BiTS™

Burn-in & Test Socket Workshop

March 7 - 10, 2004
Hilton Phoenix East / Mesa Hotel
Mesa, Arizona

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Burn-in & Test Socket Workshop

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Session 6
Tuesday 3/09/04 1:00PM

MODELING AND DESIGN

"Handling Considerations For Leadless Device Types"

Gerhard Gschwendtberger – Multitest Electronic Systems

"Measurement Of Stress Relaxation In Copper Beryllium Strip Using Dynamic Techniques"

Mike Gedeon – Brush Wellman Inc. **Jim Johnson** – Brush Wellman Inc.

"Controlling Test Cell Contact Resistance With Non-destructive Conditioning Practices"

Jerry Broz – International Test Solutions **Gene Humphrey** – International Test Solutions

"A New Finite Element Analysis Technique For Modeling Stress Relaxation Of Electro-Mechanical Spring Contacts Made Using Copper Beryllium Strip"

Chris M. Dempsey – Intel Corporation
Vinayak Pandey – Intel Corporation **Naoaki Takayama** – Enplas
Arun Aggrawal – CAE Associates **Jim L. Johnson** – Brush Wellman Inc.

Handling Considerations for Leadless Device Types

2004 Burn-in and Test Socket Workshop

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Gerhard Gschwendtberger
Multitest elektronische Systeme GmbH

Handling Leadless Packages

Contactors in test handlers...
...Where the rubber hits the road

- Which positioning accurracy between package and contact socket can be achived?

- How is an accurate & repeatable compression of the contact springs be realized?

- What additional (compared to a lab environment) requirements for contactors do exist?

Handling of (isolated) Leadless Packages

Pick and Place Handlers

QFP, BGA, PGA

Throughput ~ 7k per h

Tray to Tray

Tray to Tape

Gravity Handlers

SO, TO, DIP

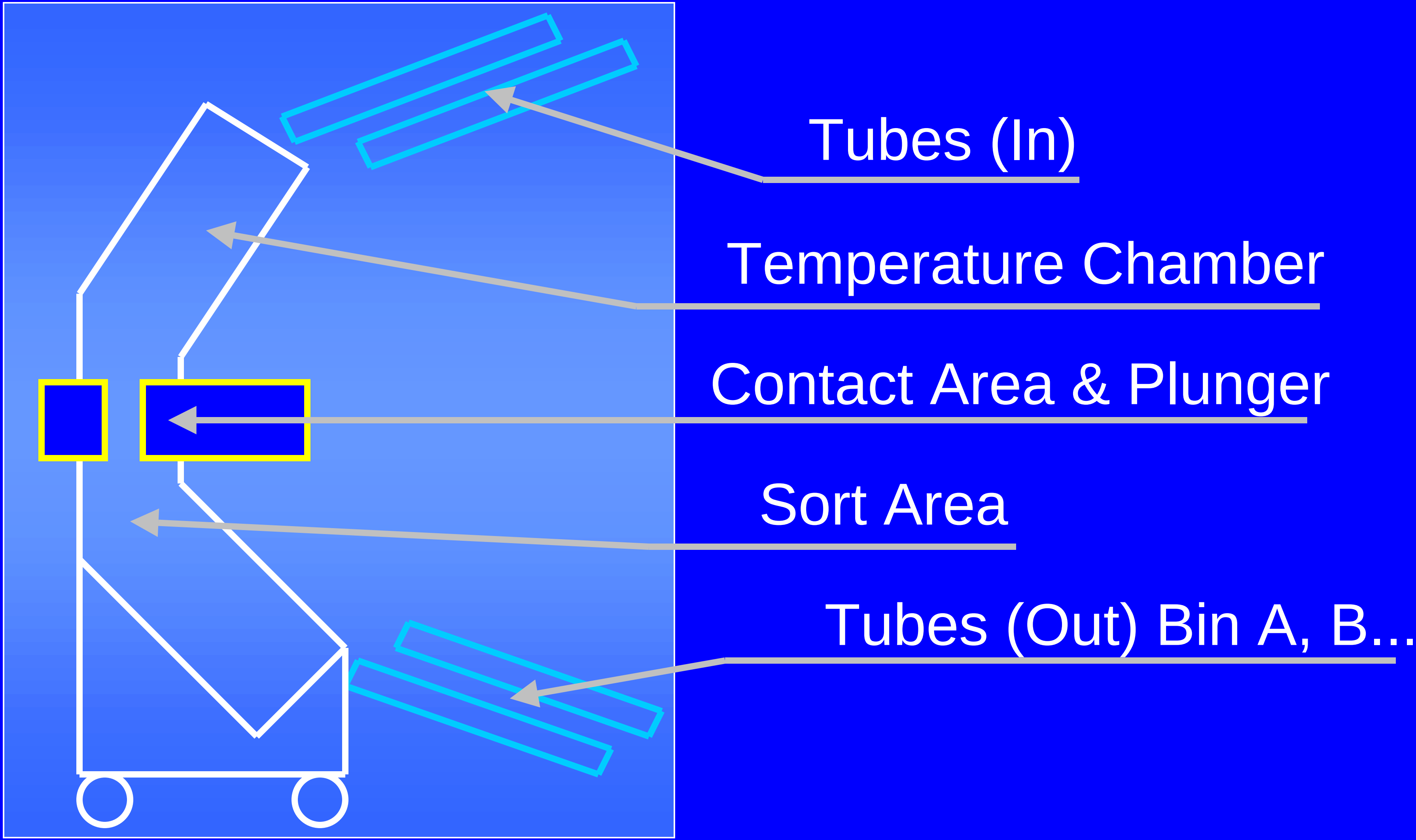
Throughput ~ 20k per h

Tube to Tube

Tube to Tape

-> peferred <-

Gravity Handlers - Concept



Tubes (In)

