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Predicting Long-Term Sealing Performance with Compressive Stress Relaxation Testing

(Retention of Sealing Force)

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PC-10 Elastomers Compatibility

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What is the primary concern of the HDEOCP regarding elastomers used in the engine?

- The elastomers used in gaskets, seals, and hoses will function reliably at the service temperatures of a HD Diesel engine.
- The elastomers used in gaskets, seals, and hoses will be compatible with the fluids they handle in service.
- The gaskets, seals, and hoses in the engine will not leak, and will maintain a seal over time under static and dynamic conditions.

PC-10 Elastomers Compatibility

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The PC-9 test protocol:

- Volume Swell after 336 hours
- Hardness Change after 336 hours
- Retention of Tensile Strength after 336 hours
- Retention of Elongation after 336 hours

Is this adequate assurance of reliability as defined in the last slide?

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What is Compressive Stress Relaxation (CSR)?

- CSR measures an elastomer's residual counter-force against compression over time, under simulated service conditions (heat and fluid), and under constant compressive deformation.
- It is a time progressive test combining compression set with heat / fluid aging to better simulate the actual service environment of seals.
- CSR data is a useful tool to predict the service life of a seal, and in evaluating potential for leaks at hose clamps.
- CSR data are now used as reference information in ranking materials for sealing applications at some automotive OEMs.

CSR Concept

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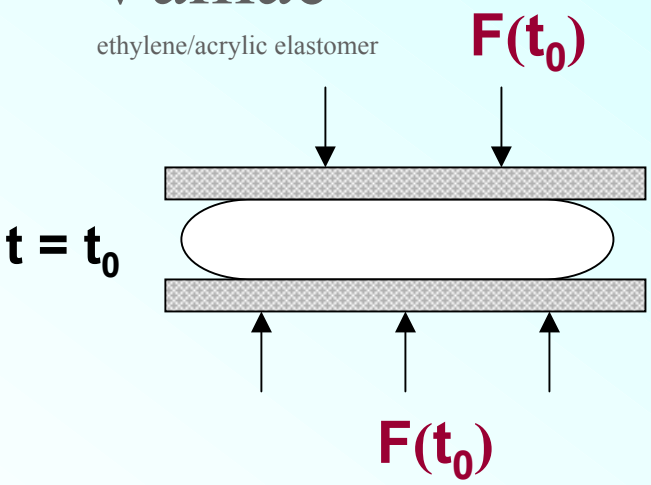
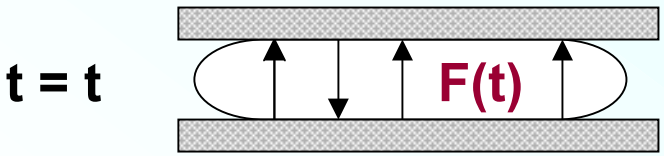


Elastomeric Material is Compressed

Compressive Energy Applied = Elastic (stored) + Viscous (dissipating)



Elastomeric material presses back

Counter Force, F(t) = Sealing Force

CSR (t) = F(t) / F(t_0)

