# Specifying Compounds for Performance at Low Temperatures

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MARTIN'S RUBBER COMPANY
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Rubber in Engineering Group

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In-house 5 axis machining

Non-linear & hyper-elastic FE analysis

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We love what we do

We dare to do the difficult

We are intent on sustainability

We care about the people we work with

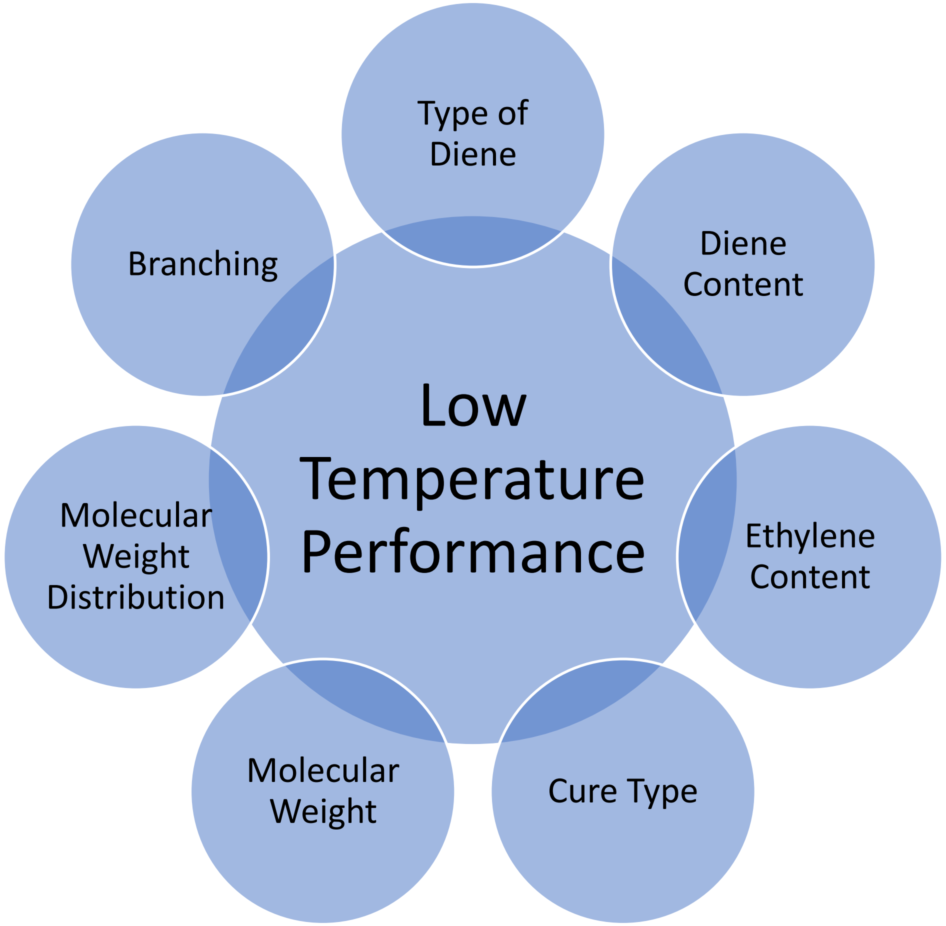
# Background

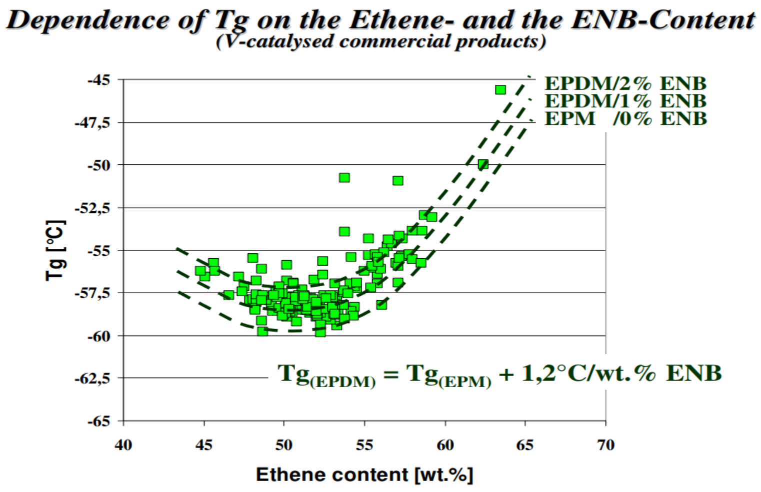
- Elastomers are used in many critical sealing applications
- Temperature range is an important aspect of selecting the right elastomer
- Behaviour at the range of temperature must be considered and is a result of the material properties, as well as the design
- May get asked for a material to suit particular service requirements, such as:
  - Operating temperature: -55°C to +125°C.
  - Non operating temperature: -78° to -55°C and +125° to +131°C