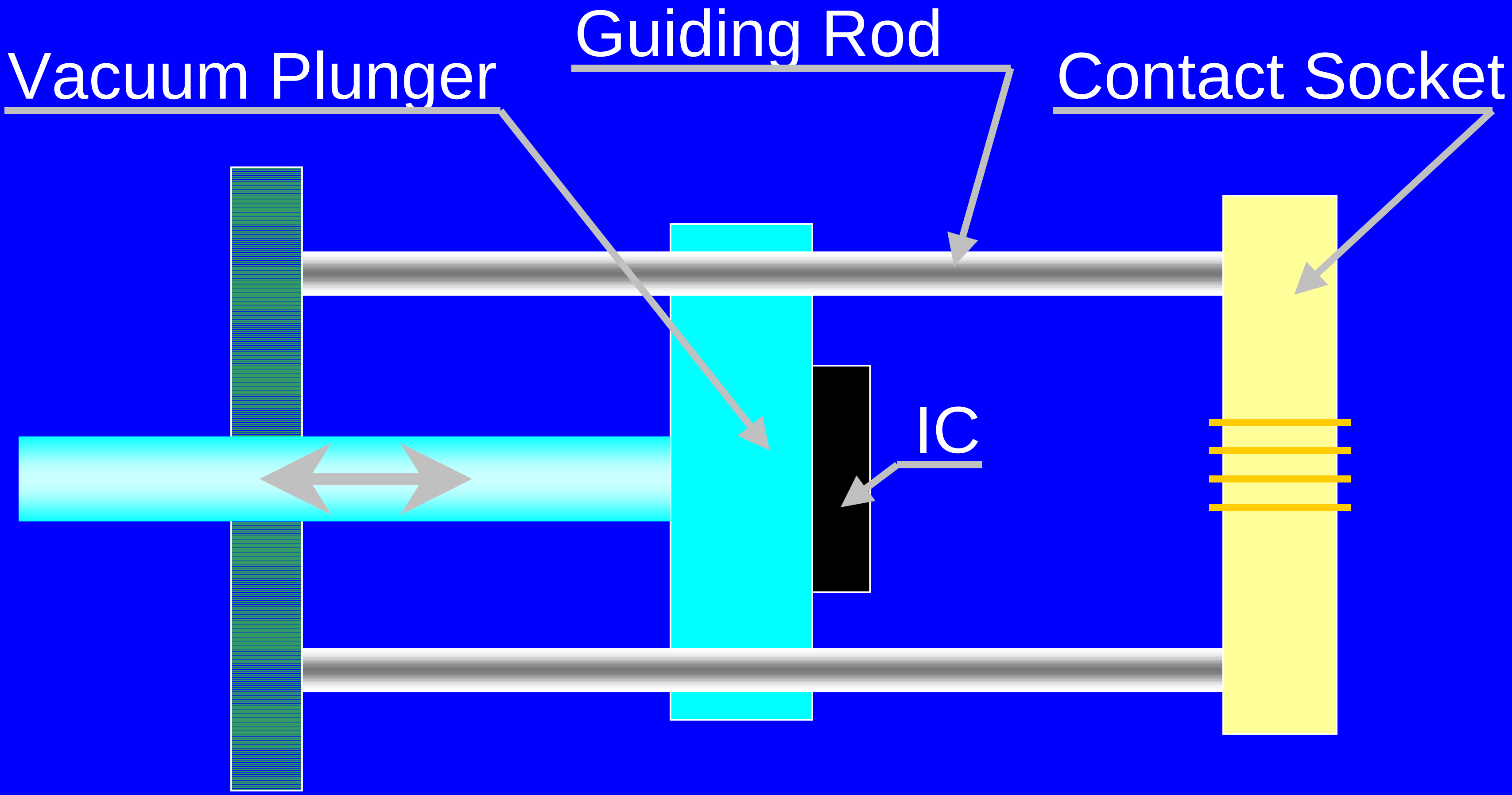
Temperature Chamber

Contact Area & Plunger

Sort Area

Tubes (Out) Bin A, B…

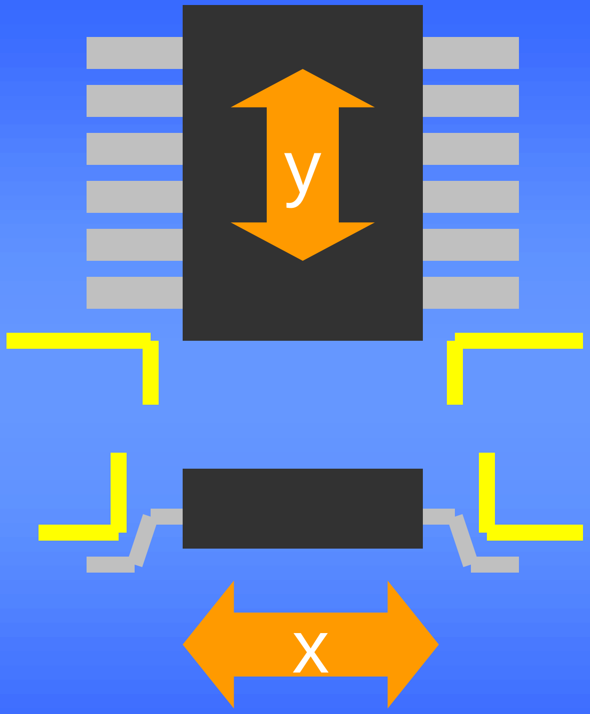
Contacting Area & Plunger



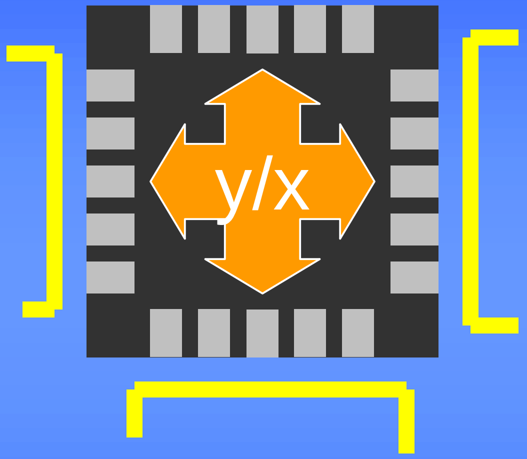
Objective: Minimized tolerance chain

Alignment of Leadless Packages

x / y Alignment Leaded vs Leadless ICs

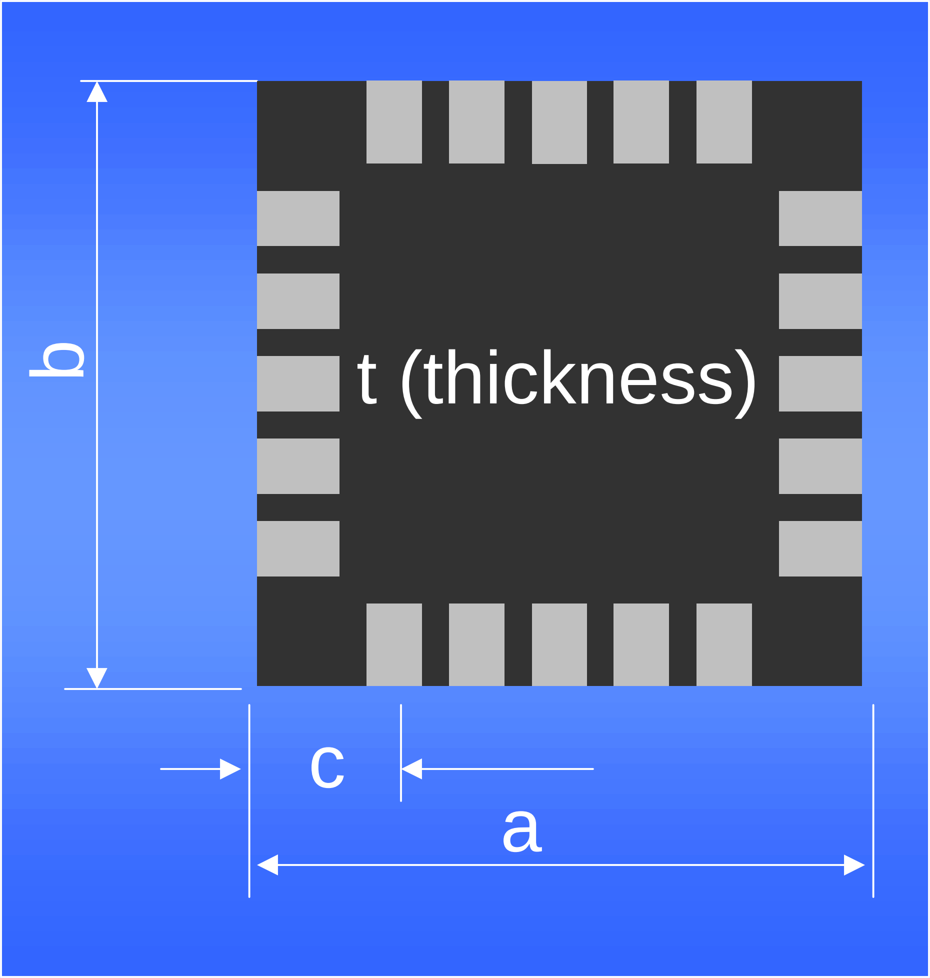


Reference: IC Leads



Reference: IC Body

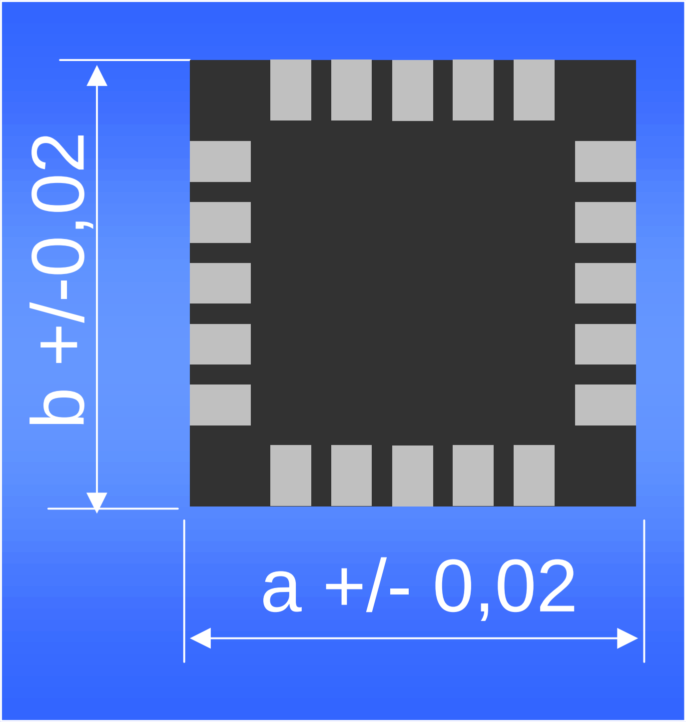
Tolerances of Leadless Packages



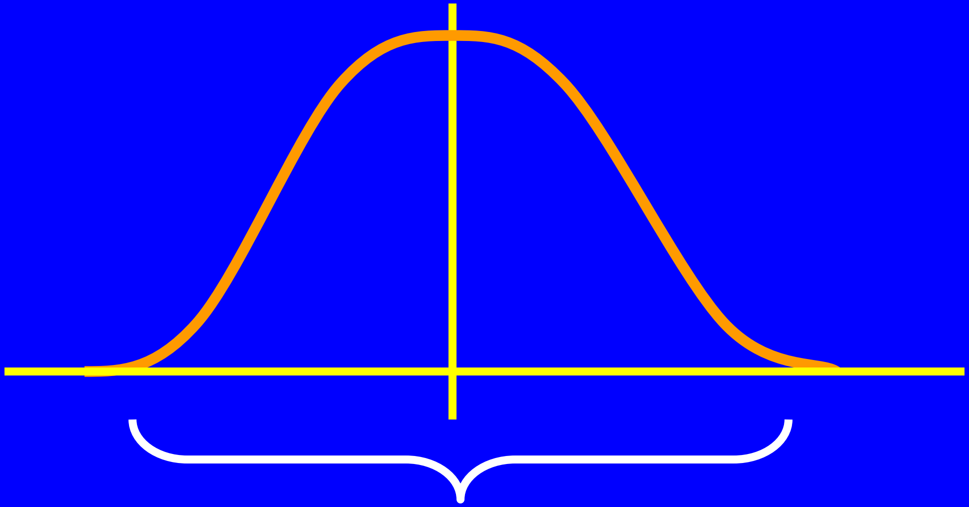
JEDEC:
a & b = +/- 0,15 mm
c = +/- 0,1mm
t = +/-0,1mm
-> no mechanical alignment possible

Measurements on real production lots:
a & b = +/- 0,02mm
c = +/- 0,01mm
t = +/- 0,02mm

Tolerances of Leadless Packages



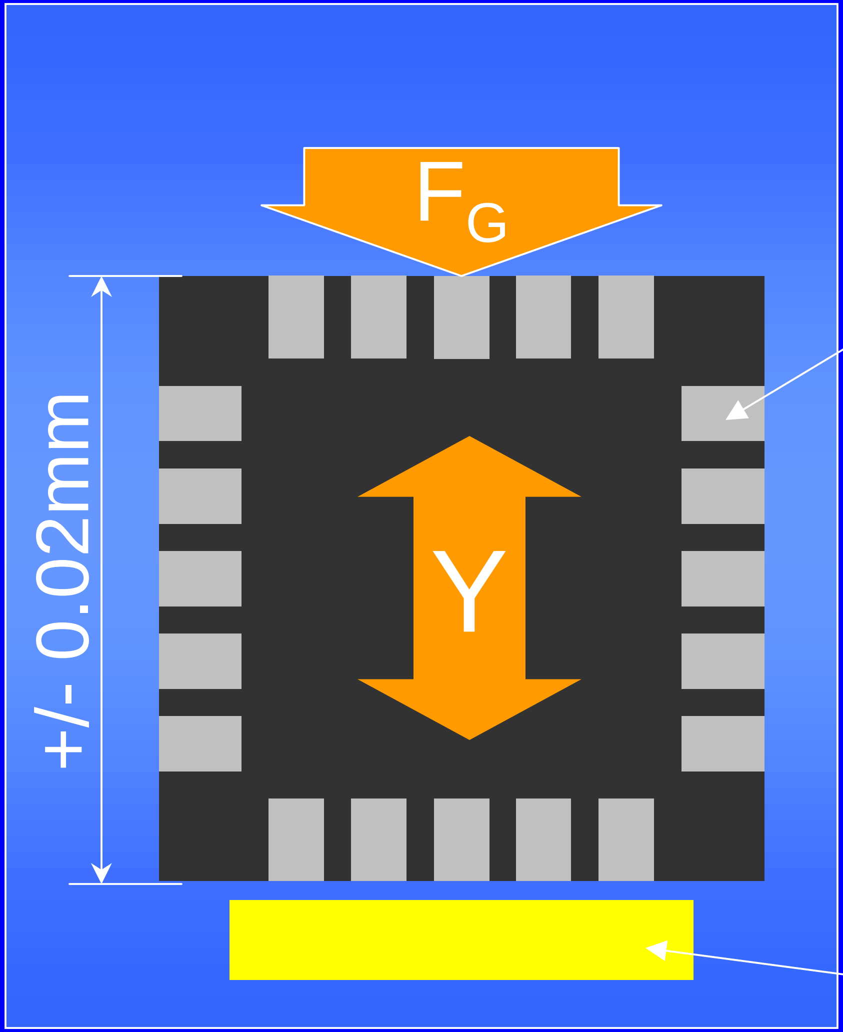
Statistic



+/- 3s

= 99,73% of all packages
in one production lot
are within these tolerances

Alignment of Leadless Packages



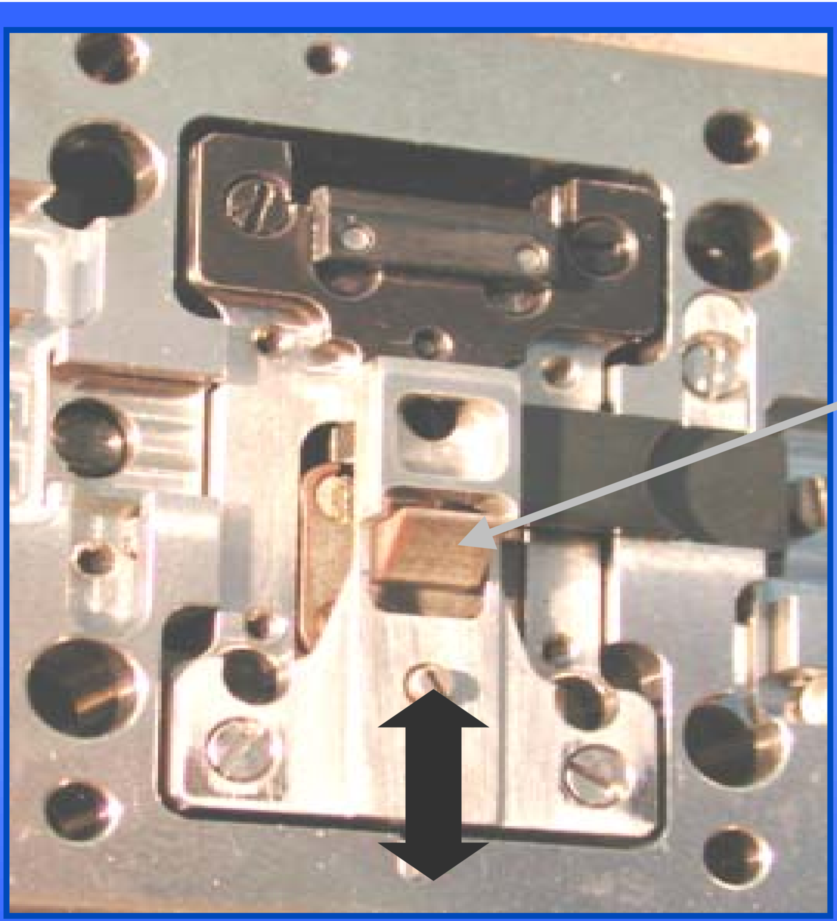
y Position

Padpostion +/- 0,02
against Package Body

y - Alignment Accuracy
= +/- 0,03mm

Hardstop (Bodystopper)

