

# Compressive Stress Relaxation Anomalies

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# CSR Anomolies

## Measurements

- force accuracy
- deflection accuracy
- % compression
- initial time accy
- test time accy
- load defl vs elec br
- continuous vs intern

## Materials

- mix variations
- state of cure
- molding conditions
- age of sample
- cut vs molded specim
- type of material
- CTE of material
- Filler loading
- volume swell
- permeation rate of m
- friction at rubber/f

## Men

- operator
- training
- experience

→ Repeatability Error

- type of container
- contamination of fix
- volume of fluid
- vibration
- aeration
- fluid changes
- fluid type
- humidity control
- temperature control

## Environment

- handling of fixtures
- number of samples
- cool down time
- excercise samples
- sample type
- lubrication of sampl
- measurement temp.
- Test Procedure

## Methods

- Elastocon
- Jones-Odom
- Modified Jamak
- Jamak
- Wykeham-Farrance
- Shawbury-Wallace
- Type of Equipment

## Machines

# Specifications

- ASTM D6147
- ISO 3384
- GMNA 3922 TP
- Ford FLTM BP 116-02

# Test Types

- Intermittent Reading Methods
  - Shawbury-Wallace
  - Wykeham-Farrance
  - Jamak
  - Modified Jamak
  - Jones-Odom

# Test Types

- Continuous Reading Methods
  - Elastocon
  - Modified Jamak

# Intermittent Reading Methods

- + Relatively easy to run
- + Can be run in pressure bombs (Coolants)
- + Number of samples limited only to number of fixtures
- - Readings usually taken at RT (Method B)
- - Exercises part during reading

# Continuous Reading Methods

- + Measurements can be taken at temperature
- + Data can be taken automatically
- + Short term effects apparent (Swell, CTE)
- - Expensive
- - Cannot be readily run in pressure vessels
- - Stability of load cells vs. time & temp

# Sample Configuration

- Large Comp Set Buttons
- Small Comp Set Buttons
- Washers
- O-rings
- Micro-pellets
- Molded to shape

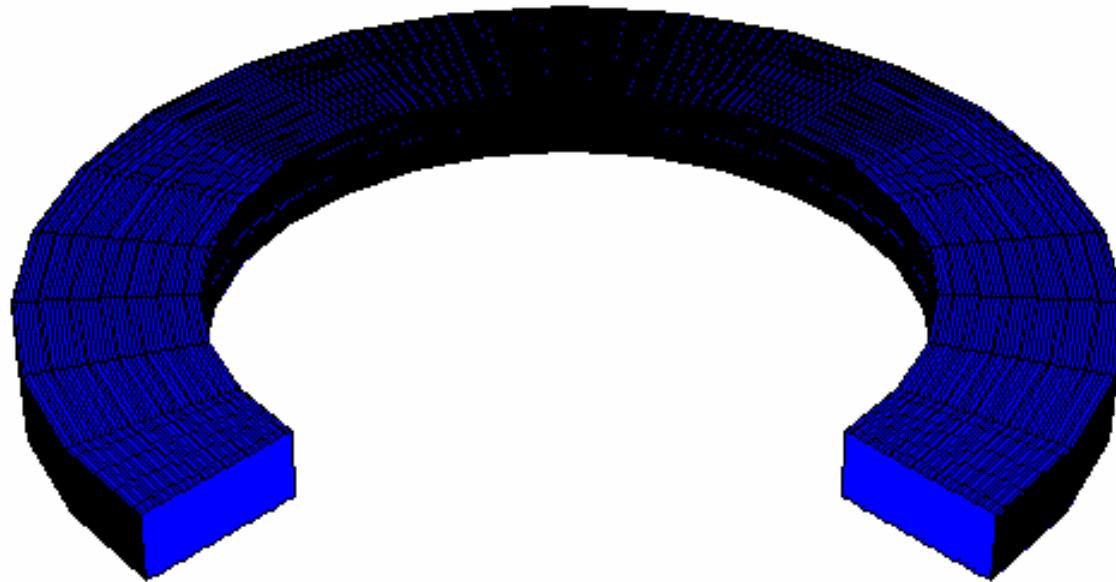
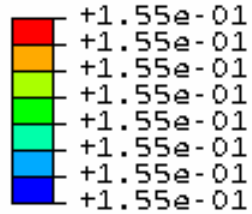


# Sample Configuration



**Washer – 75% Original Thickness – Friction = 0.0**  
**12.70 mm (0.50") ID, 19.05 mm (0.75") OD x 2.032 (0.08") mm Thick**  
**Maximum Principal Nominal Strain**

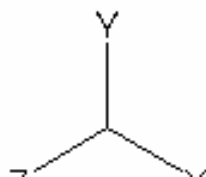
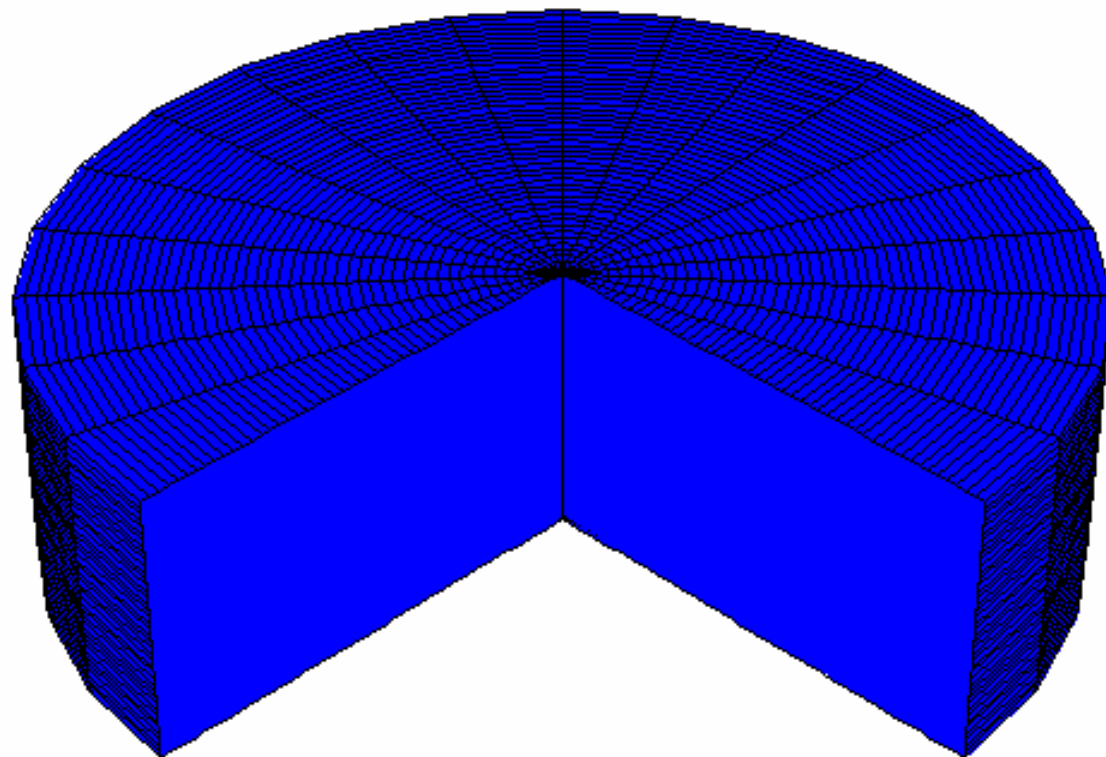
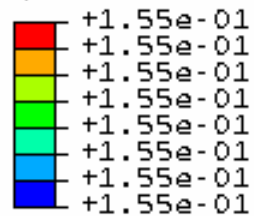
NE, Max. Principal  
(Ave. Crit.: 75%)



