Technical Report

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Title:

Low temperature integrity testing of Perlast® ICE G90LT

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Summary

- Testing was carried out by the Material Characterisation Centre (MCC) to investigate the low temperature performance of Perlast® G90LT over a number of pressures.
- The pressures used were 500PSI 1,000psi, 3,000psi, 5,000psi, and 9,000psi.
- At each of these pressures the temperature was steadily dropped and the ability of the seal to retain pressure was measured.
- In all cases pressure was held below the glass transition (Tg) and TR10 of the material. In some cases enough residual elasticity remained for the seal to reform and repressurisation was possible whilst still remaining below these values.
- These test results demonstrate the superior low temperature flexibility and sealing capability of Perlast® ICE G90LT, unique properties which are far beyond the capabilities of traditional perfluoroelastomer materials.

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MATERIAL CHARACTERISATION CENTRE

Contents

Test Method

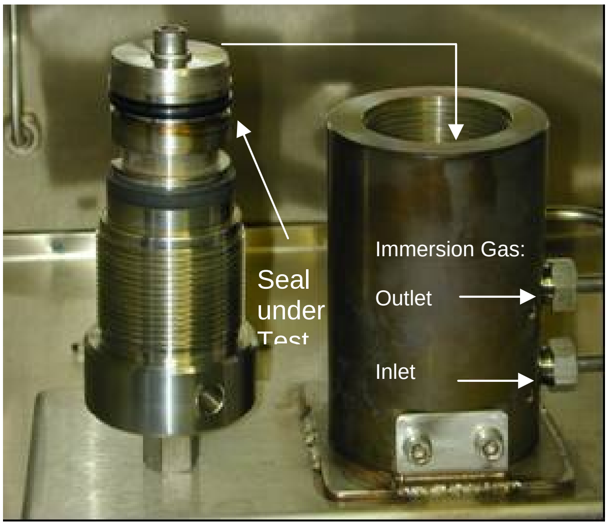

Figure 1: Test fixture.

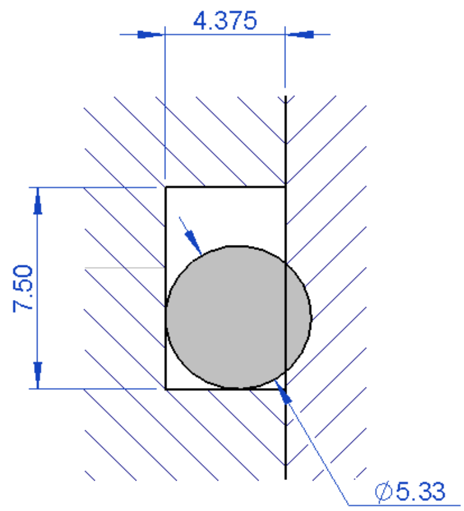

Figure 2: Groove dimensions.

A Perlast® ICE G90LT test O-ring with dimensions 37.47x5.33mm was placed in a test fixture as shown above in Figure 1, the groove dimensions are also given in Figure 2. The test fixture consists of a piston seal subjected to 1.5% stretch and 10% squeeze.

The cell was pressurised with a gaseous mixture of 10% CO_2 and 90% CH_4. Several experiments were carried out at 500psi 1,000psi, 3,000psi, 5,000psi, and 9,000psi. Each pressure was held at ambient temperature for 1 hour before being gradually reduced until failure occurred.

Firstly for 500psi the temperature was dropped from ambient to -10°C and held for an hour before being dropped 10°C on the hour until failure.

Similarly for 1,000 and 3,000psi the only difference being that the initial drop was from ambient to -40°C for 3,000psi.

For 5,000psi the temperature drops were from ambient to -25°C, -25°C to -50°C, -50°C to -75°C, and lastly -75°C to -100°C again each temperature was held for 1 hour.

At 9,000psi temperature was reduced from ambient to -50°C and from there to -100°C.

Results

Figures 3-7 show pressure and temperature against time for each experiment, points of interest on the plots have been annotated. It is also of note that there was a correlation between the initial point of failure and the pressure at which the test was carried out, this is shown in Figure 8.