CSR is typically plotted as a function of time

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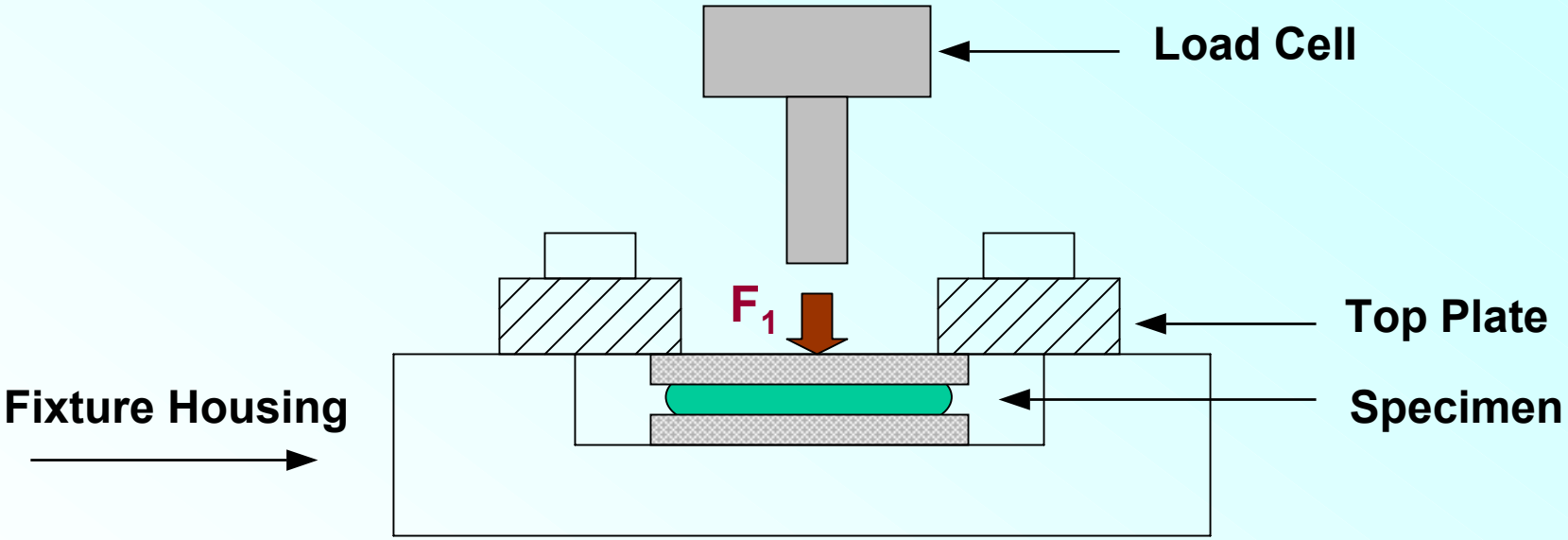
CSR Test Fixtures - Load Deflection



- Constant deformation of the elastomer (typically 25%) is maintained by the top plate during aging and measurement.
- The sample is loaded in the fixture, and force/deflection curve is generated to determine the counter-force in the specimen.
- Measurements are taken at specified time intervals to plot retention of sealing force over time

CSR Fixture

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CSR Test - Data Reporting

- Force readings are taken 3 times for each sample.
- The data are reported as percentage of the initial counter force

Force Retention **FR (t) = F(t) / F(t_0)**

- For FR(t), the median value of the 3 samples is used.
- It is generally accepted that a residual counter force at 10% of original is the lower limit for maintaining a static seal. Dynamic sealing applications are more complicated.
- For elastomers, positive fluid volume swell (5 - 10 %) can be helpful in maintaining the sealing force depending upon property changes.