ABAQUS job created on 10-Sep-01 at 15:37:53  
ODB: washer.odb ABAQUS/Standard 6.2-1 Thu Sep 13 13:28:14 EDT 2001  
Step: Step-1

Button #1 – 75% Original Thickness – Friction = 0.0  
28.956 mm (1.14") Dia. x 12.446 (0.49") mm Thick  
Maximum Principal Nominal Strain

NE, Max. Principal  
(Ave. Crit.: 75%)

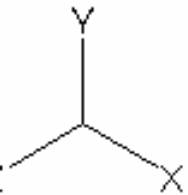
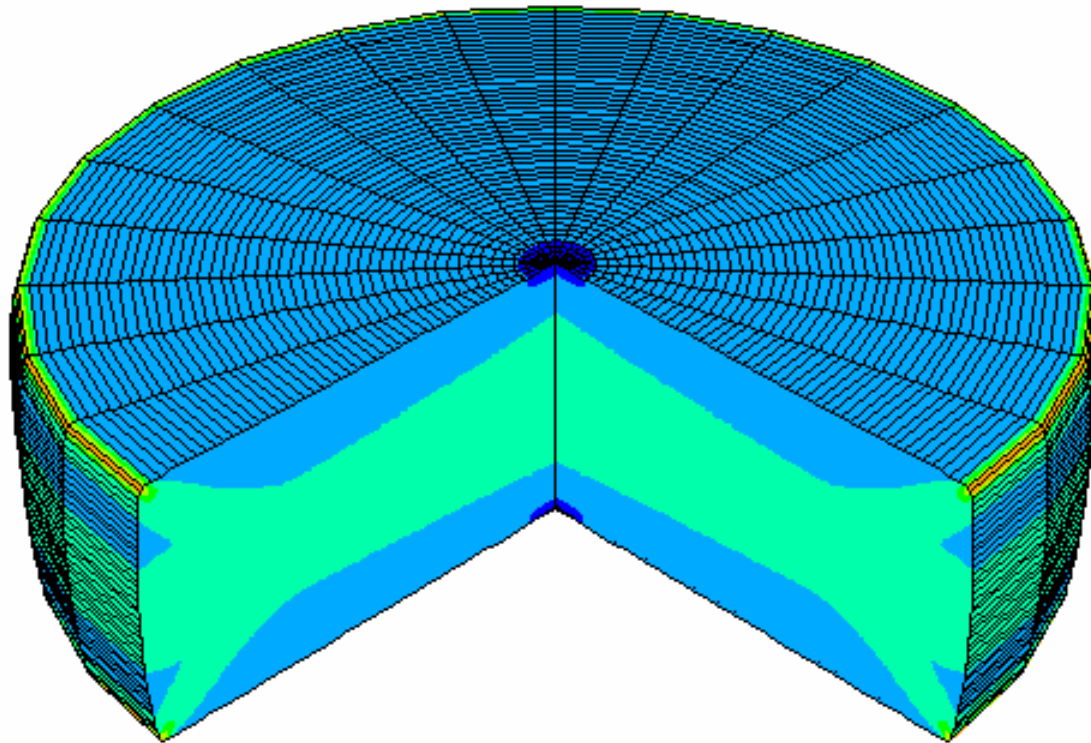
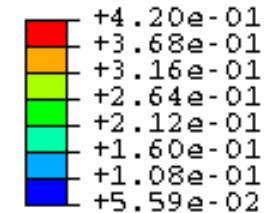


ABAQUS job created on 10-Sep-01 at 15:30:25  
ODB: button1.odb ABAQUS/Standard 6.2-1  
Step: Step-1

Thu Sep 13 13:02:17 EDT 2001

Button #1 "B" – 75% Original Thickness – Friction = 0.1  
28.956 mm (1.14") Dia. x 12.446 (0.49") mm Thick  
Maximum Principal Nominal Strain

NE, Max. Principal  
(Ave. Crit.: 75%)



ABAQUS job created on 10-Sep-01 at 15:30:25

ODB: button1b.odb ABAQUS/Standard 6.2-1

Fri Sep 14 18:00:07 EDT 2001

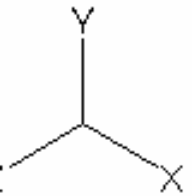
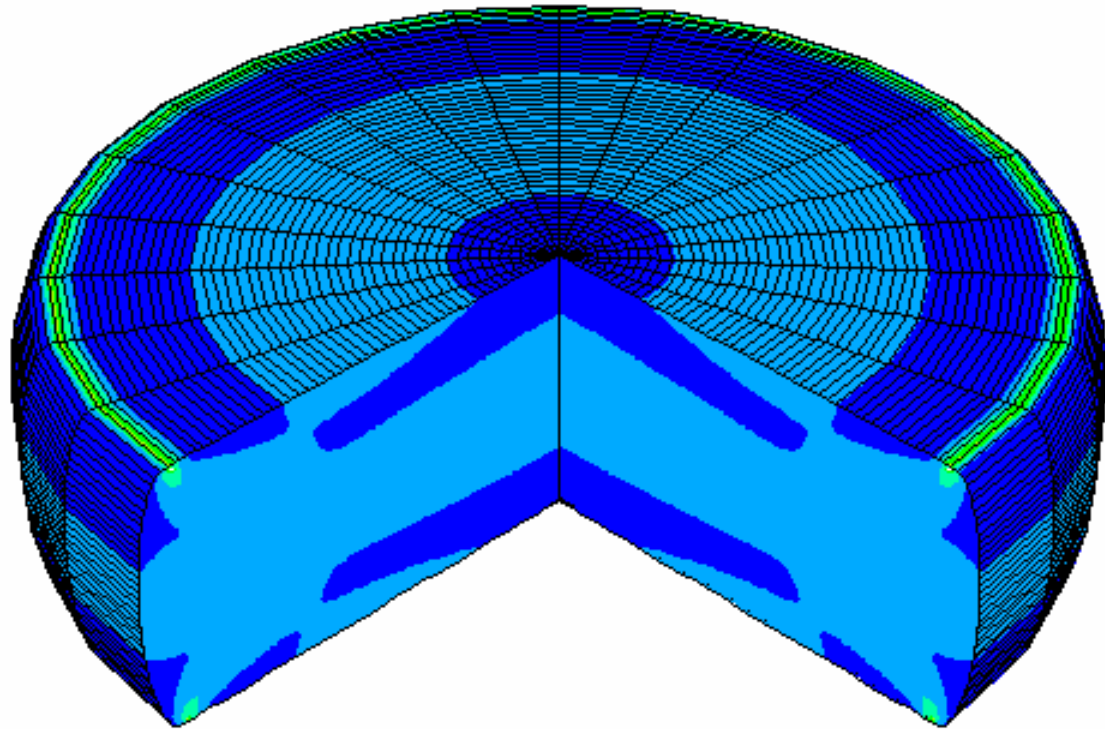
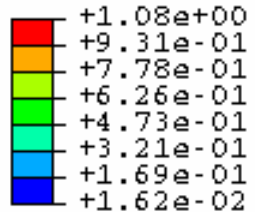
Step: Step-1