Alignment of Leadless Packages



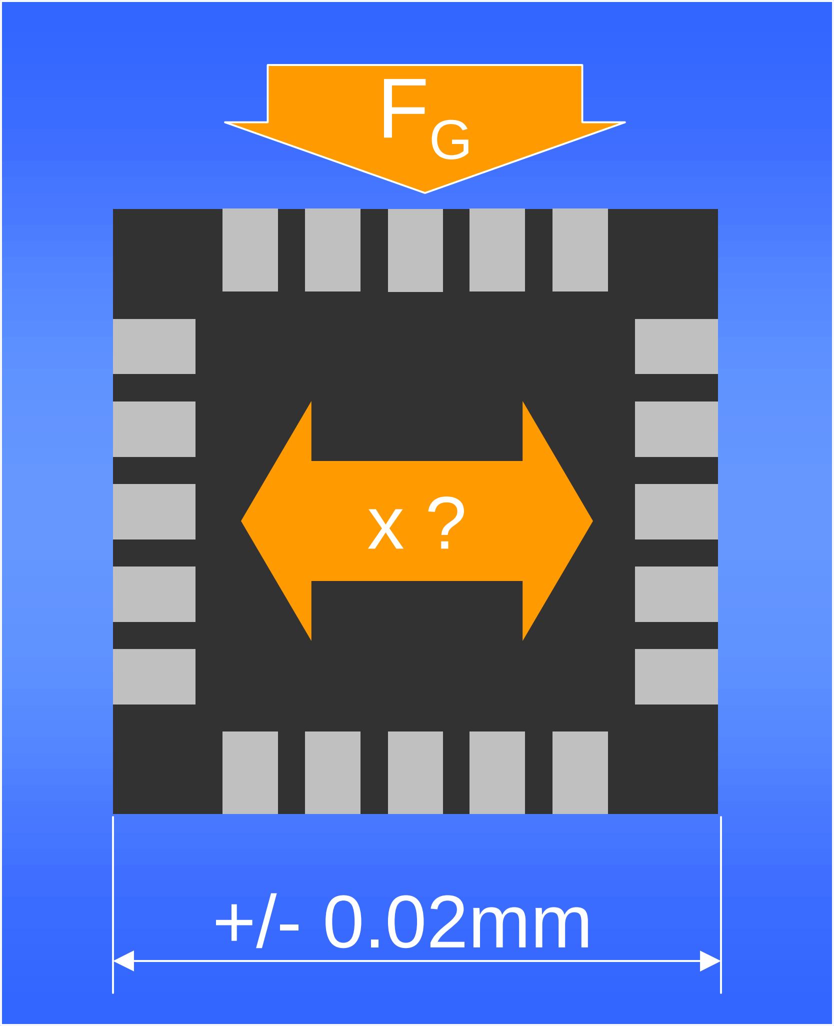
View on plunger head

y Position

Adjustable Hardstop

Stopper material
Steel / Sapphier
to reduce wear of the stopper & increase repeatability of
y- position alignment

Alignment of Leadless Packages



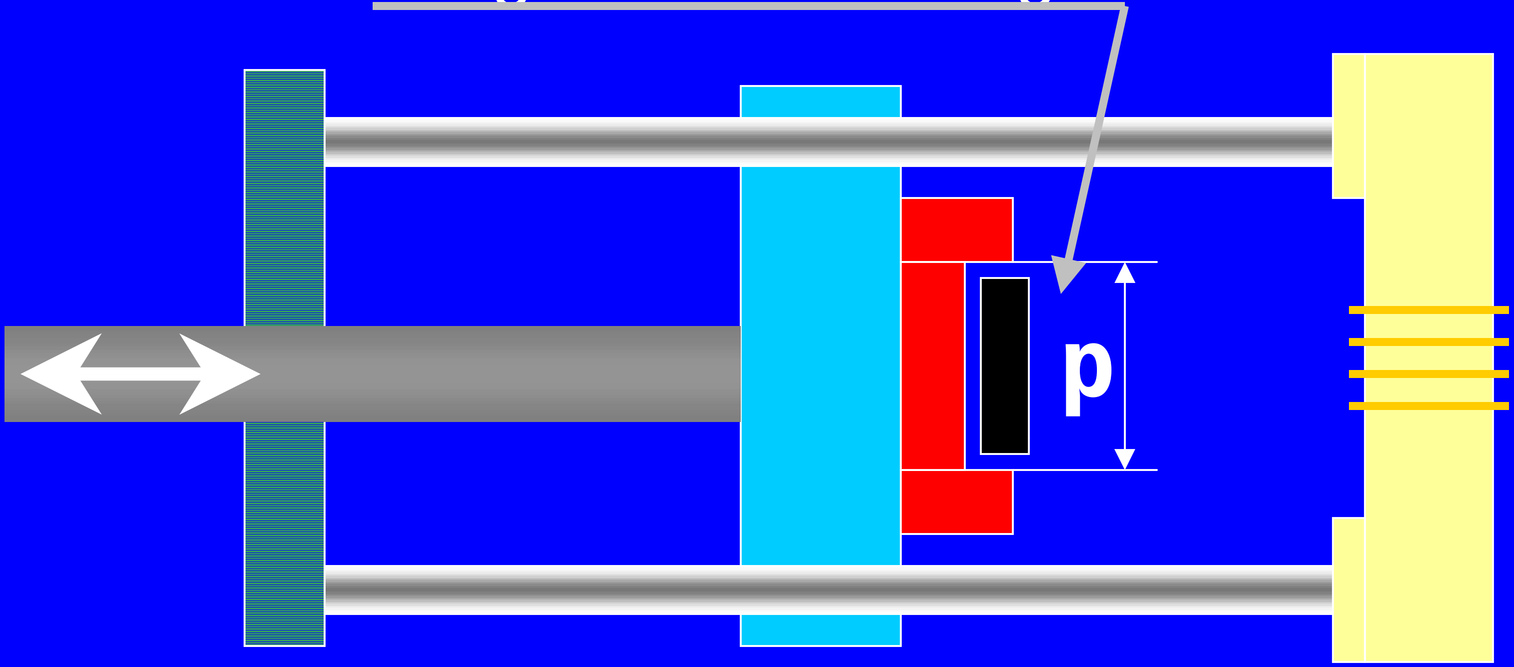
x Position

In x direction there is no instant force available

There are different concepts used in gravity handlers to align the package in x - direction

