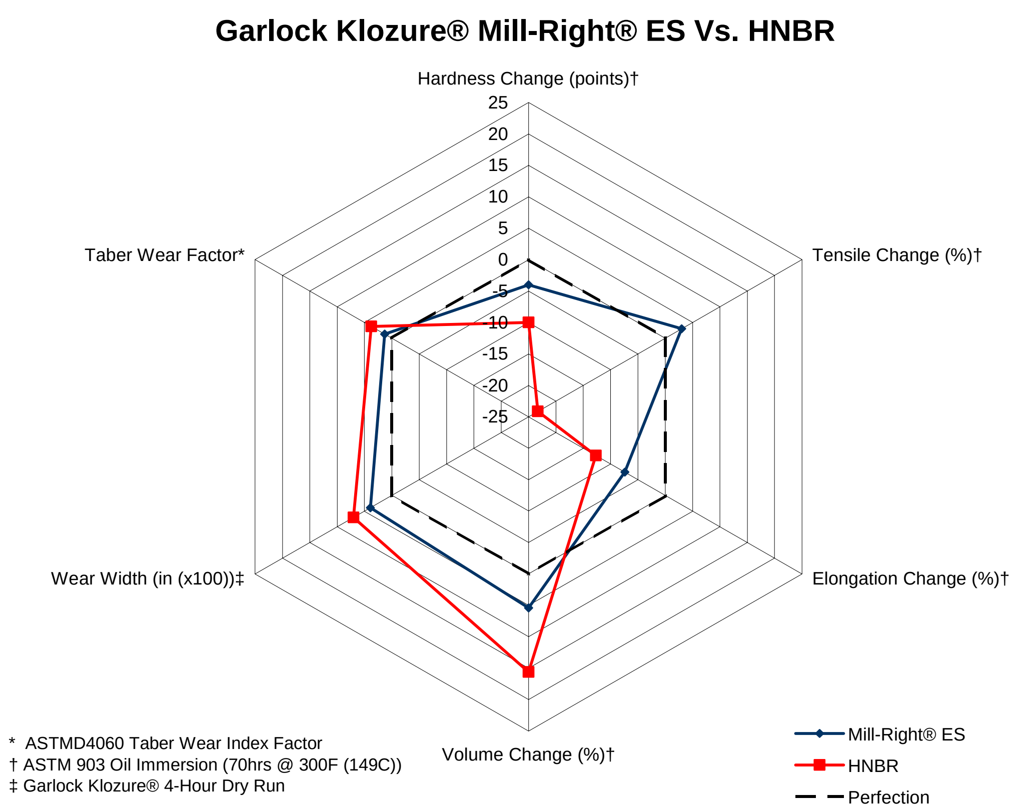

Figure 2 HNBR Formulations Radar Chart

As Figure 2 shows, the chemical compatibility of elastomer ES is much closer to the ideal line than that of the HNBR formulation. Similar to the NBR data, elastomer ES shows an enhanced chemical compatibility and a significant increase in abrasion resistance. Much like the abrasion enhancements of elastomer N, elastomer ES has a sixty-five percent (65%) improvement in abrasion resistance over the HNBR formulation. The enhanced abrasion resistance, again, translates into increased life and ultimately, increase equipment uptime.

4.3 Mill-Right® V

Figure 3 represents two different fluoroelastomer (FKM) formulations measured against an ideal elastomer. The FKM formulation is yet another example of material used by bonded seal manufacturers. Although the FKM formulation performs well, elastomer V is an example of an FKM engineered to possess yet even higher abrasion resistance and chemical compatibility.