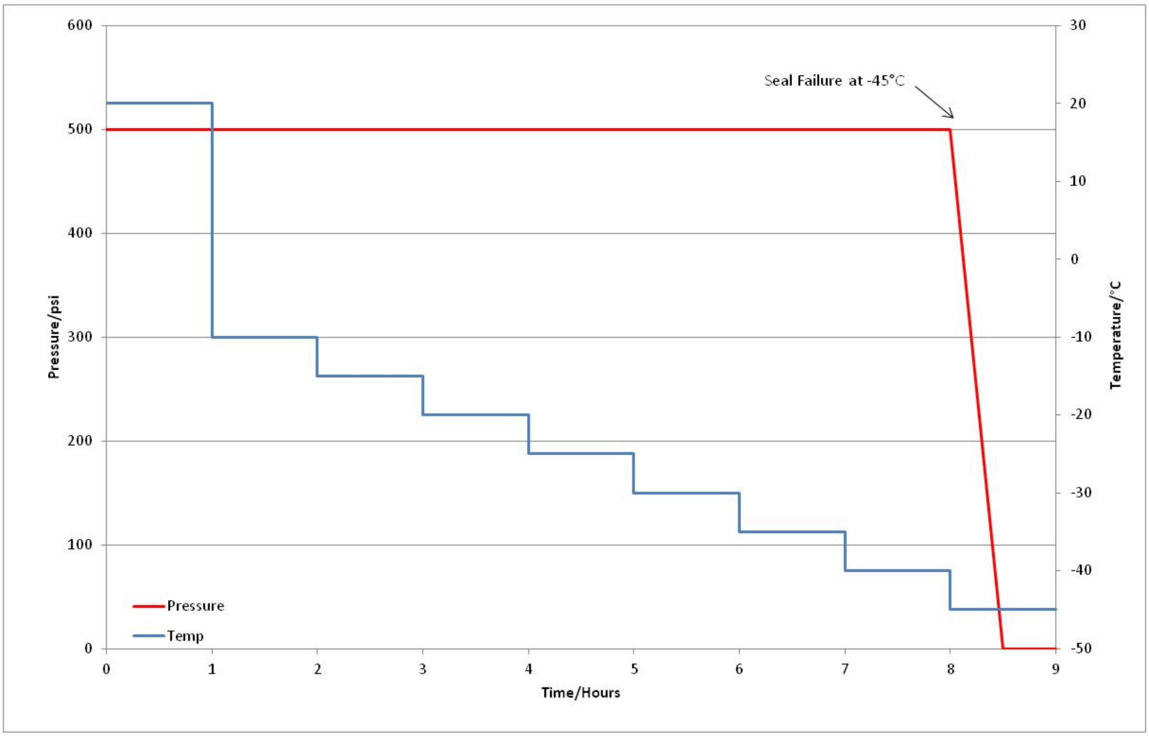

Figure 3: Pressure (red) and temperature (blue) for low temperature integrity testing at 500psi. Points of interest have been annotated.