Alignment of Leadless Packages

Version A: Alignment on Plunger

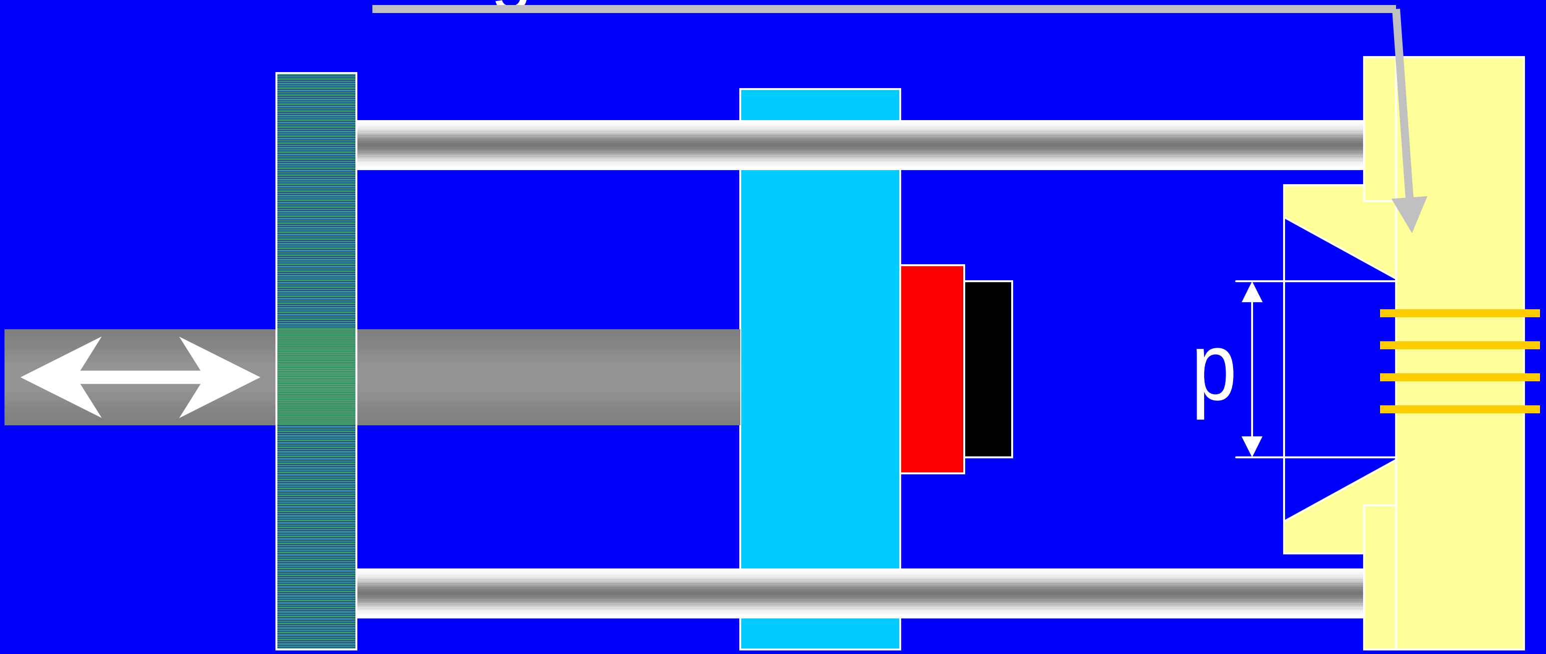


Size p must be adjusted to the maximum device width plus additional ~0,06mm

x - Alignment Accuracy
Version A:
= +/- 0,06mm

Alignment of Leadless Packages

Version B: Alignment on Contact Socket

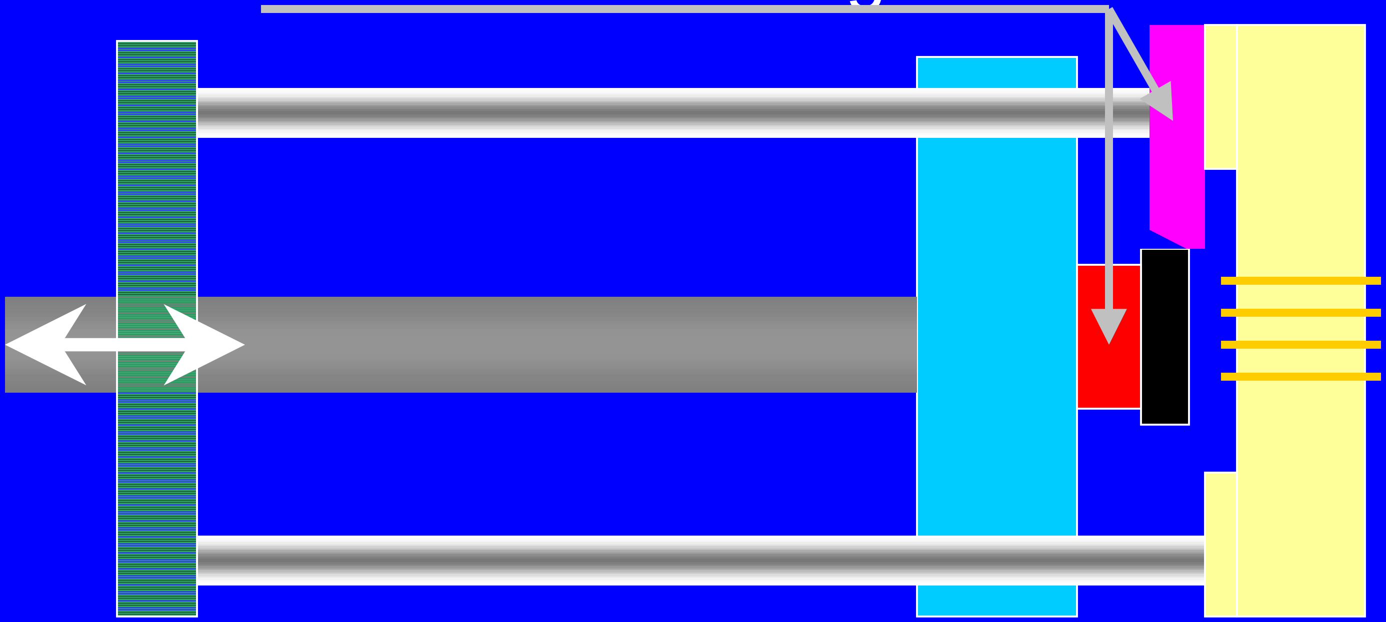


Size p must be adjusted to the maximum device width plus additional ~0,04mm

x - Alignment Accuracy Version B:
= +/- 0,05mm

Alignment of Leadless Packages

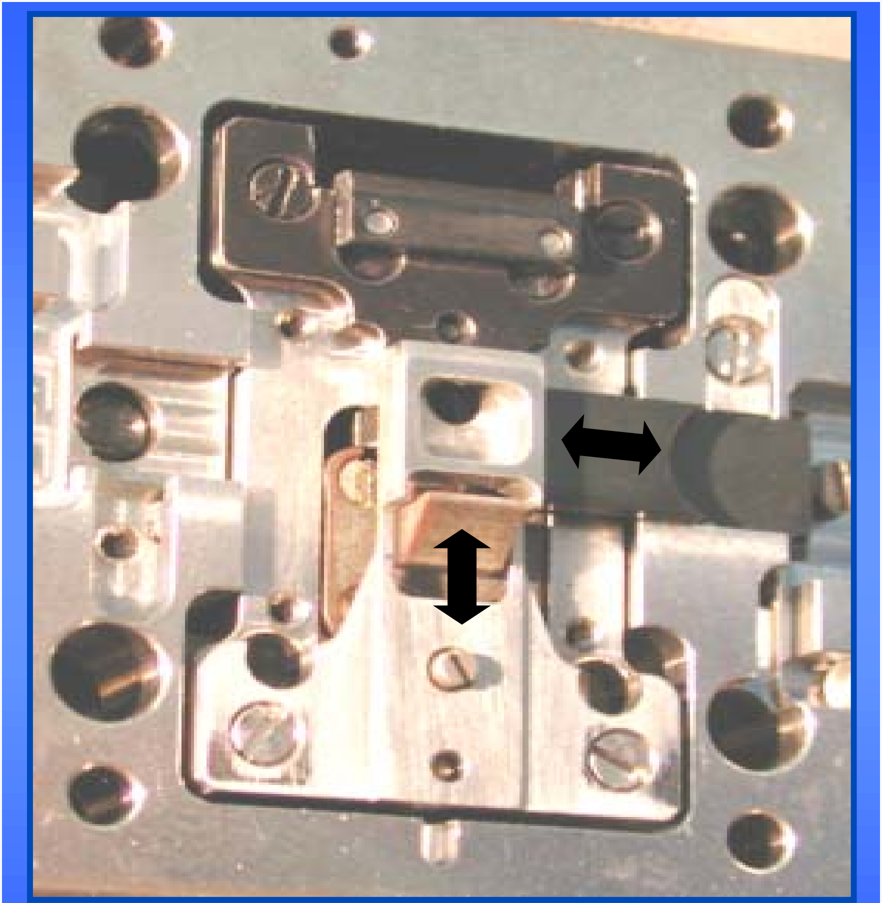
Version C: Pre and Final Alignment



The package is prealigned on the plunger, and get the final alignment on the way to the contact socket

x - Alignment Accuracy Version C:
= +/- 0,03mm

Alignment of Leadless Packages



View on plunger head

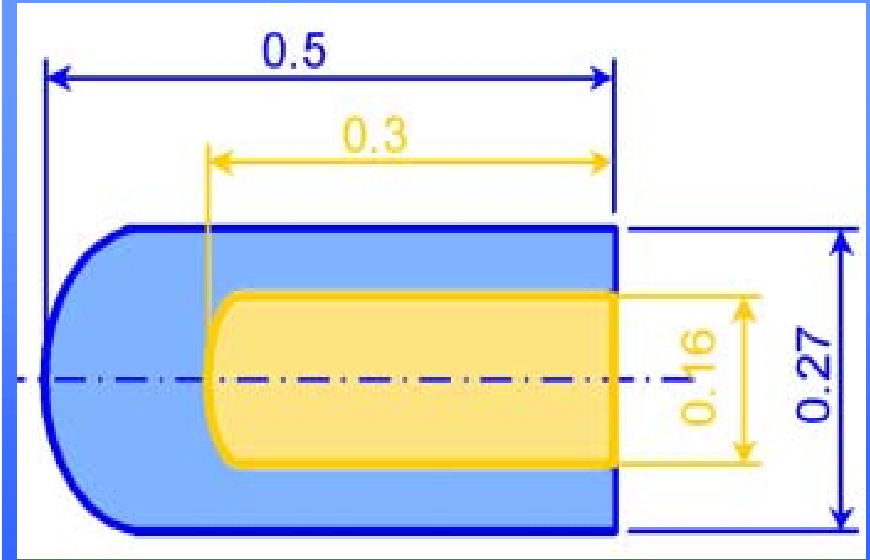
y Positon +/- 0,03mm

x Position

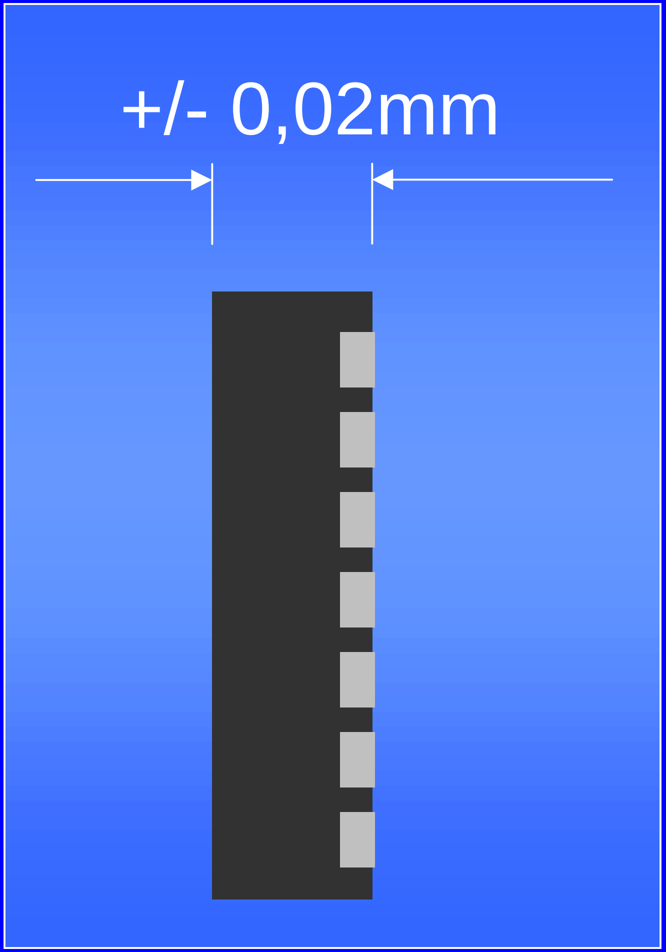
Version A   +/- 0,06mm

Version B   +/- 0,05mm

Version C   +/- 0,03mm



Alignment of Leadless Packages



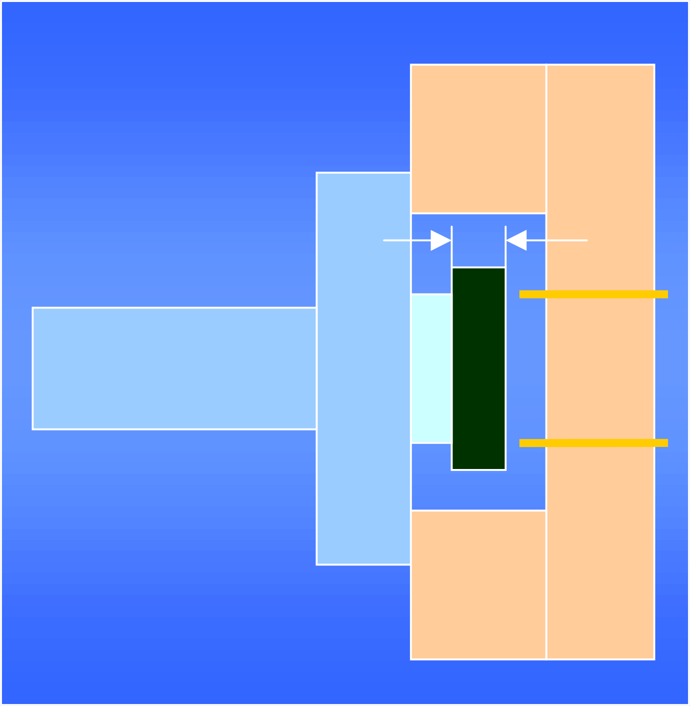
- Position

The handler plunger is moving the package into z direction to the contactor.