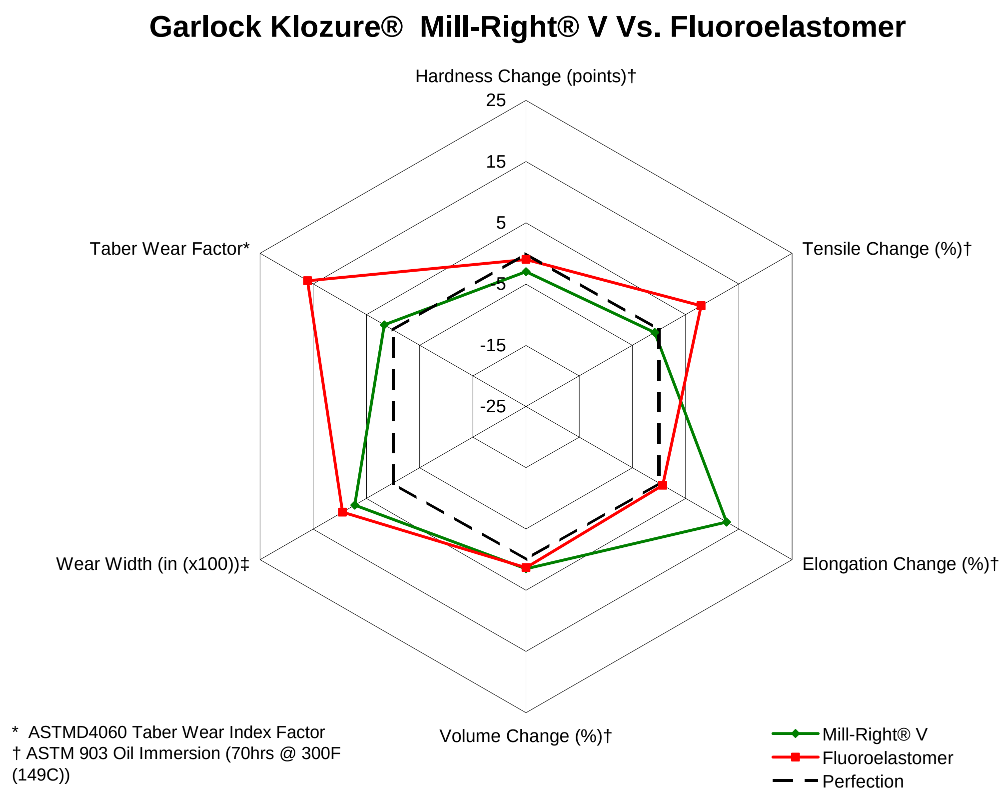

Figure 3 Fluoroelastomer Formulations Radar Chart

As Figure 3 shows, the chemical compatibility of elastomer V is much closer to the ideal line than that of the FKM formulation. Similar to that of the NBR and HNBR data, elastomer V shows an enhanced chemical compatibility and a significant increase in abrasion resistance. Similar to the abrasion enhancements of elastomer N and ES, the elastomer V has a ninety (90) percent improvement in abrasion resistance over the FKM formulation!

5 ENGINEERING DATA – THE SIMPLE MEANING

Engineering data is wonderful, but what does it all mean to the people that must use radial lip oil seals? It is simple; the greater the abrasion resistance of the elastomer, the longer the seal will last in the application. Radial lip oil seals are contact seals. Although in theory a thin film of lubrication (a meniscus) is present between the seal and the rotating shaft, the seals do eventually wear out. They wear out because the seal and the shaft contact each other. This contact, between a static surface and a dynamic surface, causes the seal material to wear away. Decreasing the amount of material that is worn away from the seal, therefore will directly impact the total operational life of the seal. So, the greater the abrasion resistance of the elastomer (the oil seal), the longer you will be able to use the seal in the application. It is literally that simple. Of course other mechanical properties of the seal are important, and in fact they are; they all impact the final abrasion resistance of the elastomer. In order to achieve the enhanced abrasion resistance, you must have great tensile strength, tear resistance, coefficient of friction, and so on. These values, therefore, must also be superior and stable in both the benign environment and the extremely harsh environments.

6 SUMMARY

Chemical compatibility and abrasion resistance impacts the life of the elastomer and the seal during operation in harsh environments. Seal life can be a critical maintenance driver for many users. The data referenced above demonstrates how new elastomer technologies can empower users to extend life, improve productivity, and ultimately reduce total maintenance cost. The family of Mill-Right® materials are world-proven to do just that; empower users to make significant improvements in equipment uptime and ultimately reduce costs!