Increment 10: Step Time = 1.000

Primary Var: NE, Max. Principal

**Button #1 "C" - 75% Original Thickness - Friction = 0.2**  
**28.956 mm (1.14") Dia. x 12.446 (0.49") mm Thick**  
**Maximum Principal Nominal Strain**

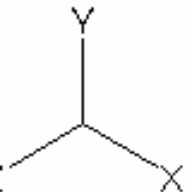
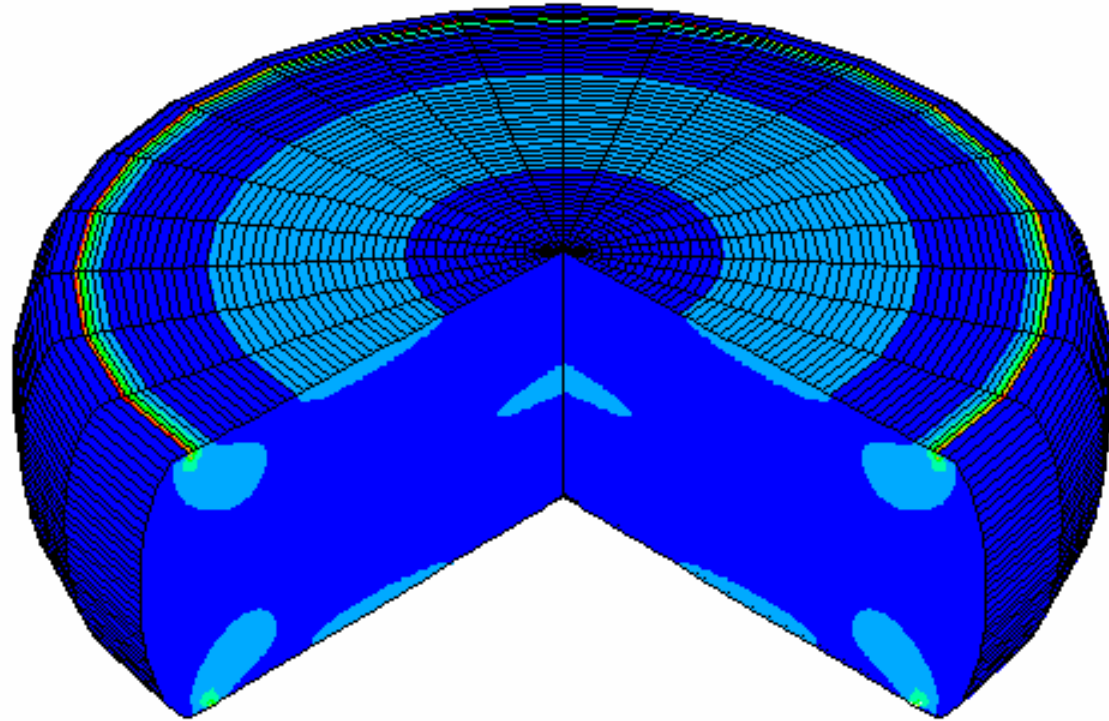
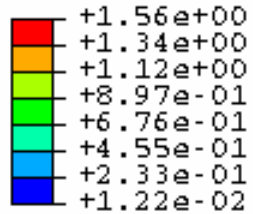
NE, Max. Principal  
(Ave. Crit.: 75%)



ABAQUS job created on 10-Sep-01 at 15:30:25  
ODB: buttonlc.odb      ABAQUS/Standard 6.2-1      Fri Sep 14 19:00:07 EDT 2001  
Step: Step-1  
Increment      20: Step Time =      1.000  
Primary Var: NE, Max. Principal

**Button #1 "D" – 75% Original Thickness – Friction = 0.3**  
**28.956 mm (1.14") Dia. x 12.446 (0.49") mm Thick**  
**Maximum Principal Nominal Strain**

NE, Max. Principal  
(Ave. Crit.: 75%)



ABAQUS job created on 10-Sep-01 at 15:30:25

ODB: button1d.odb ABAQUS/Standard 6.2-1

Fri Sep 14 20:00:06 EDT 2001

Step: Step-1

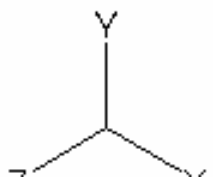
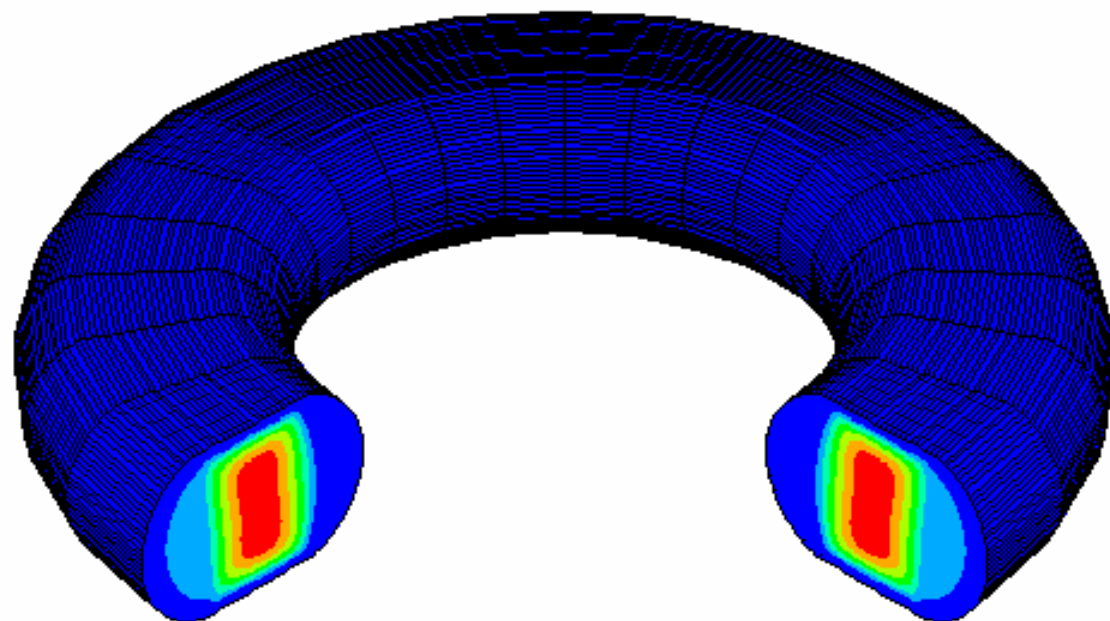
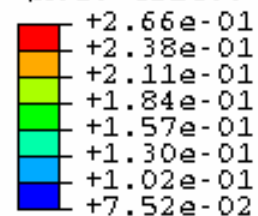
Increment 23: Step Time = 1.000