This movement is used to define the compression of the contact springs. Two concepts are currently used in gravity handlers

Alignment of Leadless Packages

Harstop between plunger and contact socket



Pros:

Simple plunger mechanism with less wear parts

Cons:

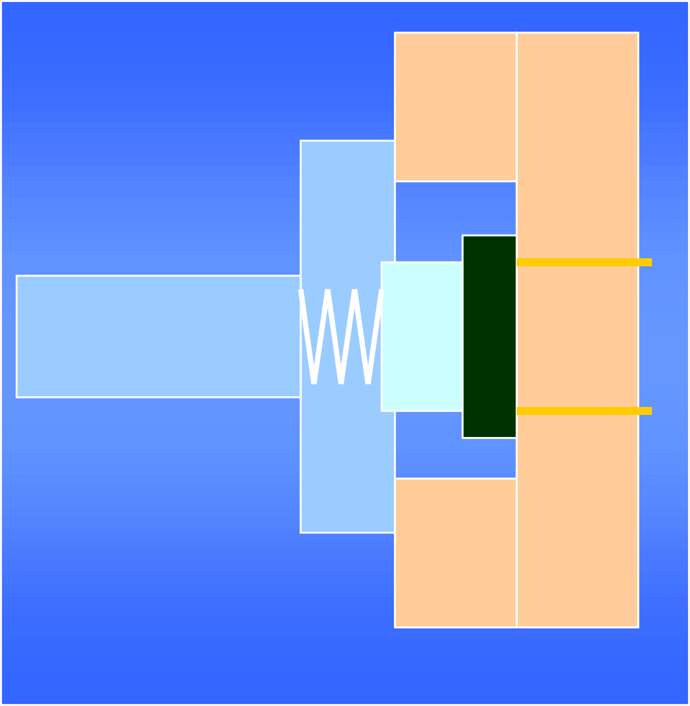
Package thickness tolerances influence the contact spring compression

Preferred for contactors:

Compression range > Package thickness tolerance

Alignment of Leadless Packages

Final harstop between package and contact socket



Pros:

Contact spring compression is independent of package thickness tolerances

Cons:

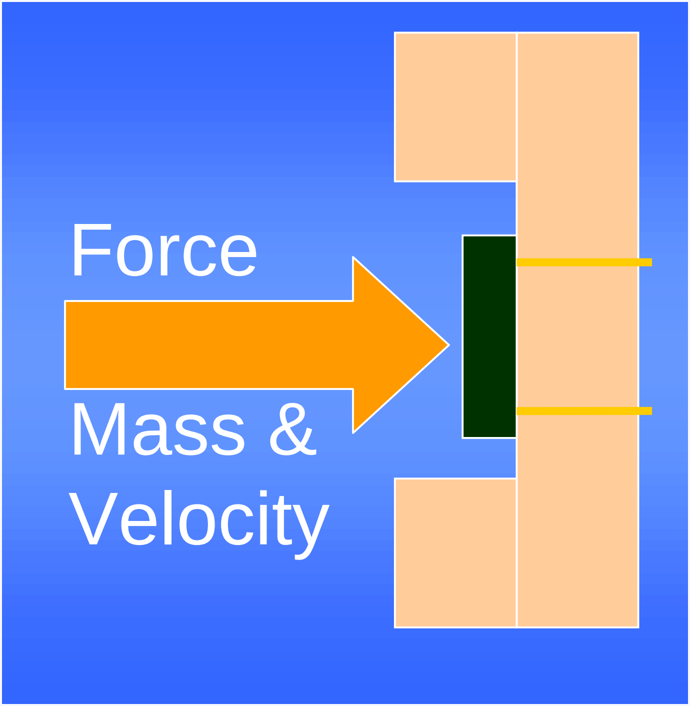
Wear of contact socket floor because of acting as a hardstop for the package

Preferred for Contactors:

Compression range =< Package thickness tolerance

Contact Socket Considerations

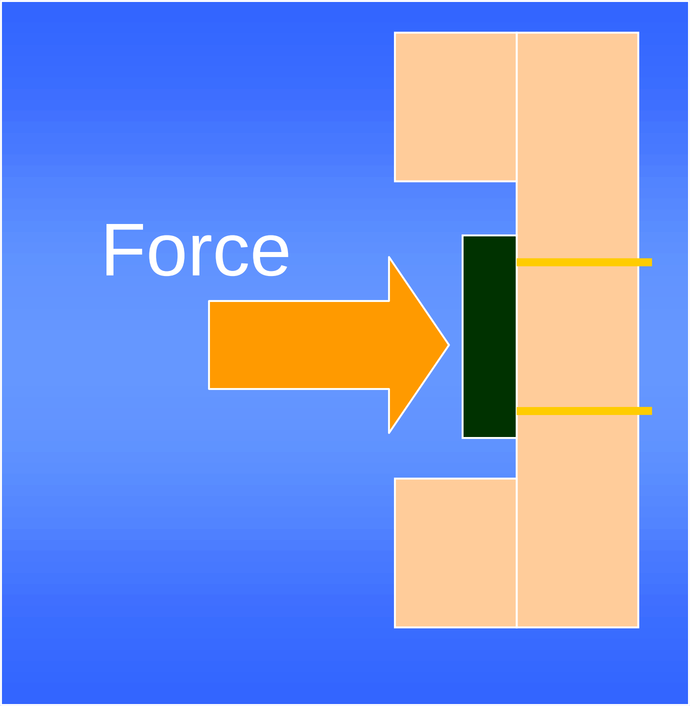
When using the socket floor as a hardstop:



The socket floor must be capable to withstand a static force equivalent to 20% of the total contact force (defined by all springs), As well as a shock given by the plunger mass and velocity

Contact Socket Considerations

When using the socket floor as a hardstop:

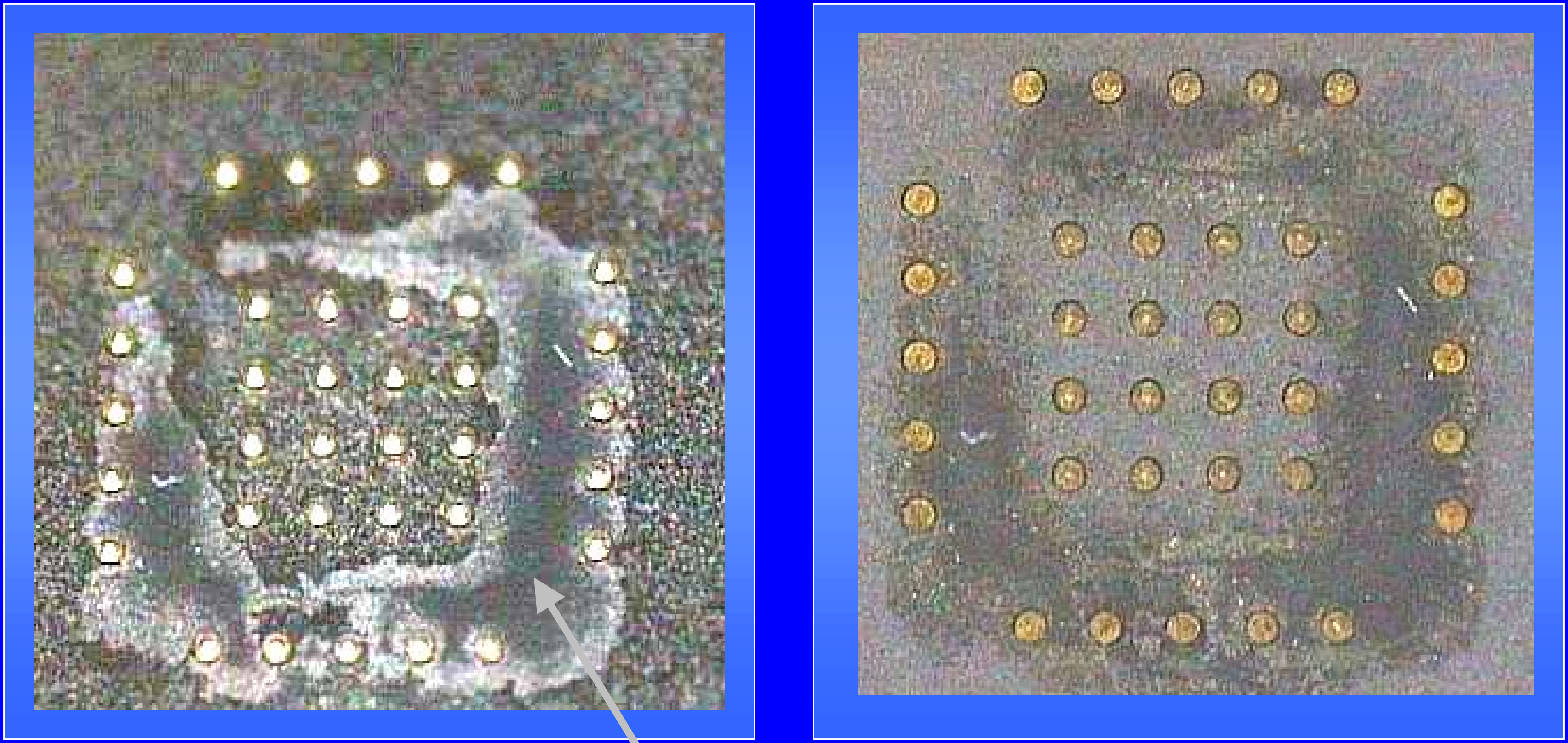


Device surface is pressed against socket surface:

Mould particles, dust from laser marking as well as tin etc. gets transferred onto the socket floor over thousands of insertions

Contact Socket Considerations

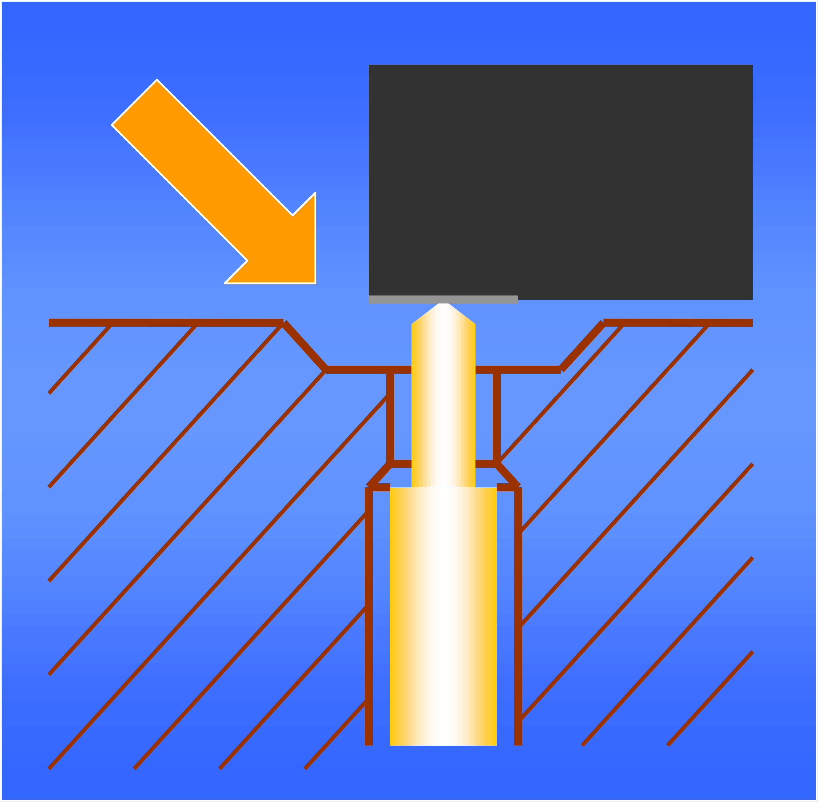
When using the socket floor as a hardstop:



Debris of mould compound

Contact Socket Considerations

When using the socket floor as a hardstop:



Example: Spring Probes

Cutouts around the contact probes avoid that particles gets pressed into the contact probe holes.