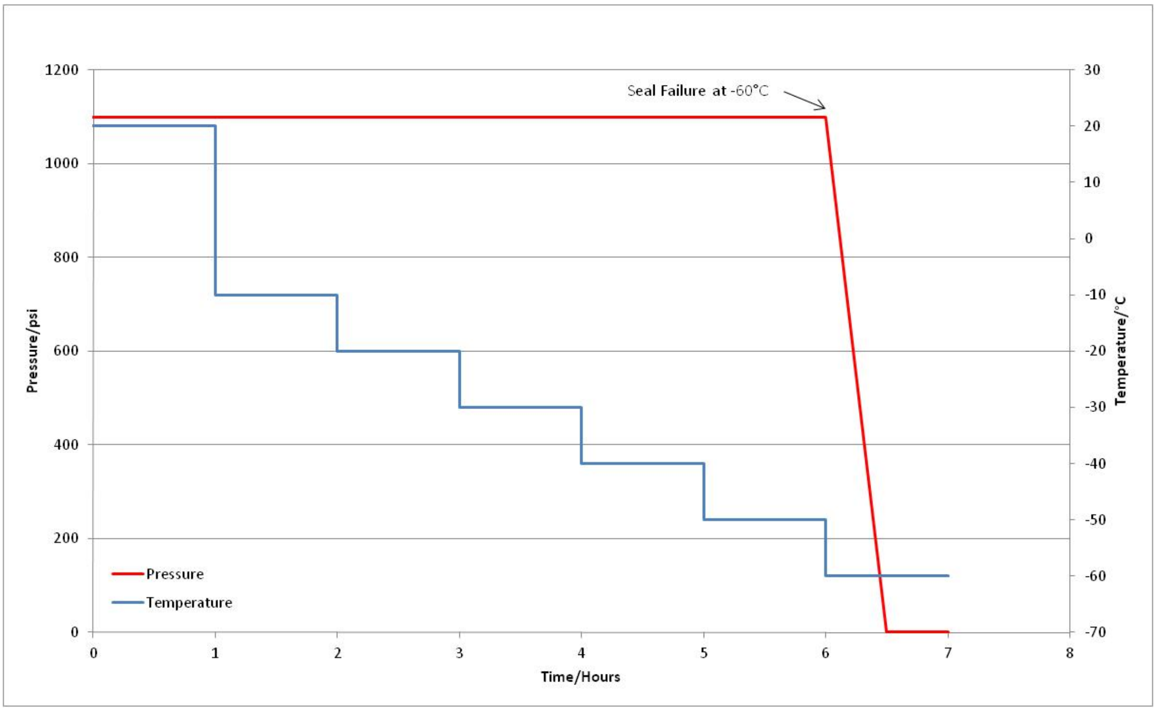

Figure 4: Pressure (red) and temperature (blue) for low temperature integrity testing at 1,000psi. Points of interest have been annotated.

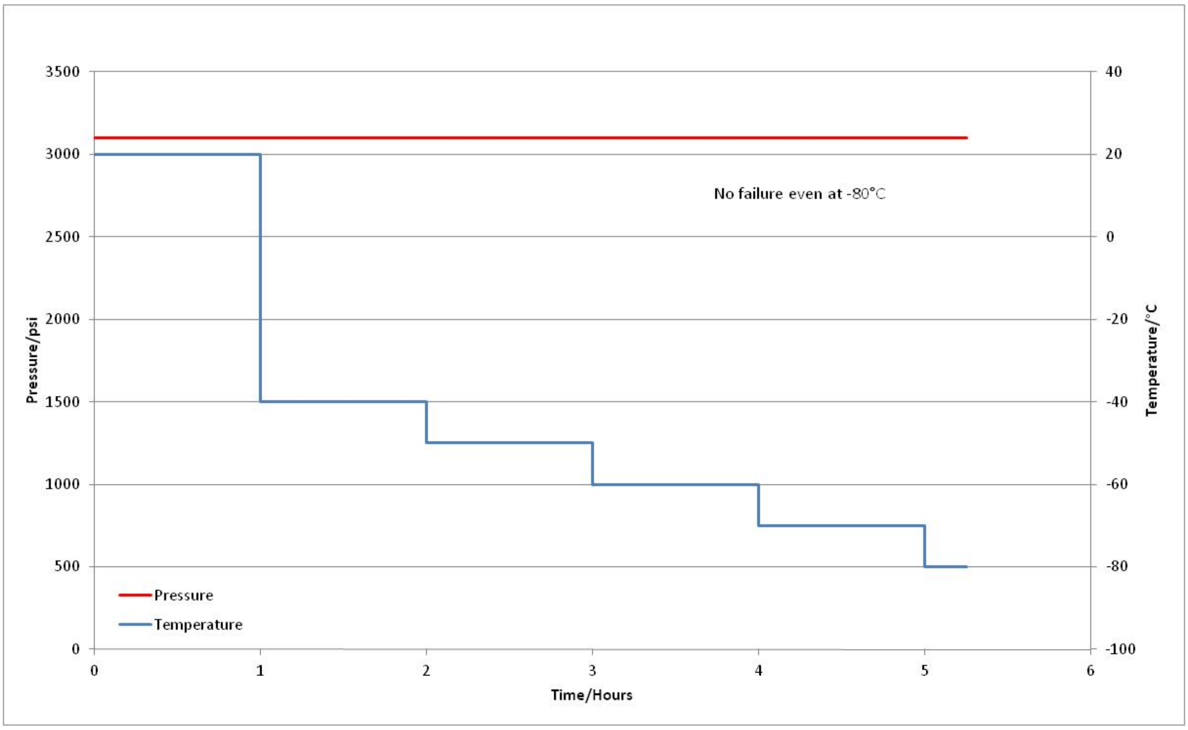

Figure 5: Pressure (red) and temperature (blue) for low temperature integrity testing at 3,000psi. Points of interest have been annotated.