Primary Var: NE, Max. Principal

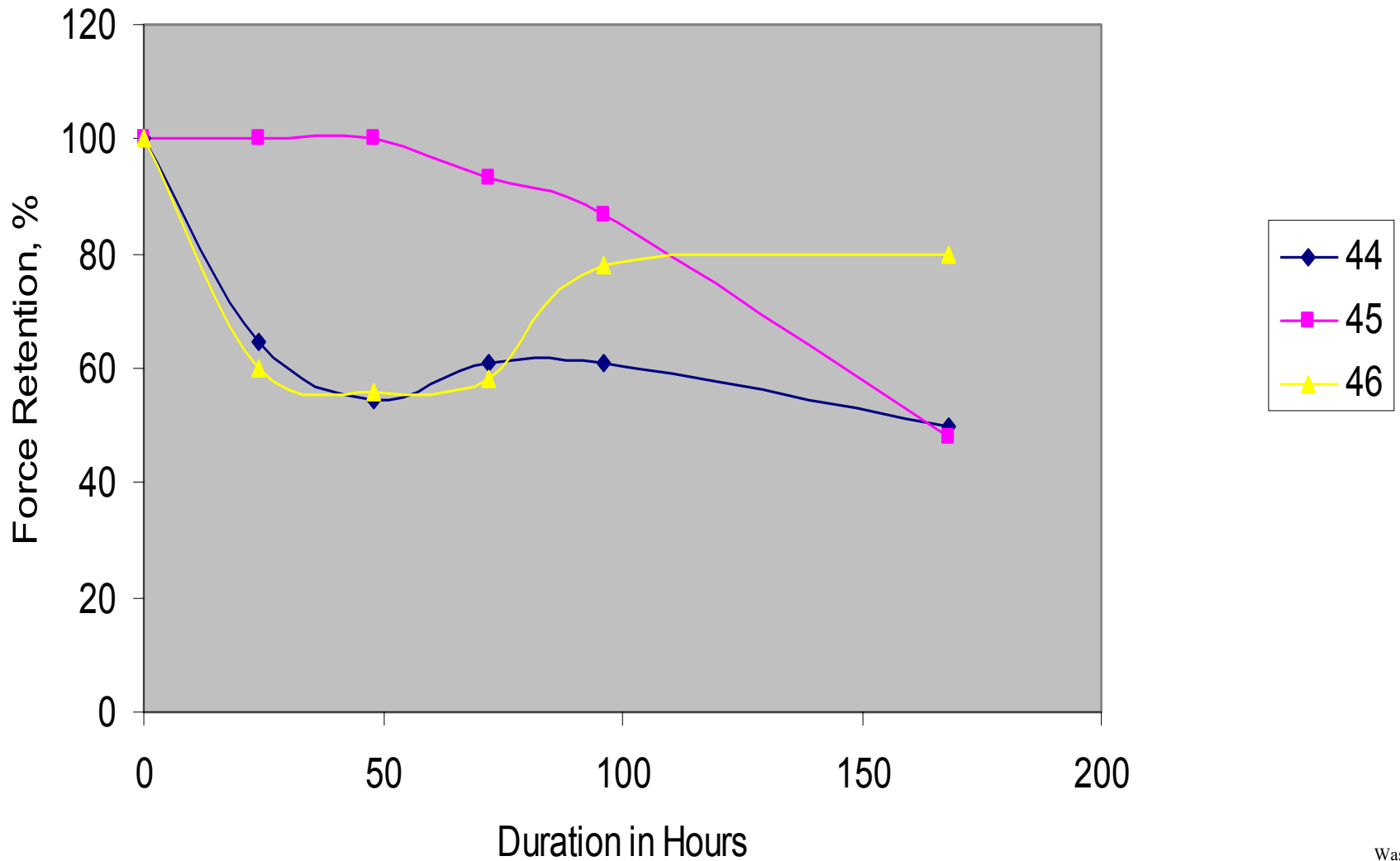
**O-ring #2 – 75% Original Thickness – Friction = 0.0**  
**12.7 mm (0.5") ID x 6.350 (0.25") mm Thick**  
**Maximum Principal Nominal Strain**

O-ring

NE, Max. Principal  
(Ave. Crit.: 75%)