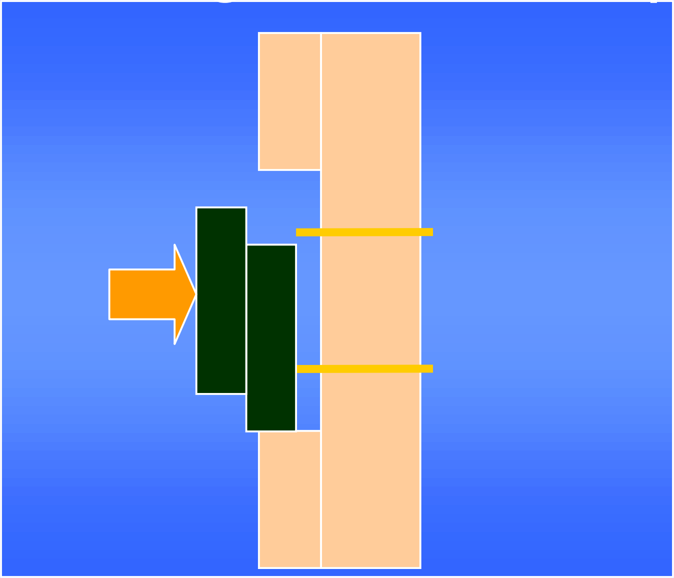
Contact Socket Considerations

Debris on leadless packages, which can not be eliminated by the internal handler cleaning procedure, can accumulate in the contact socket and can cause contact problems as well as premature wear and tear.

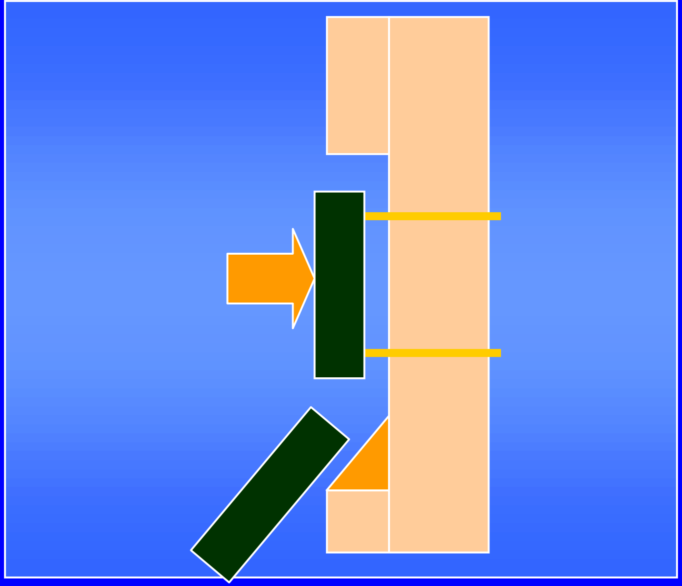
Particles from Laser Mark

Contact Socket Considerations

Handling of leadless packages: Lost devices issue



Contact socket with a „pocket“ : The lost device stays in the contact site



Small modification: The lost device can „slip“ away from the contact site

Summary & Outlook

- Package x / y positioning tolerances and repeatability depend on the handler design concept.
- If the package is used as a hardstop against the socket floor -> new requirements for the contact socket design / materials have to be considere
- Debris from mould compound, laser mark, tin flakes ect. are more or less always present in test handlers
- Future handler developments:
  Active alignment features for leadless packages and advanced package cleaning methods in handlers

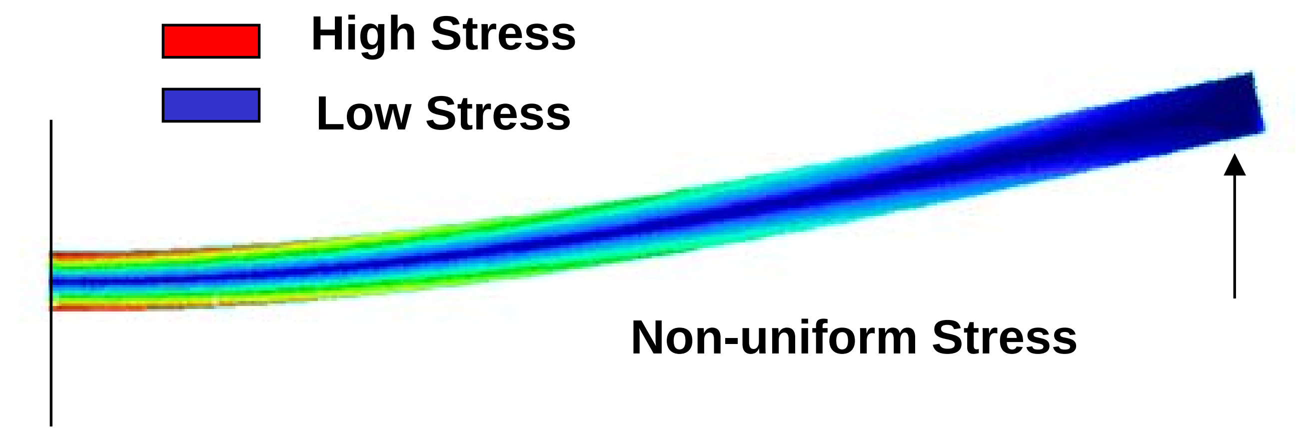
BRUSHWELLMAN
ENGINEERED MATERIALS

Measurement of Stress Relaxation in Copper Beryllium Strip Using Dynamic Techniques

Mike Gedeon & Jim Johnson
Brush Wellman Inc.

Stress Relaxation

- For FEA purposes, need to correlate stress relaxation with absolute stress
- Bending test samples = stress gradient



Stress Relaxation

- Test samples with uniform x-section under tension = uniform stress
- How to measure?

Wire Testing

- Natural frequency of a vibrating wire in tension (rad/s)

$$\omega_n = \frac{n \cdot \pi}{L}\sqrt{\frac{T}{\rho \cdot \pi \cdot r^2}}$$

- Other relevant equations

$$\sigma = \frac{T}{A}$$

$$f_n = \frac{\omega_n}{2 \cdot \pi}$$

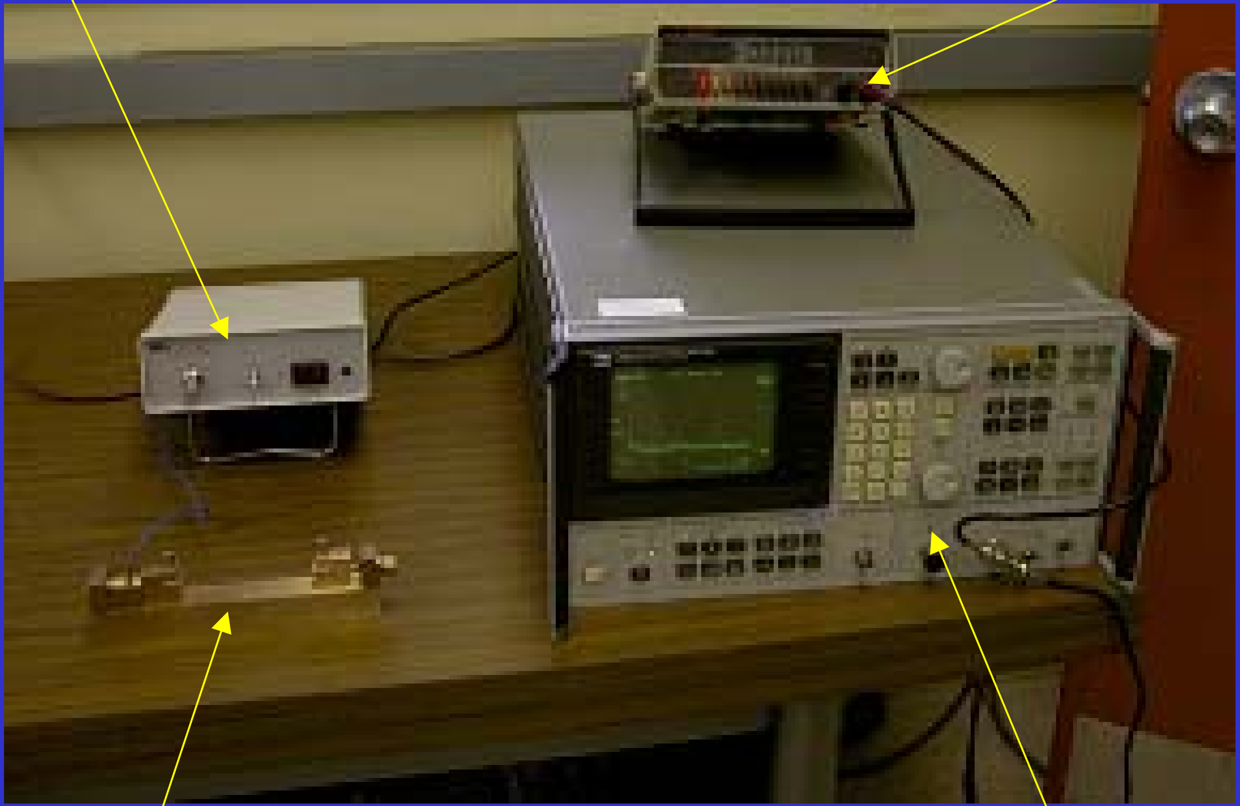
Wire Testing

- 1st fundamental frequency of vibration (Hz) as a function of stress

$$f_1 = \frac{1}{2 \cdot L} \sqrt{\frac{\sigma \cdot A}{\rho \cdot \pi \cdot r^2}} = C \cdot \sqrt{\sigma}$$