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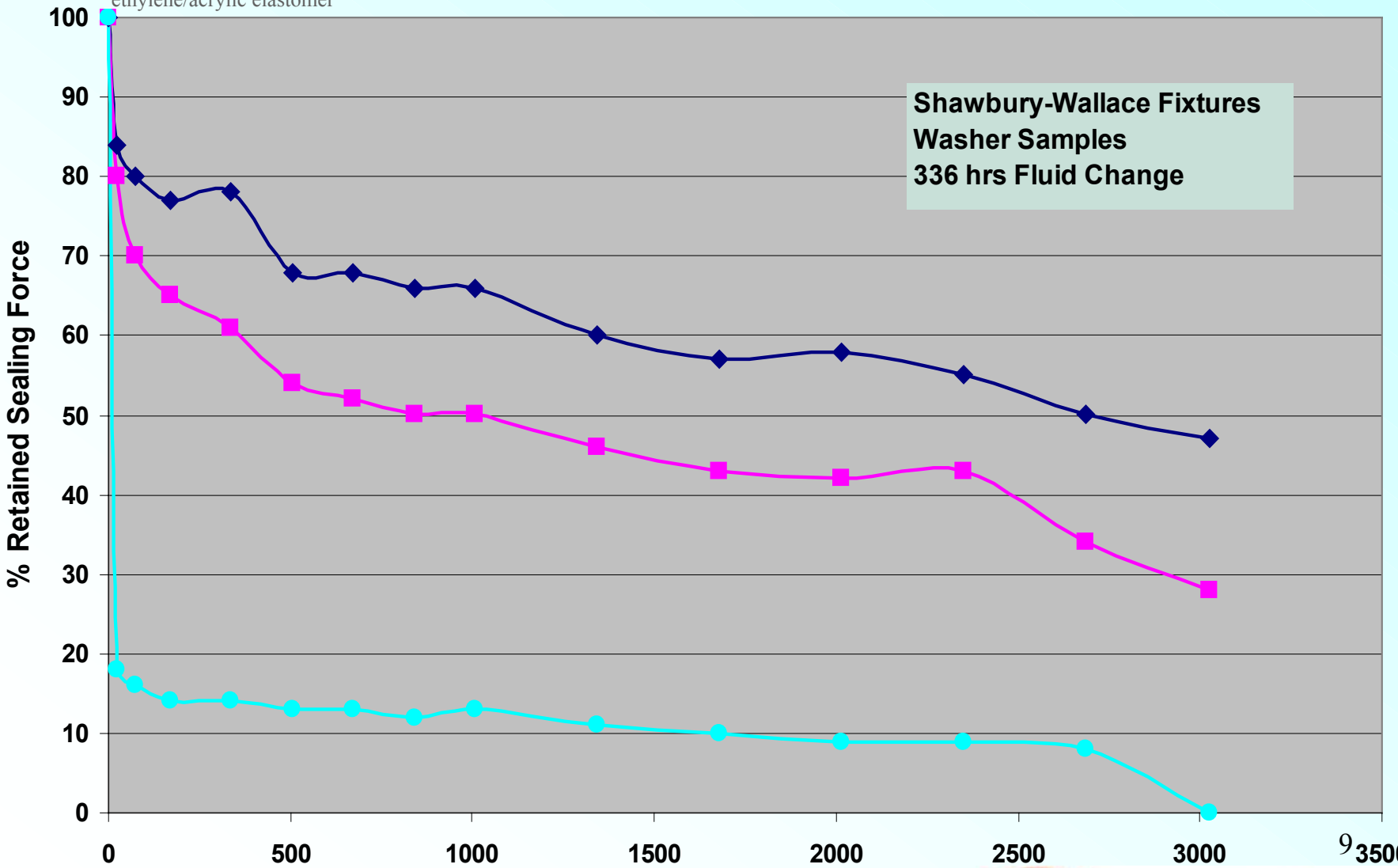
CSR Data - SF105 @ 150 °C