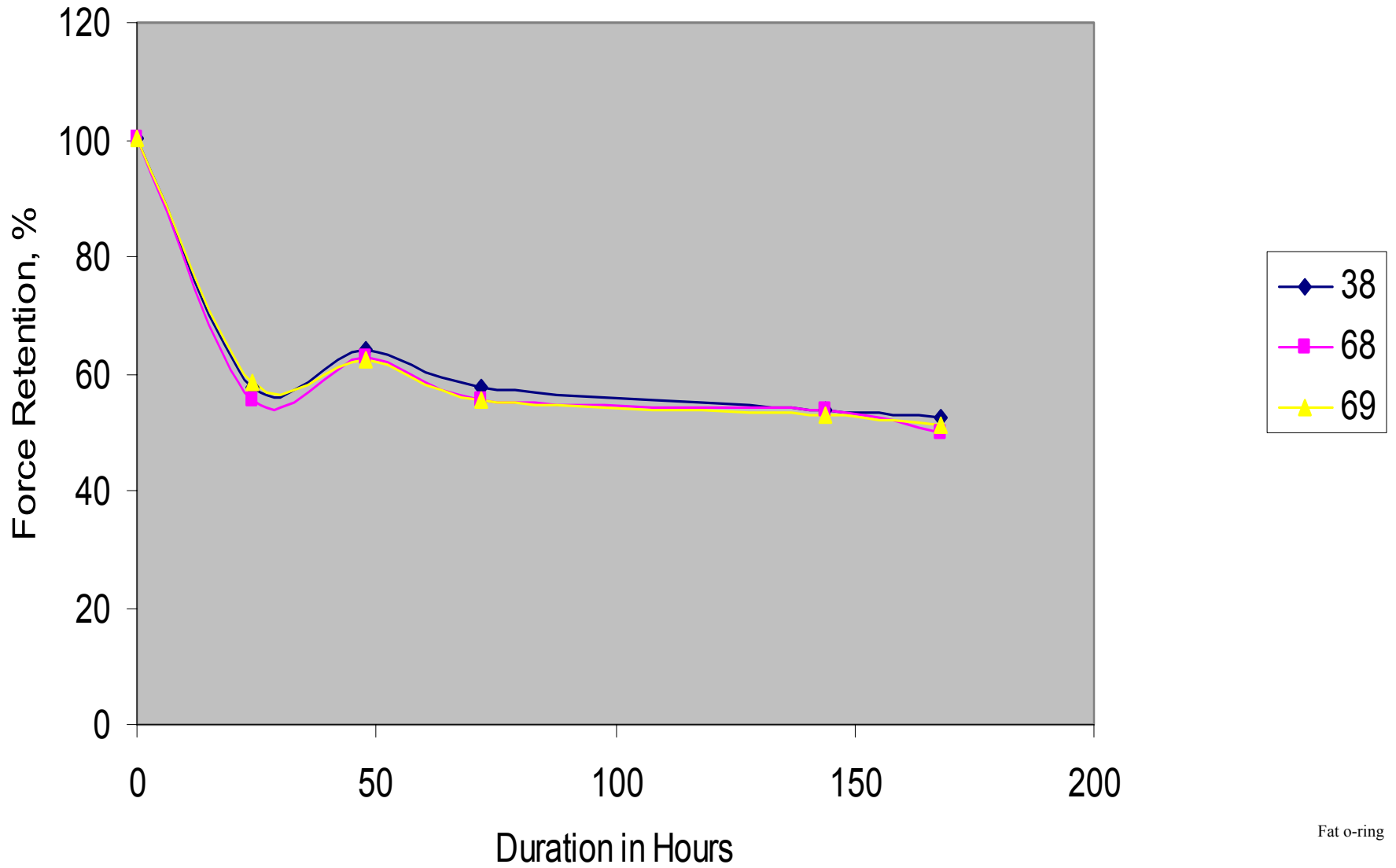


# CSR: PCC524-086B In Mobil I Oil- Washer



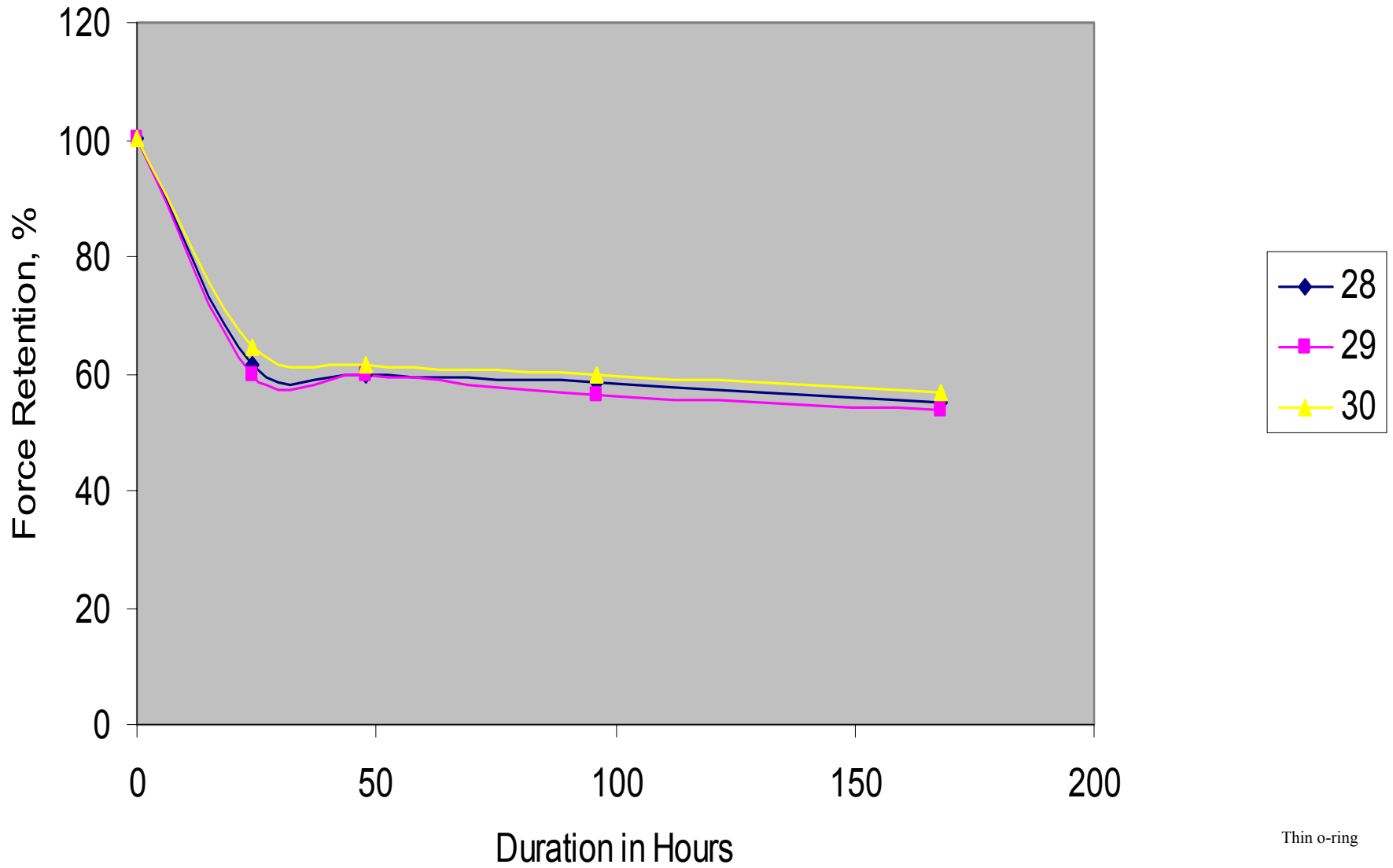


# CSR: PCC524-086B In Mobil I Oil- Fat O-Ring



Fat o-ring

# CSR: PCC524-086B In Mobil I Oil- Thin O-Ring



Thin o-ring

# Test Considerations

- Coefficient of Thermal Expansion – Stress can change significantly with temperature. Materials that look good at high or RT may have no stress at low temperature.

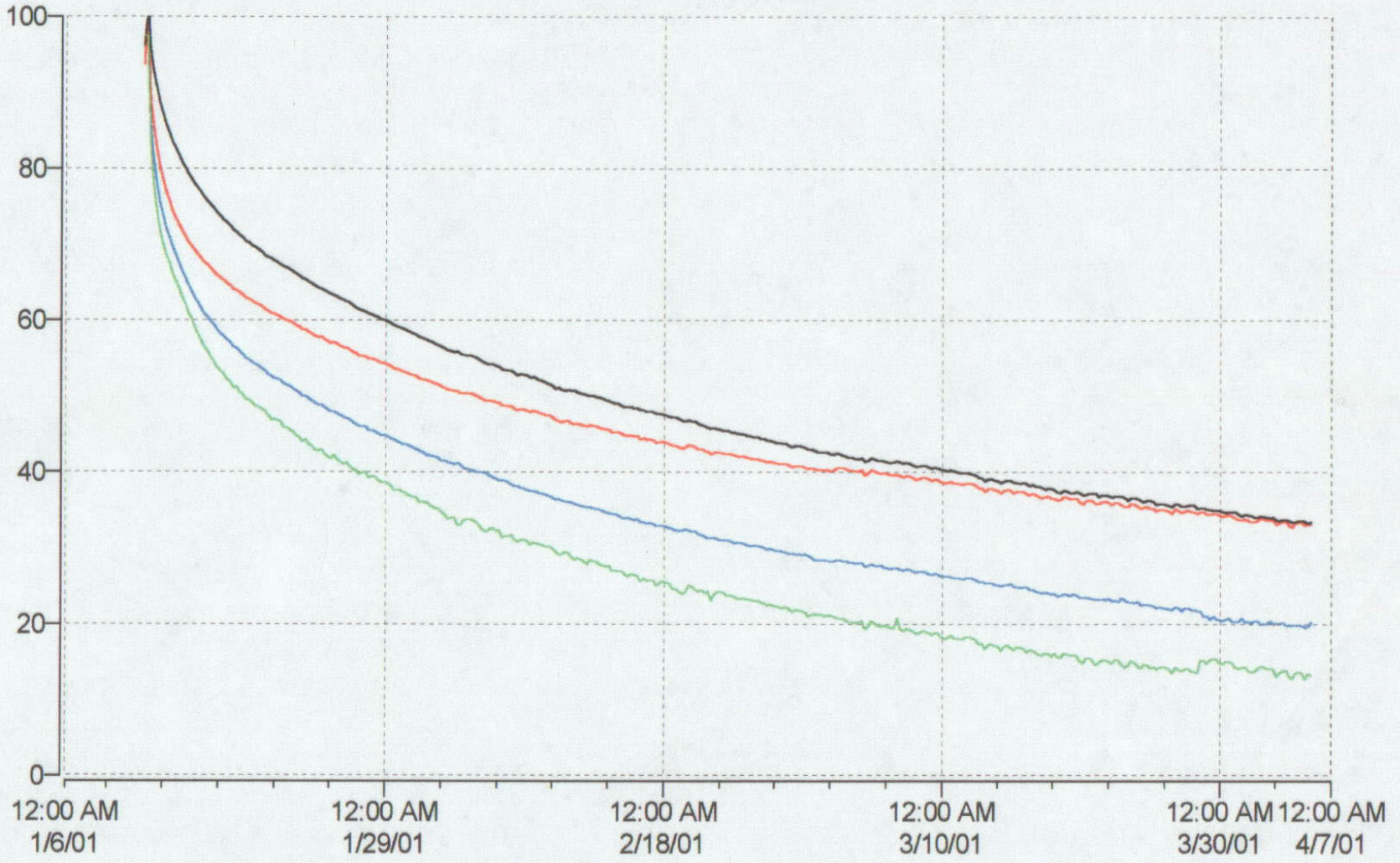


# Test considerations

- State of Cure – Differences in the state of cure of lab molded samples vs. production molded parts may result in poor predictability of test results.