- Loss of stress is manifested by a corresponding change in natural frequency

Test Set-up



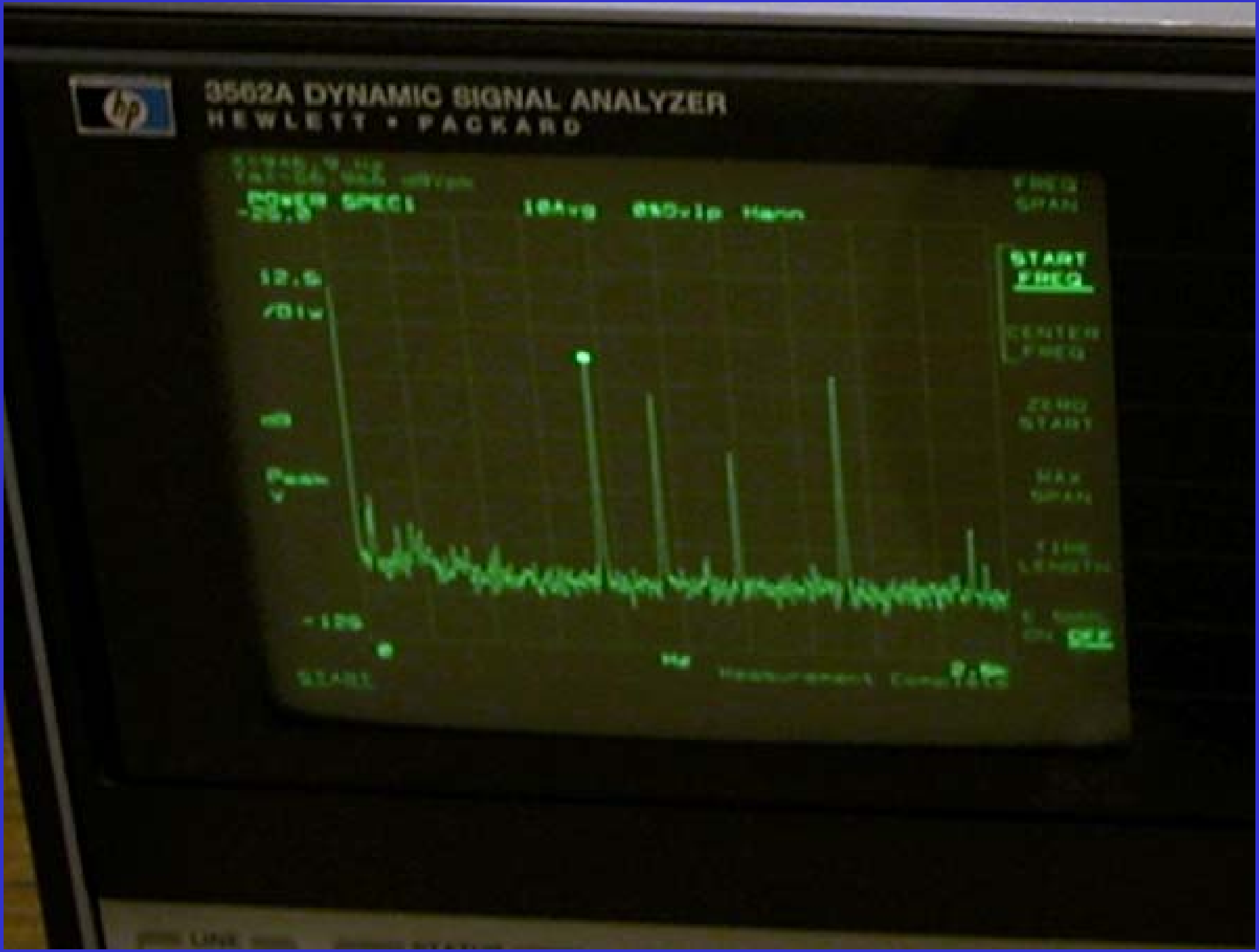
Signal conditioner

Digital multimeter

Test fixture

Spectrum analyzer

Frequency Response - Analyzer Output



Strip Vs. Wire

- Wire:
  - Length >> Area - 1-D wave equation applies

- Strip:
  - Planar vibration modes factor in
  - Stress not directly calculable from frequency
  - Calibration curve - Stress vs. Frequency
  - Photo-etched to control stress risers

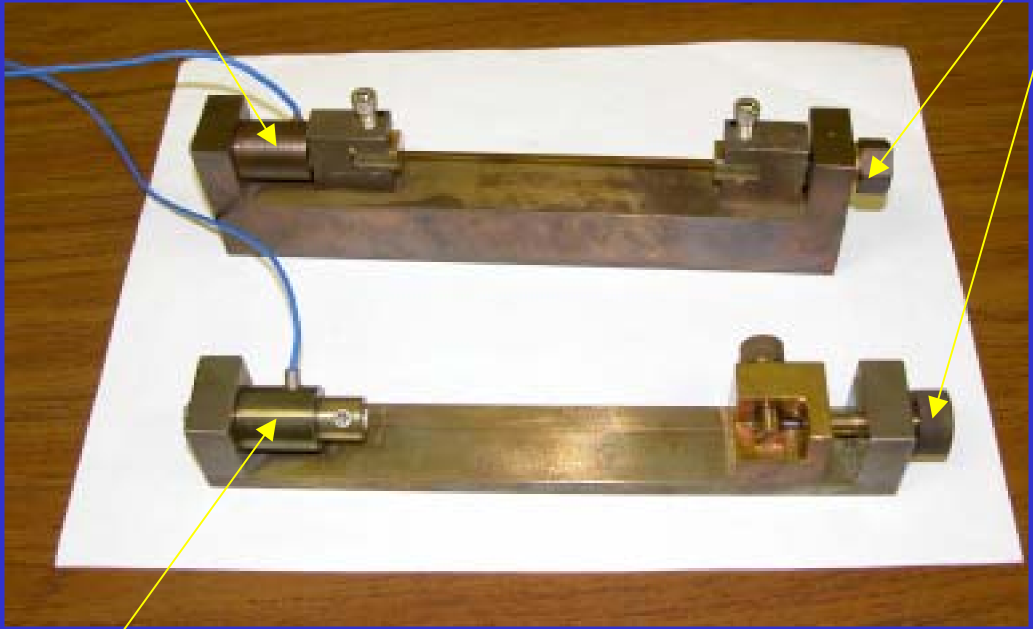
Strip Vs. Wire

Piezoelectric sensor
& load cell

Tension
adjustment knob

Strip fixture

Wire fixture



Piezoelectric sensor

Strip Fixture Challenges

- Premature yielding/fracture
  - Clamping mechanism change
- Clamping force balance
  - Too little = slippage
  - Too much = yielding/fracture
- Sensor Drift

Signal Conditioner

- Load mode
  - Voltage vs. Load (lbs.) output to multimeter
- Resonance mode
  - Voltage vs. Frequency output to spectrum analyzer

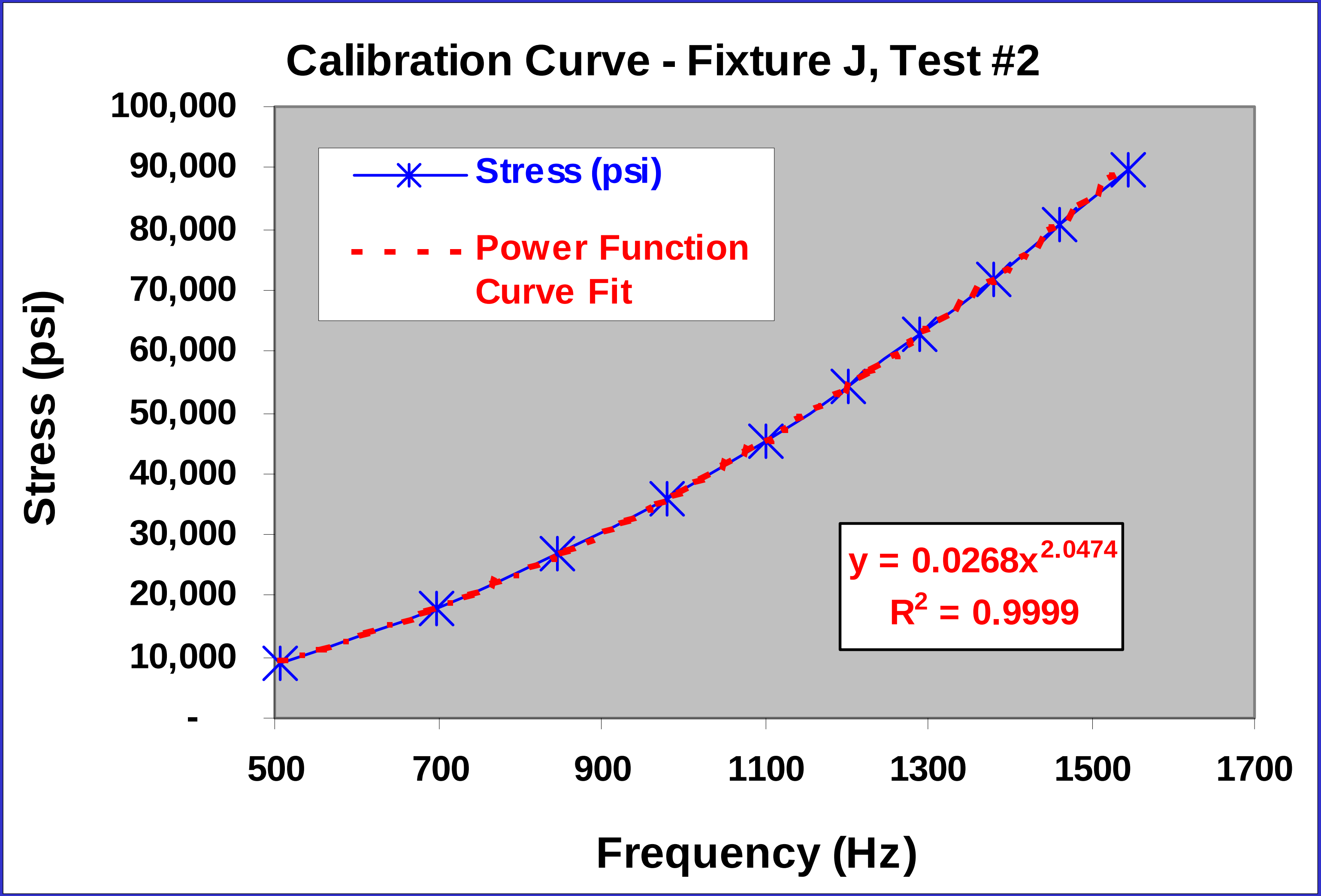
Calibration Procedure

- Conditioner to load
- Increase load to desired voltage level
- Conditioner to resonance
- Measure and record frequency
- Unload strip
- Repeat at 10% reduced increments of desired stress level

Tracking Spreadsheet - Calibration

Test Temp (C)	100		Alloy	390 HT		Percent Yield	94%		Test Matrix	2
Fixture #	E 13UH		pC/lb	16.54		mV/pC	2.0		Frequency Span	2.5 kHz
Width (in)	0.0625		Thickness (in)	0.00315		Yield Strength (psi)	138750			
Target Stress (psi)	Target Force (lbs)	Target pC	Target mV		Actual mV	Actual Stress (psi)	Freq 1	Freq 2	Freq 3	
0	0.00	0.000	0.000		0	0	0	0	0	
13008	2.56	42.352	84.704		84	12900	675	975	1303.1	
26016	5.12	84.704	169.409		168	25799	868.7	1134.4	1412.5	
39023	7.68	127.057	254.113		255	39160	1037.5	1281.2	1521.9	
52031	10.24	169.409	338.818		339	52059	1153.1	1390.6	1603.1	
65039	12.80	211.761	423.522		424	65112	1250	1478.1	1671.9	
78047	15.36	254.113	508.227		508	78012	1381.2	1603.1	1821.9	
91055	17.92	296.465	592.931		594	91219	1468.7	1684.4	1840.6	
104063	20.48	338.818	677.635		677	103965	1562.5	1759.4	1903.1	
117070	23.05	381.170	762.340		762	117018	1665.6	1859.4	1987.5	
130078	25.61	423.522	847.044		849	130378	1700	1900	2028	