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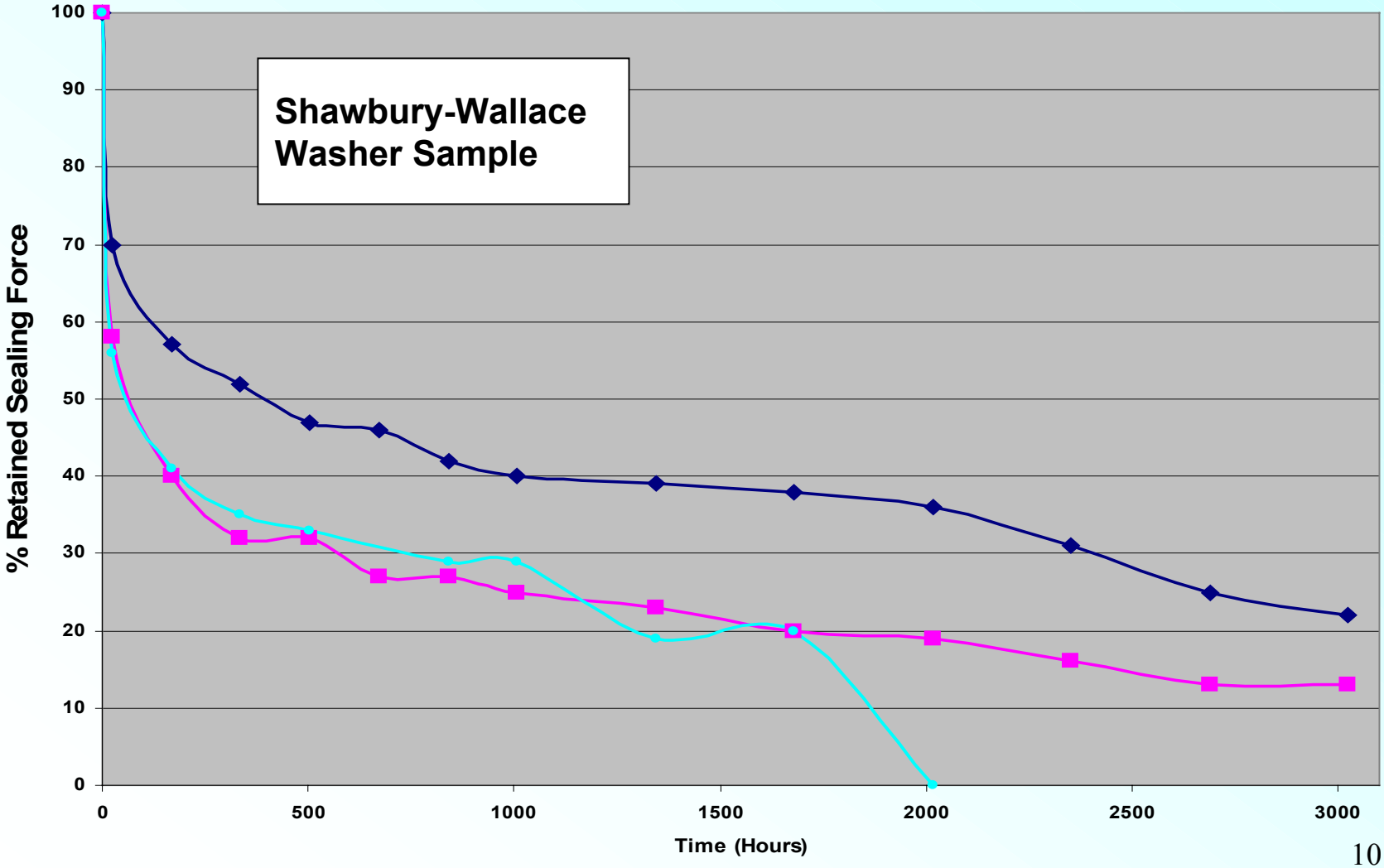
CSR in Motorcraft 0W-30 Oil @ 150 °C