# Specifying Compounds for LT

Why do my seals fail at low temperature when I have specified to a proven standard?

# Compounding Considerations for EPDM

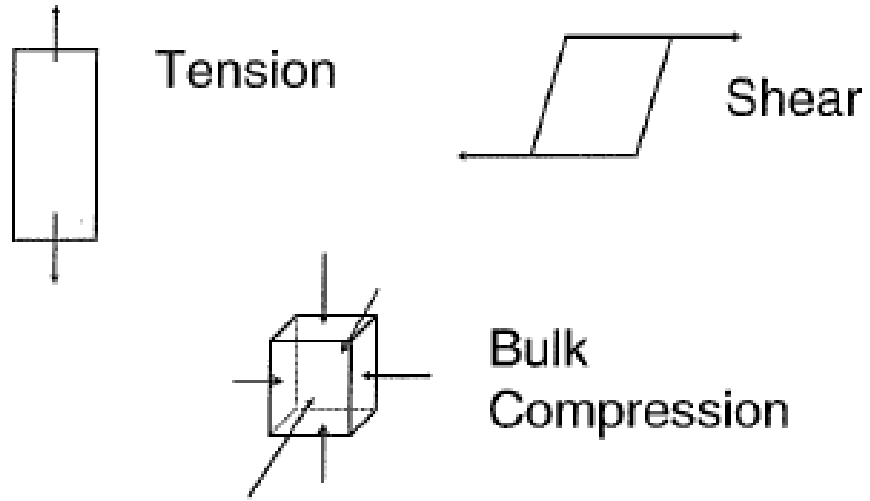


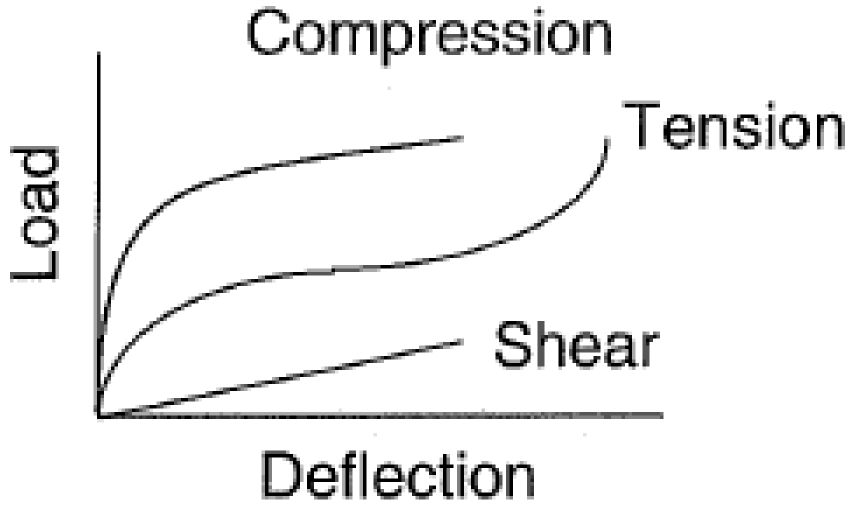




Source: M. Hoch, M. Arndt-Rosenau, Bayer-Report ARO 1, HCM 40 of 16.02.2001

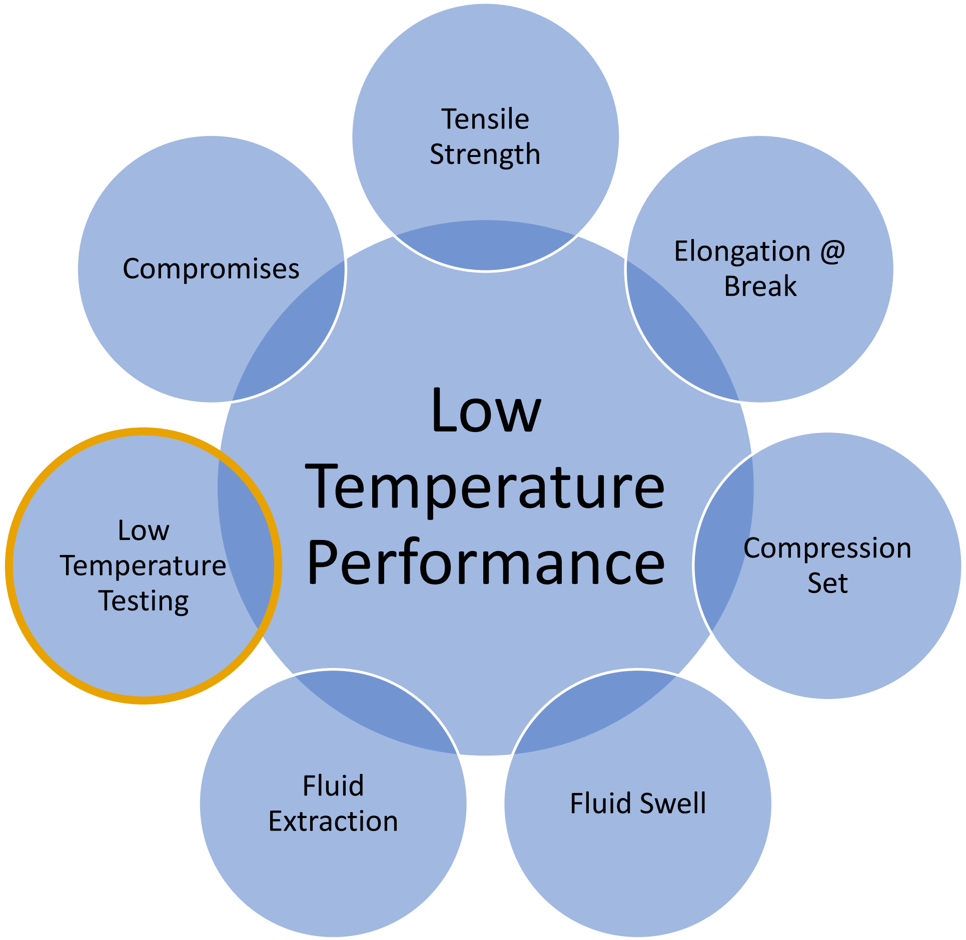
# Application Considerations

## Static vs. Dynamic



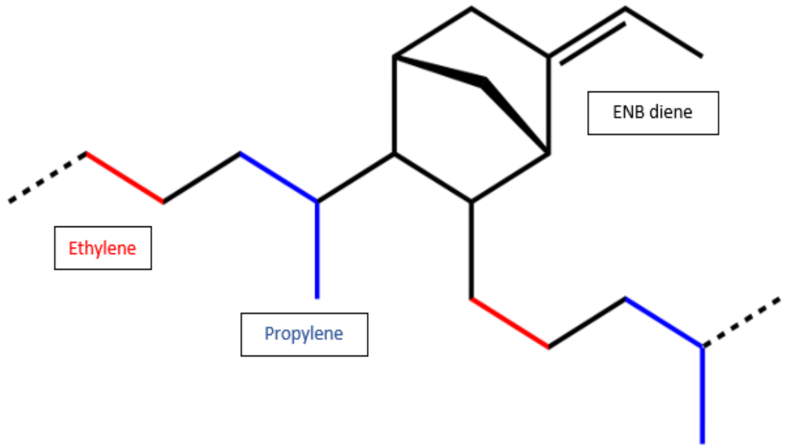