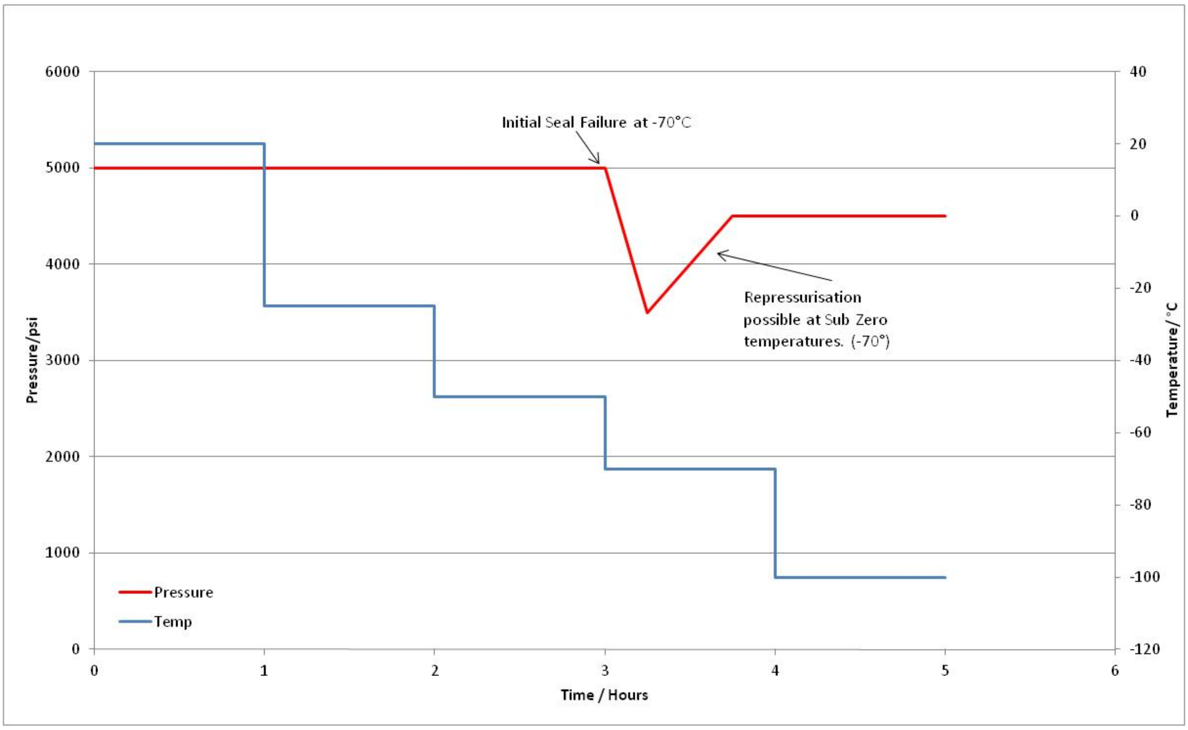

Figure 6: Pressure (red) and temperature (blue) for low temperature integrity testing at 5,000psi. Points of interest have been annotated.