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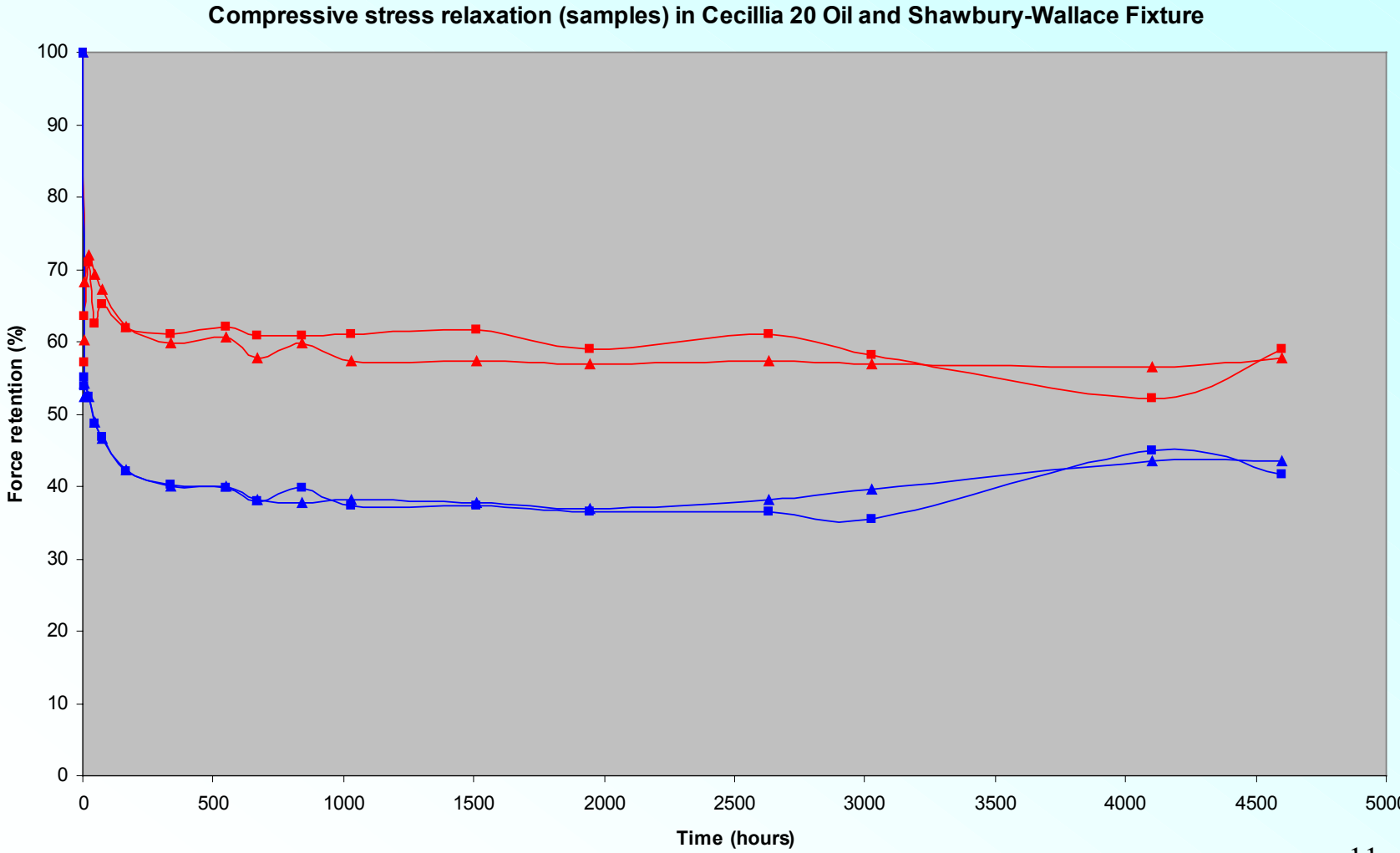
CSR Data - Cecilia 20 @ 150 °C



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GM and Ford Dry Heat CSR Test Temp.

Elastomer	GMNA 3922TP	Ford Proposal
FKM (fluoroelastomer, Viton®)	**150 °C**	**190 °C**
FVMQ (fluorosilicone)	**150 °C**	**190 °C**
VMQ (silicone)	**150 °C**	**190 °C**
AEM (Vamac®, ethylene acrylic)	**150 °C**	**150 °C**
ACM (polyacrylate)	**150 °C**	**150 °C**
EPDM (ethylene propylene)	**150 °C**	**135 °C**
HNBR (hydrogenated nitrile)	**150 °C**	**135 °C**
ECO (epichlorohydrin)	**125 °C**	**135 °C**
CSM (chlorosulfonated PE, Hypalon®)	**125 °C**	**135 °C**
NBR (nitrile)	**125 °C**	**121 °C**
TPE	**125 °C**	**- - -**

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Conclusions

- Compressive Stress Relaxation is the most representative test for predicting sealing performance over time under end use environment.
- CSR maintains compression of the sample during the entire evaluation period, and function, not uncompressed size, is the determining factor.
- Test conditions can be tailored to meet specific application needs (e.g., temperature cycling, oil changing, oil aeration, etc.)
- Automotive OEMs are now requiring CSR test data as reference info in new material specifications for seals and gaskets.
- **ASTM** and **ISO** procedures for Compression Stress Relaxation provide guidelines for developing specifications :
  - ASTM D6147
  - ISO 3384