# Physical Property Considerations




# Experimental Set-Up

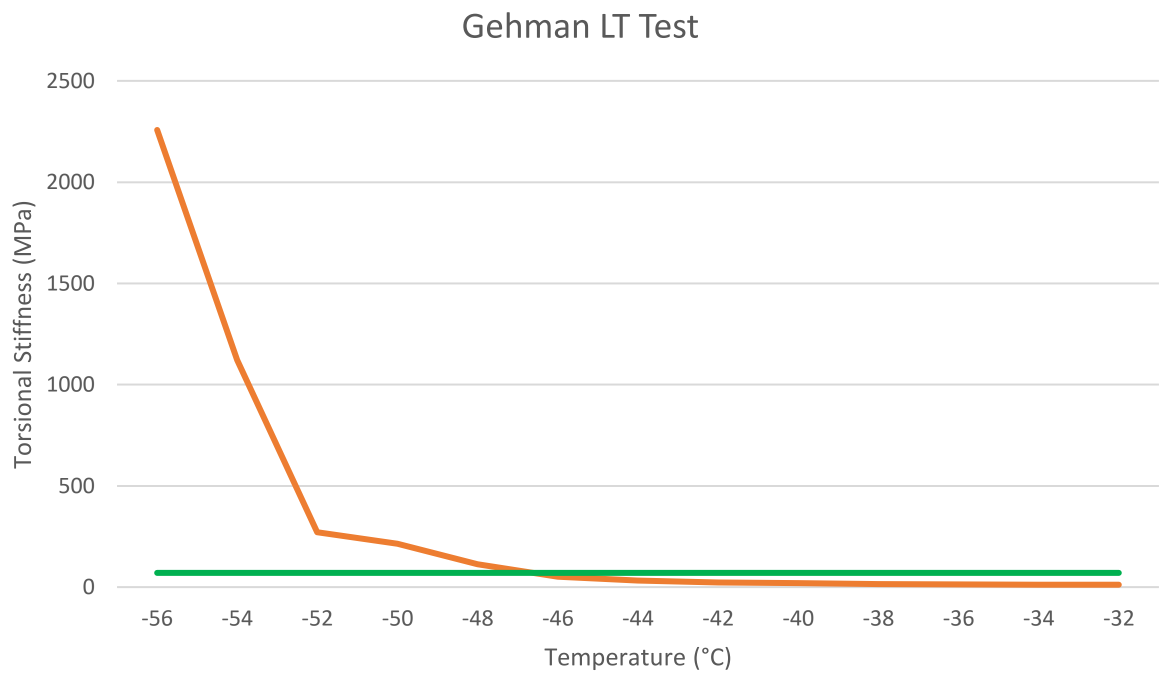
We will investigate the result from various standardized tests for rubber performance at low temperatures.

- Gehman Torsional Stiffness to BS ISO 1432
- Brittleness Point to ASTM D2137
- Differential Scanning Calorimetry (DSC) to ASTM D3418
- Dynamic Mechanical Analysis (DMA) to ASTM D4065
- Temperature Retraction (TR10) to BS ISO 2921