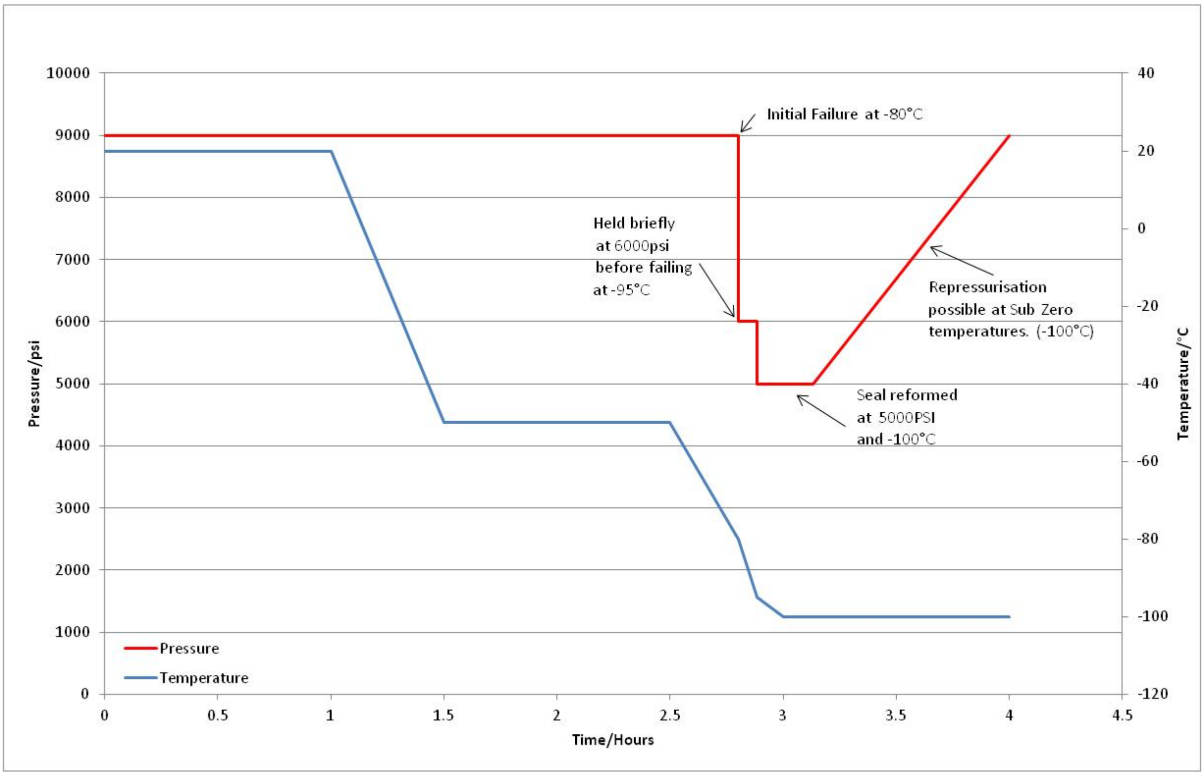

Figure 7: Pressure (red) and temperature (blue) for low temperature integrity testing at 9,000psi. Points of interest have been annotated.

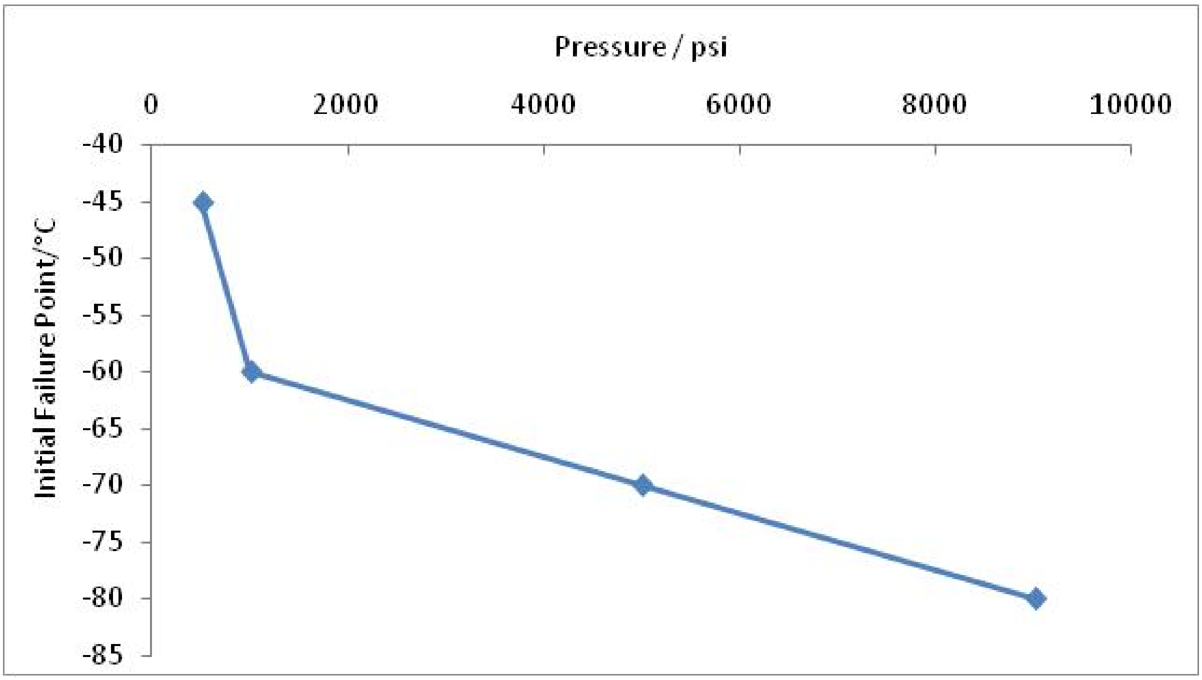

Figure 8: Initial failure point as a function of pressure.