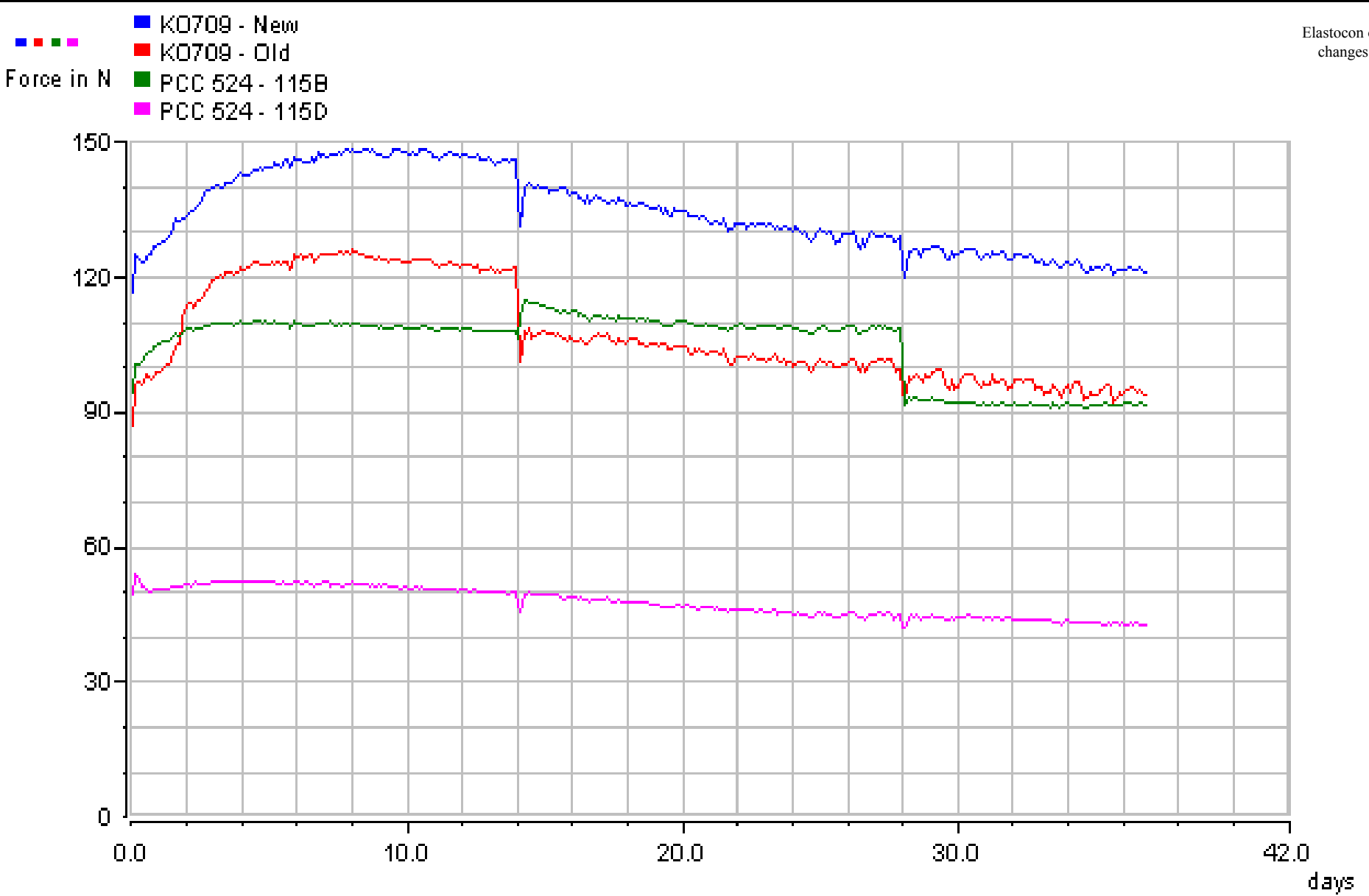
# Temperatortrend

- 10 min @ 340F
- 15 min @ 340F
- 4 min @ 340F pc 4-400F
- 7 min @ 340F



# Test Considerations

- Swell – Experience has shown that stress often increases in the first few days when aged in oils.
- Oil Changes – The type of oil and its frequency of change.



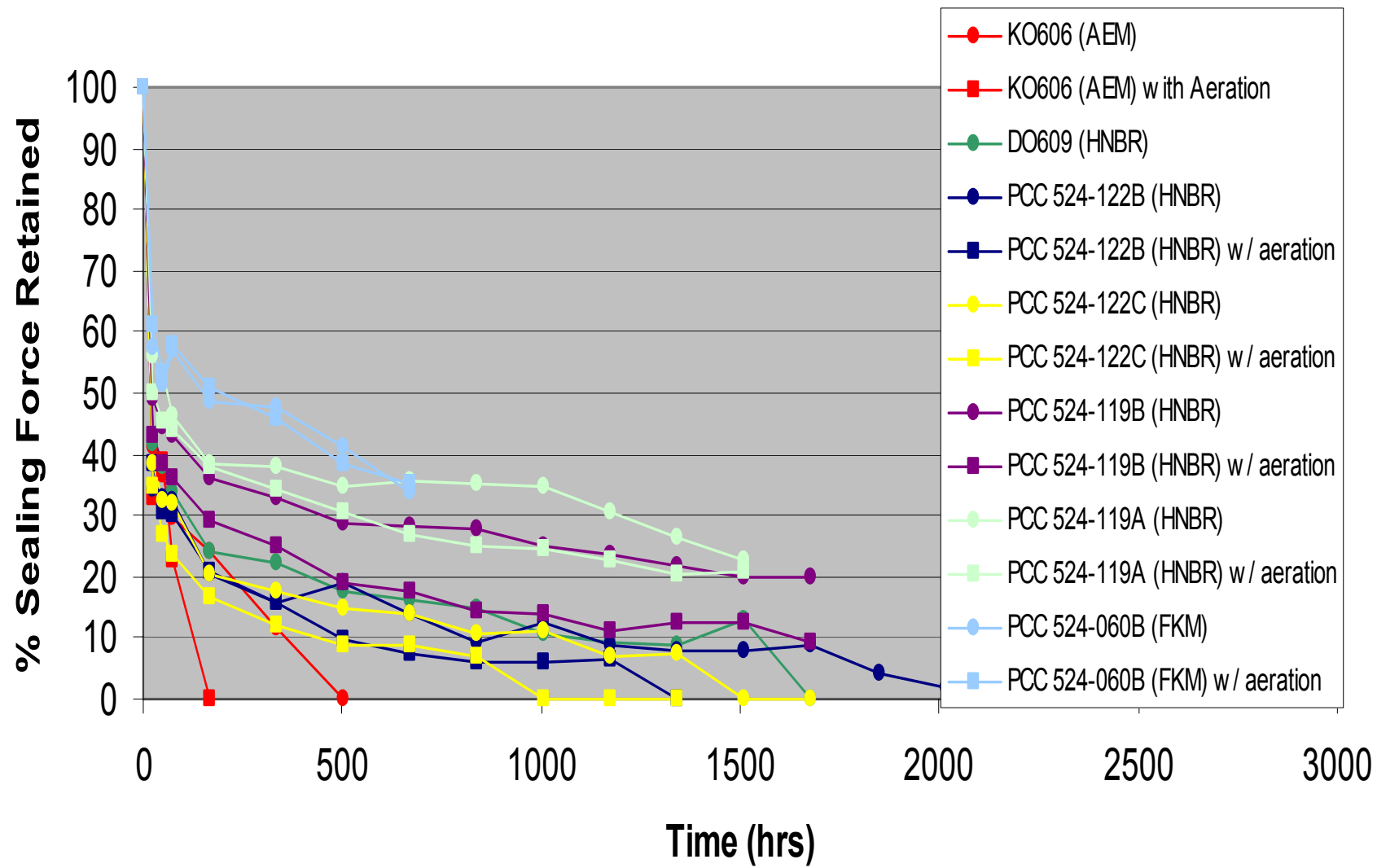


# Test Considerations

- Aeration of test fluids – Aerated vs. non-aerated oil can have a major effect on the deterioration of some types of rubber.