# Gehman Torsional Stiffness

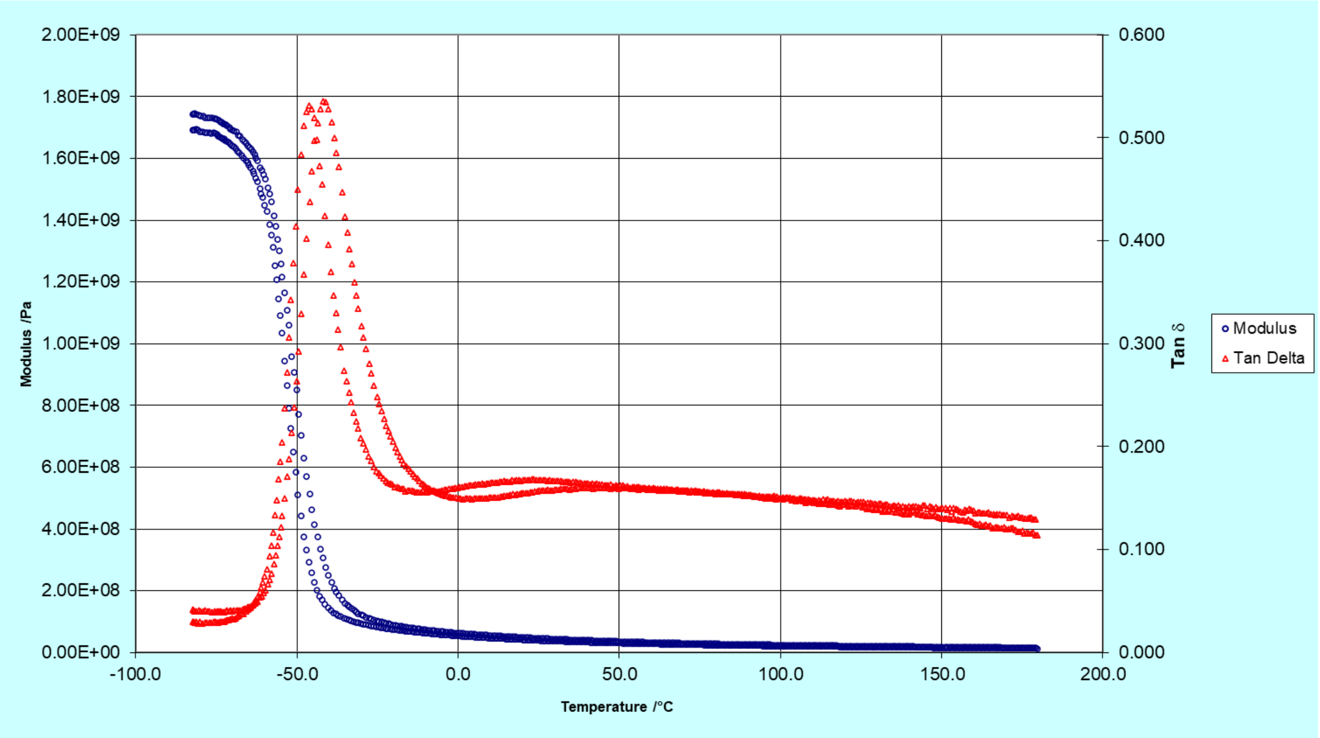
| Temperature | Twist Angle | Torsional Stiffness |
|---|---|---|
| °C | ° | MPa |
| -32 | 93 | 12 |
| -34 | 90 | 13 |
| -36 | 85 | 14 |
| -38 | 80 | 16 |
| -40 | 70 | 20 |
| -42 | 62 | 24 |
| -44 | 50 | 33 |