Discussion

Figure 3 shows that at 500psi seal integrity was lost at -45°C (-49°F). It is worth noting that even at this modest pressure where seal energisation will be relatively low failure did not occur to until well below both the Tg (-30°C, -22°F) and TR10 (-31°C, -24°F) of the material.

When the testing was carried out at 1,000psi failure occurred at -60°C (-76°F), as shown in Figure 4. Similarly this is far below the usual indicators of low temperature performance Tg and TR10.

At 3,000psi seal integrity was preserved even at -80°C (-112°F) as demonstrated in Figure 5, again some way below both Tg and TR10.

The 5,000psi testing revealed some interesting features which are shown in Figure 6. There was initially failure at -70°C (-94°F), however the seal reformed at around 3,500psi and it was possible to repressure the system to 4,500psi whilst remaining at -70°C (-94°F). The temperature was then reduced to -100°C (-148°F) and the seal integrity remained.

Lastly, when considering Figure 7 it can be seen that at 9,000psi seal integrity was maintained to -80°C (-112°F) which is well below the Tg of the material and despite an initial failure enough residual elasticity remained in the Perlast® ICE G90LT for a seal to reform briefly at -95°C (-139°F) and 6000psi before settling at -100°C (-148°F) and 5000psi. And even at these sub-zero temperatures the pressure cell was able to be repressurised to 9000psi.

The 500, 1,000, and 3,000psi tests demonstrate that an adequate seal can be held well below the Tg and TR10 of the material. This shows that although these values are useful indicators of low temperature performance and provide an excellent tool for forming the basis of an assessment of sub ambient performance it is also important to consider the conditions which the seal will operate, particularly the pressure, and design of the hardware. The seal and hardware design can significantly influence material performance in low temperature conditions.

The effect of design pressure is clearly displayed in Figure 8, in that there is a clear trend, as pressure increases the temperature at which failure occurs decreases. As the pressure increases as does the energisation in the seal, so the proportion of the sealing force provided by the elasticity of the seal does not need to be as high to maintain a seal. Below the Tg of a material it becomes glassy and there is less elasticity present, hence the effect of this on sealing force is reduced at higher pressures.

Although at 5,000 and 9,000psi low temperature sealing will be aided by the relatively high pressure and hence seal energisation; the reforming of the seal and subsequent repressurisation at such low temperatures demonstrates the excellent low temperature integrity and stability of Perlast® ICE G90LT, and shows that some residual flexibility has remained far below Tg and TR10.

Conclusions

- The above results demonstrate the excellent sealing integrity of Perlast® ICE G90LT. Irrespective of the pressure used sealing was possible far below the Tg (-30°C, -22°F) and TR10 (-31°C, -24°F) of the material.

- The failure points were found to be -45°C (-49°F), 60°C (-76°F), -70°C (-94°F) and -80°C (-112°F) for 500psi, 1,000psi, 5,000psi, and 9,000psi respectively. At 3,000psi failure did not occur even at -80°C (-112°F).

- Although system energisation will play a part particularly at the higher pressures this demonstrates the excellent low temperature sealing characteristics of the Perlast® ICE G90LT material.

- It is also worth noting that at the higher pressures of 5,000 and 9,000psi, even after initial failure, enough flexibility and elasticity remained for the system to be repressurised, while remaining in the glassy phase of the material. This clearly demonstrates the superlative low temperature flexibility and capability of Perlast ICE G90LT.

- Perlast® ICE G90LT provides a step change improvement in low temperature performance well beyond a traditional FFKM, for which sub zero operation was often impossible. In addition, the material retains the excellent thermal and chemical resistance associated with an FFKM, although not presented here; extensive testing has been carried out to ensure this is the case.

- The low temperature improvement is achieved by careful manipulation of the polymer structure to achieve performance that is reliable, repeatable and sustained over time. Rather than alternative techniques which involve the addition of low molecular weight ingredients such as waxes and oils, which often result in poor long-term performance.

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