# Mobil 1 CSR

(150C, 336 Hrs Fluid Change, aeration 4 hrs/daily)



How Good is CSR Data?  
Should CSR be added to print  
callouts?

# ASTM Interlaboratory Test Program - 1994

- 5 of 7 laboratories used Shawbury-Wallace Method A
- Both 12.7 mm buttons and washers were tested on a single material
- Gage R&R data analysis done with MINITAB
- 3 aging periods used in data analysis

## Gage R&R

### Shawbury-Wallace with washer

Source	VarComp	StdDev	5.15*Sigma
Total Gage R&R	67.505	8.21616	42.3132
Repeatability	16.467	4.05795	20.8984
Reproducibility	51.038	7.14412	36.7922
lab	48.654	6.97527	35.9226
lab*time	2.384	1.54404	7.9518
Part-To-Part	26.873	5.18389	26.6970
Total Variation	94.378	9.71484	50.0314

Source	%Contribution	%Study Var
Total Gage R&R	71.53	<b>84.57</b>
Repeatability	17.45	41.77
Reproducibility	54.08	73.54
lab	51.55	71.80
lab*time	2.53	15.89
Part-To-Part	28.47	53.36
Total Variation	100.00	100.00

Number of Distinct Categories = 1

# Shawbury-Wallace with washer

Gage name:

Date of study:

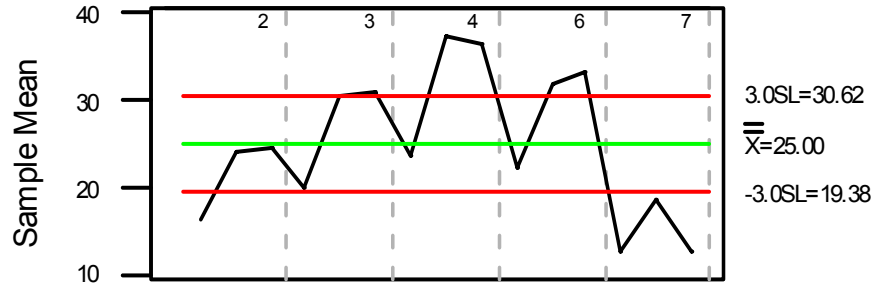
Reported by:

Tolerance:

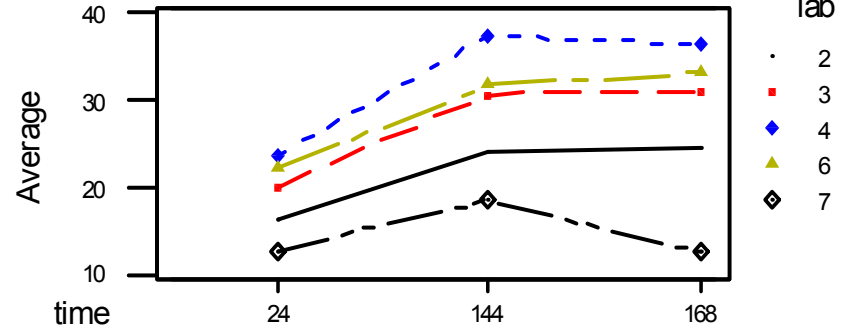
Misc:

Washer graphics

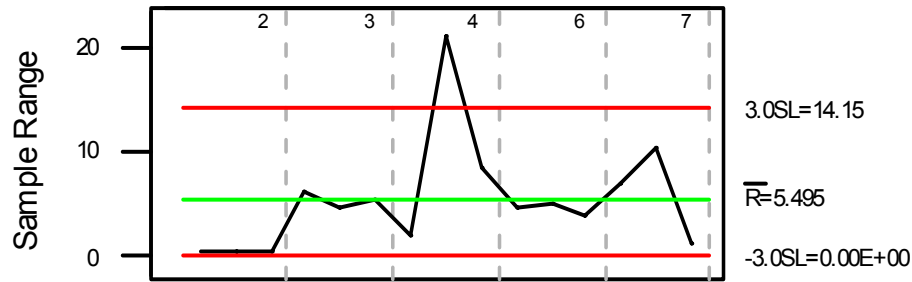
### Xbar Chart by lab



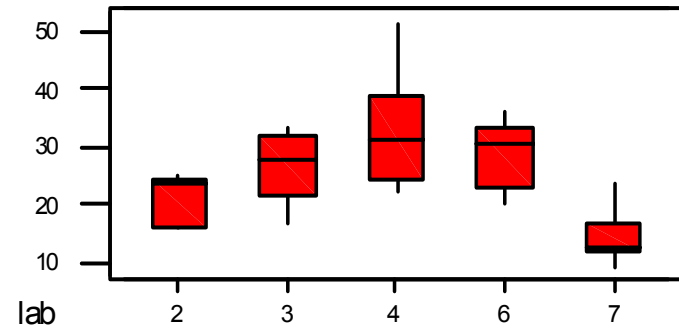
### lab\*time Interaction



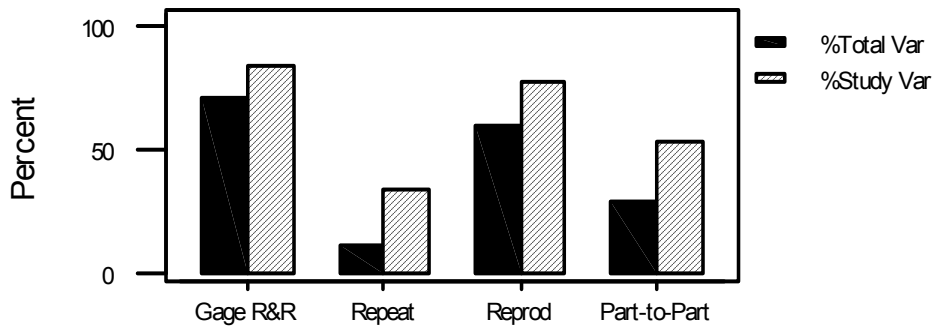
### R Chart by lab



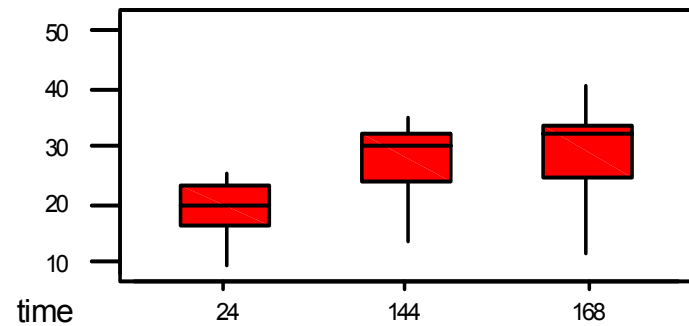
### Response by lab



### Components of Variation



### Response by time



## Gage R&R

Button analysis

Source	VarComp	StdDev	5.15*Sigma
Total Gage R&R	23.239	4.82071	24.8266
Repeatability	3.248	1.80220	9.2813
Reproducibility	19.991	4.47116	23.0265
lab	19.991	4.47116	23.0265
Part-To-Part	12.427	3.52514	18.1545
Total Variation	35.666	5.97209	30.7562