| -46 | 35 | 52 |
| -48 | 18 | 114 |
| -50 | 10 | 214 |
| -52 | 8 | 271 |
| -54 | 2 | 1122 |
| -56 | 0 | 2257 |



# ASTM Non-Brittle

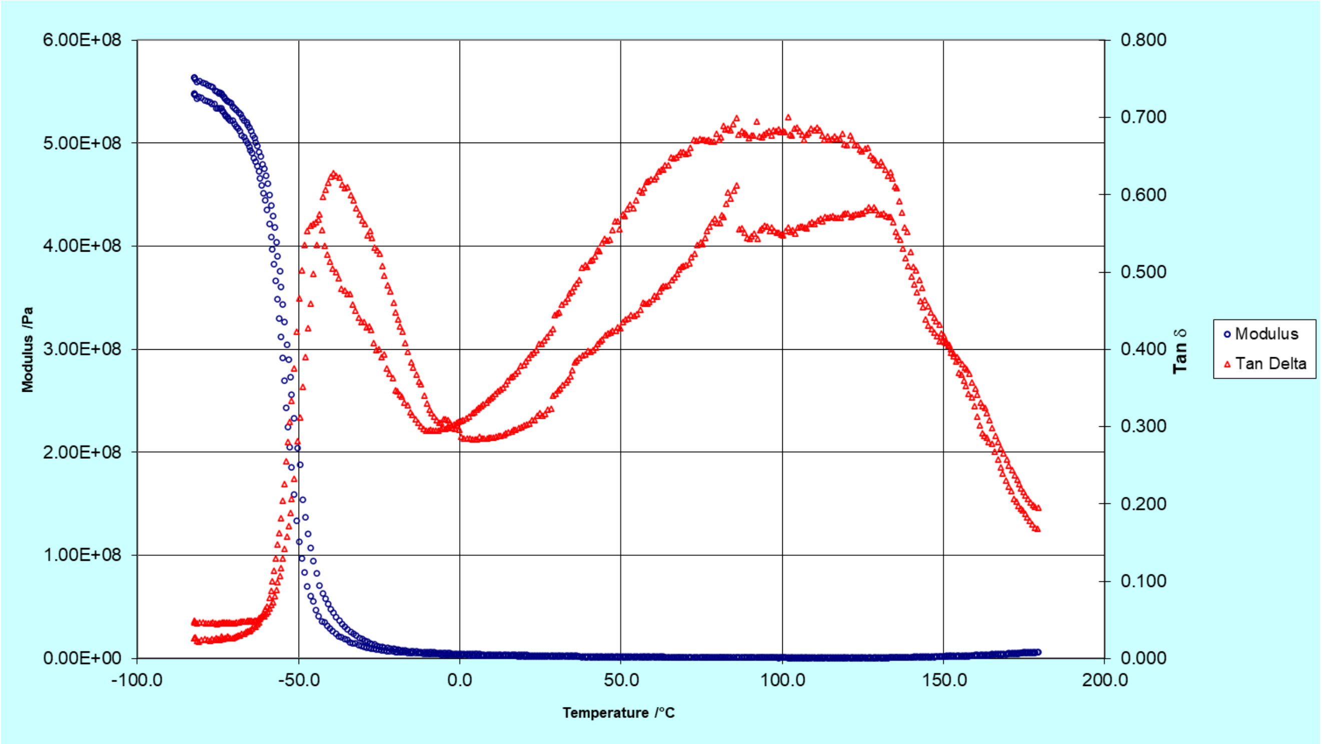
| Temperature | Samples Remaining | Result |
|---|---|---|
| -55°C | 5/5 | PASS |
| -60°C | 0/5 | FAIL |