Source	%Contribution	%Study Var
Total Gage R&R	65.16	80.72
Repeatability	9.11	30.18
Reproducibility	56.05	74.87
lab	56.05	74.87
Part-To-Part	34.84	59.03
Total Variation	100.00	100.00

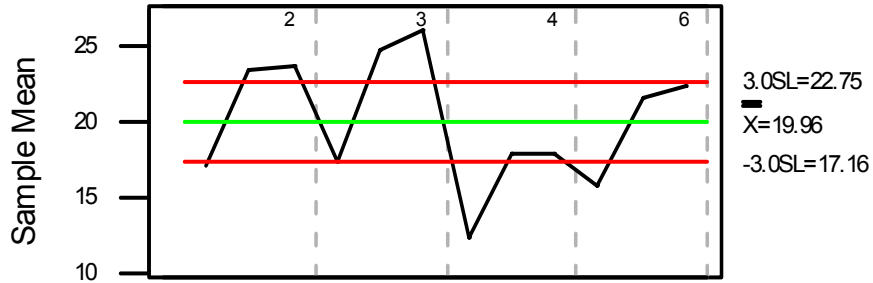
Number of Distinct Categories = 1

# Shawbury-Wallace with button

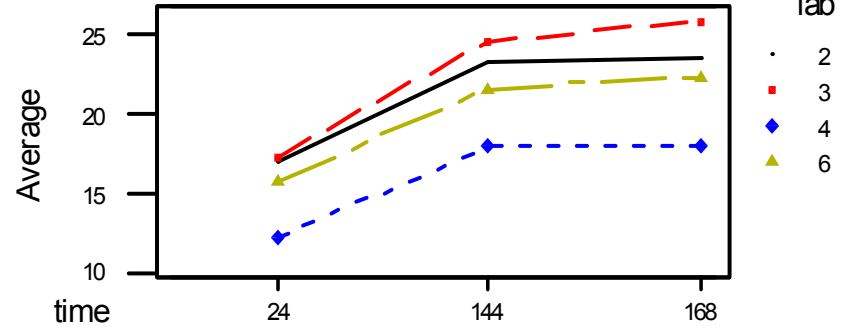
Gage name: Shawbury Wallace  
 Date of study: IPT #2, 1994  
 Reported by: ASTM  
 Tolerance:   
 Misc: D4483

Button graphics

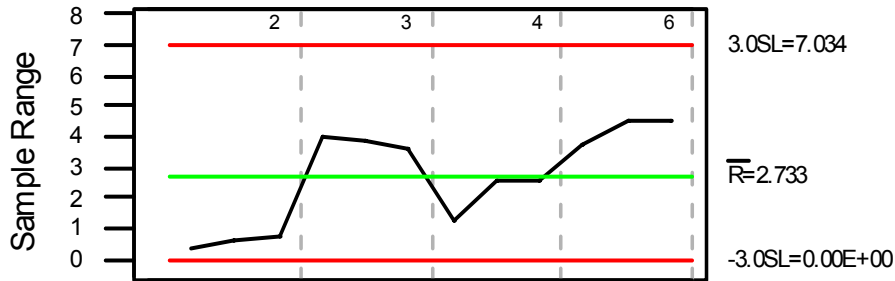
### Xbar Chart by lab



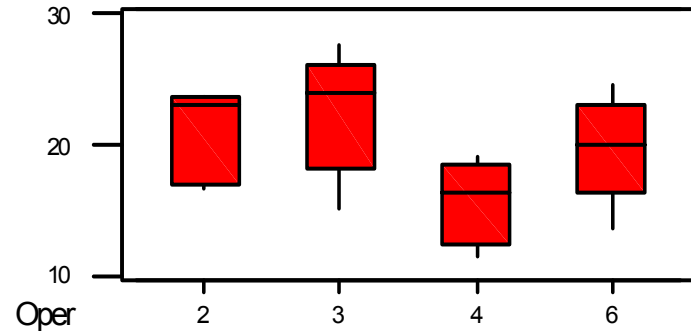
### lab\*time Interaction



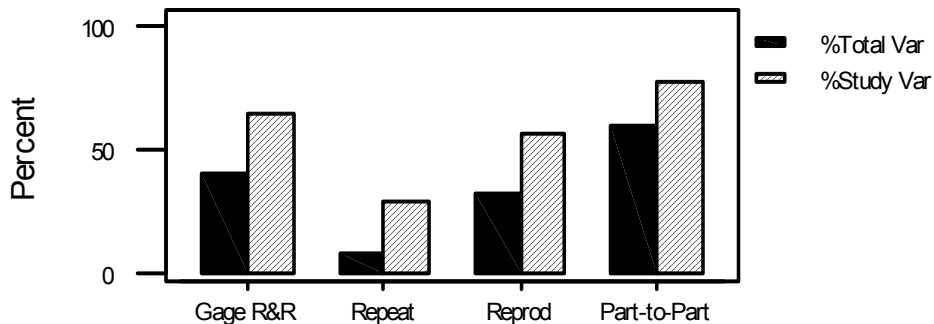
### R Chart by lab



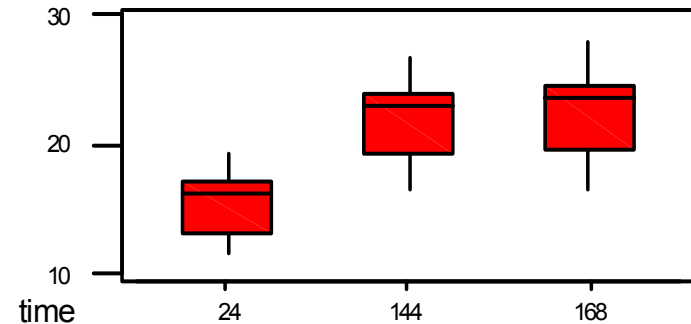
### Response By lab



### Components of Variation



### Response By time





# The Report of the Interlaboratory Test Program is available for purchase from ASTM.

- ASTM calls the laboratory variation or reproduceability as “excessively high” and “not worthy of serious consideration for interlaboratory testing”

# QS-9000 Guidelines for Acceptance of gage Repeatability and Reproducibility

- Under 10% error – the measurement system is acceptable
- 10% to 30% error – may be acceptable based upon importance of application, cost of gage, cost of repairs, etc.
- Over 30% error – measurement system needs improvement. Make every effort to identify the problems and have them corrected.

# Recommendations

- Do an internal R & R Study.
- Do not compare your data with any lab that is using dissimilar equipment or methods.
- Do not compare your data with any other lab without an R & R Study with that lab.
- Educate your customers and don't blindly accept CSR requirements on prints.

With proper care, CSR can be used as an internal screening method in conjunction with other material evaluation methods.