# Differential Scanning Calorimetry



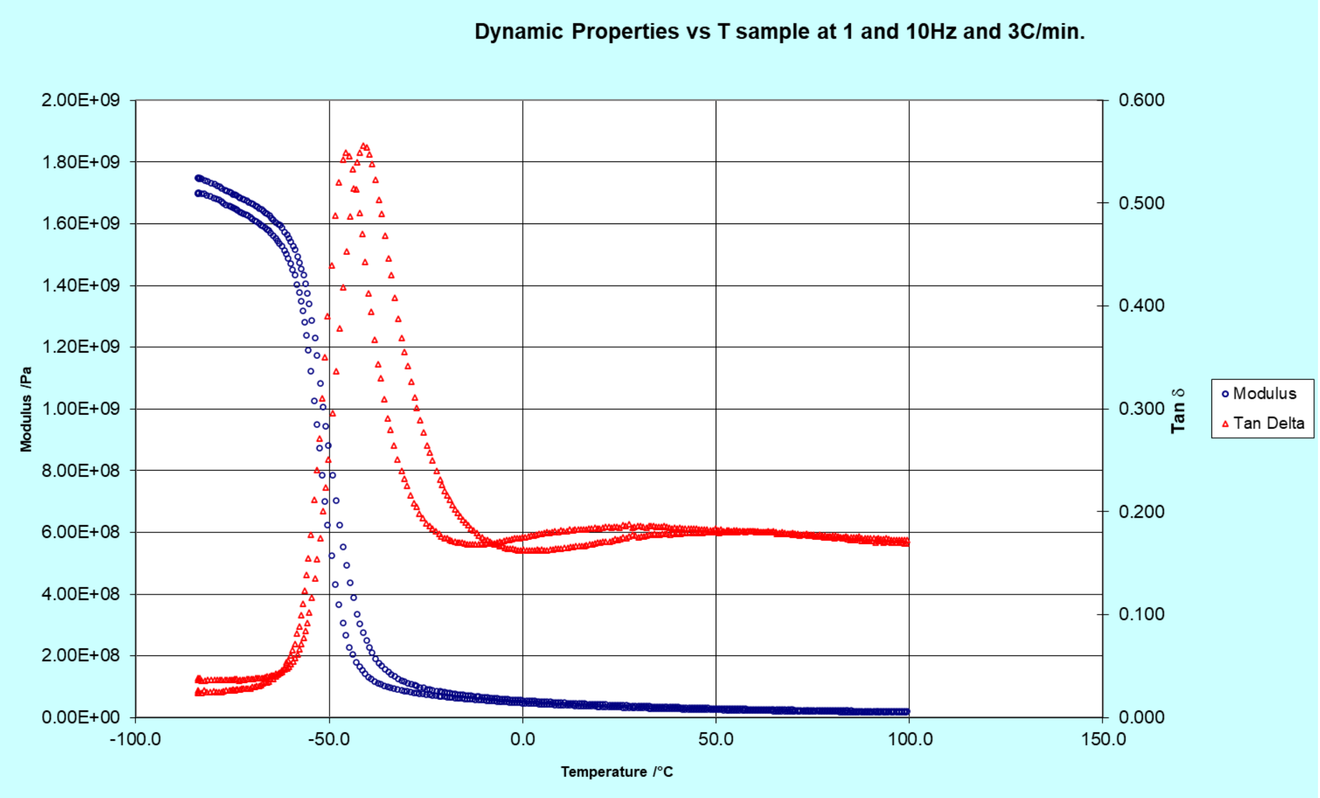

| | |
|---|---|
| $T_c$ as shown by peak tan delta | -47°C |

# Differential Scanning Calorimetry




| | |
|---|---|
| $T_c$ as shown by peak tan delta | -47°C |

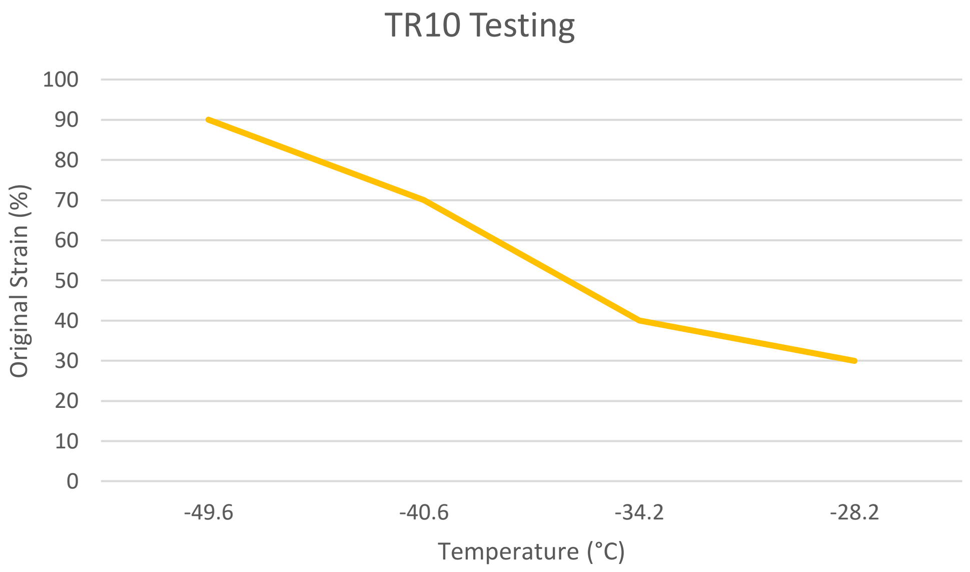
# Dynamic Mechanical Analysis




| | 1 Hz | 10 Hz |
|---|---|---|
| $T_g$ as shown by peak tan delta | -46°C | -42°C |

# Temperature Retraction

| Temperature Retraction | | | |
|---|---|---|---|
| TR10 | TR30 | TR60 | TR70 |
| -49.6°C | -40.6°C | -34.2°C | -28.2°C |



# Low Temperature Testing

- Five methods, five different results. Up to 13°C difference.
- However, all tell you something about the nature of the material.
- But must ensure the test is reflective of the performance in service.

| Test Method | Result | Suitable for |
|---|---|---|
| Gehman Torsional Stiffness | -47°C | Low temperature stiffness |
| ASTM Non-Brittle | -55°C | Low temperature durability |
| Differential Scanning Calorimetry (DSC) | -47°C | Material glass transition & crystallisation temperatures |
| Dynamic Mechanical Analysis (DMA) | -46°C/-42°C | Glass transition & crystallisation with frequency dependence |
| Temperature Retraction (TR10) | -49.6°C | Low temperature energising |

# LT Seal Failure

Why do my seals fail at low temperature when I have specified to a proven standard?

- Are the wrong tests specified in the standard?
- Or is it just the wrong parametric definition in the standard for the intended use?
- It may be that the application needs its own material specification to suit the use & ensure consistent & reliable performance in service.

# Summary

- Allow seal designers in early to aid with seal & housing design
  - Avoid asking too much of a seal by leaving it to the end
- Consider the part geometry & the modes of deformation
  - Shear deformation can result in lower stiffness
- Consider the most representative low temperature test for that design
  - Real world testing can offer the best insight
- Sometimes a balance must be struck to maximise performance in other areas, such as fluid swell
- Consider other factors which may affect the component, such as thermal or mechanical shock


# QUESTIONS

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