Example Calibration Curve



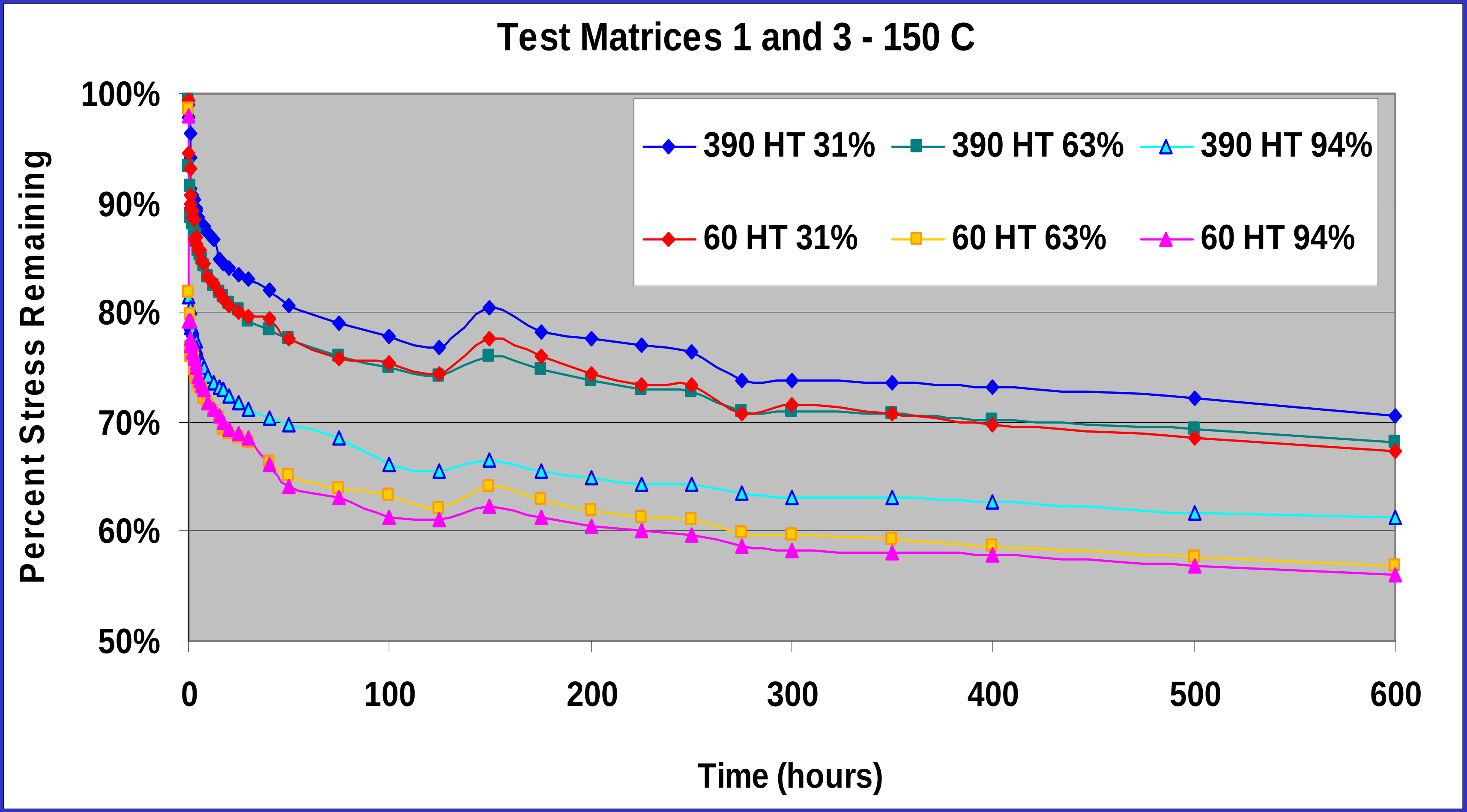
Test Procedure

- Conditioner to load
- Increase load to desired voltage level
- Conditioner to resonance
- Measure & record frequency
- Entire fixture in furnace for desired time
- Cool to equilibrium
- Record change in frequency

Tracking Spreadsheet - Results

Target Time (Hours)	Actual Time	Freq 1	Freq 2	Freq 3	Stress (psi)	Percent Remaining	Target Time	Actual Time	Freq 1	Freq 2	Freq 2	Stress (psi)	Percent Remaining
Initial Loading	-	1712.5	1912.5	2037.5	129415	100.0%	15	15.0	1587.5	1790.6	1931.2	108439	83.8%
0	0	1684.4	1887.5	2012.5	124514	96.2%	17.5	17.5	1587.5	1790.6	-	108439	83.8%
0.25	0.25	1665.6	1868.7	2000.0	121296	93.7%	20	20.0	1584.4	1790.6	-	107946	83.4%
0.5	0.5	1637.5	1842.5	1975.0	116576	90.1%	25	25.0	1585.0	1790.0	1930.0	108041	83.5%
0.75	0.75	1634.4	1837.5	1971.9	116061	89.7%	30	30.0	1581.2	1784.4	1925.0	107438	83.0%
1	1	1640.6	1840.6	1971.9	117091	90.5%	35	35.0	1578.1	1782.5	1925.0	106947	82.6%
1.25	1.25	1634.4	1834.4	1968.7	116061	89.7%	40	40.0	1578.1	1781.2	-	106947	82.6%
1.5	1.5	1630.0	1831.2	1965.6	115334	89.1%	50	50.0	1575.0	1780.0	-	106458	82.3%
2	2	1622.5	1825.0	1960.0	114099	88.2%	60	60.0	1571.9	1778.1	1918.7	105969	81.9%
2.5	2.5	1620.0	1823.5	1957.5	113690	87.8%	80	80.0	1570.0	1775.0	-	105671	81.7%
3	3	1618.7	1821.9	1956.2	113477	87.7%	100	100.0	1567.5	1775.0	-	105279	81.3%
3.5	3.5	1615.6	1818.7	1956.2	112970	87.3%	125	125.0	1565.0	1772.5	-	104887	81.0%
4	4	1615.0	1817.5	1953.1	112873	87.2%	150	150.0	1565.0	1770.0	-	104887	81.0%
5	5	1603.1	1806.2	1943.7	110942	85.7%	175	175.0	1562.5	1770.0	1912.5	104497	80.7%
6	6	1596.9	1800.0	-	109943	85.0%	200	200.0	1560.0	1767.5	-	104107	80.4%
7	7.0	1596.9	1800.0	-	109943	85.0%	225	225.0	1557.5	1765.0	1907.5	103718	80.1%
8	8.0	1592.5	1795.0	-	109238	84.4%	250	250.0	1557.5	1765.0	-	103718	80.1%
10	9.75	1590.6	1796.9	-	108934	84.2%	275	275.0	1555.0	1762.5	-	103330	79.8%
12.5	12.5	1590.0	1792.5	-	108838	84.1%	300	300.0	1555.0	1762.5	-	103330	79.8%
							350	350.0	1552.5	1760.0	-	102943	79.5%
							400	400.0	1550.0	1757.5	-	102557	79.2%
							500	500.0	1547.5	1755.0	-	102171	78.9%

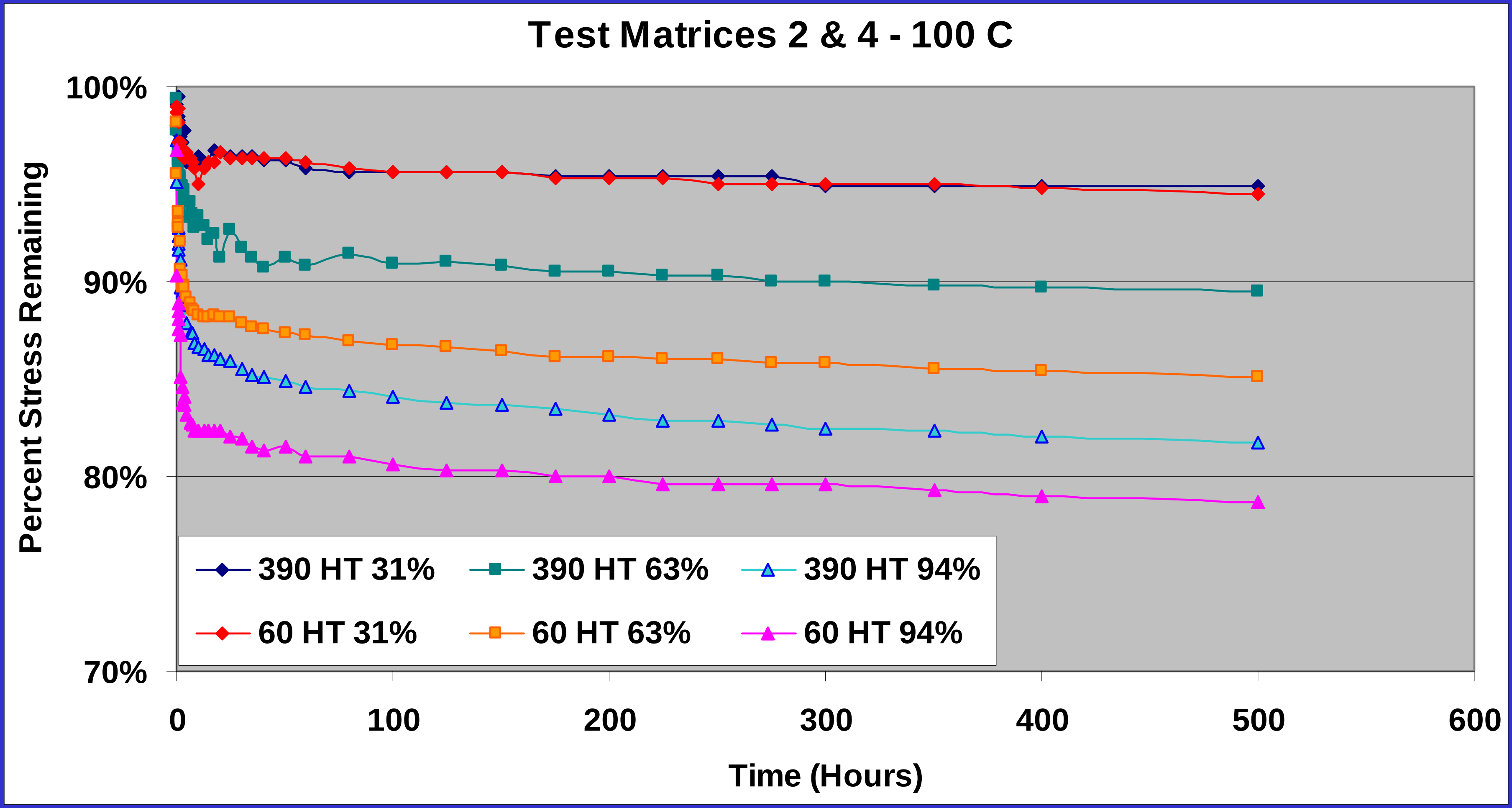
Results


Test Matrices 1 and 3 - 150 C
Percent Stress Remaining
100%
90%
80%
70%
60%
50%
0
100
200
300
400
500
600
Time (hours)
390 HT 31%
390 HT 63%
390 HT 94%
60 HT 31%
60 HT 63%
60 HT 94%

Findings

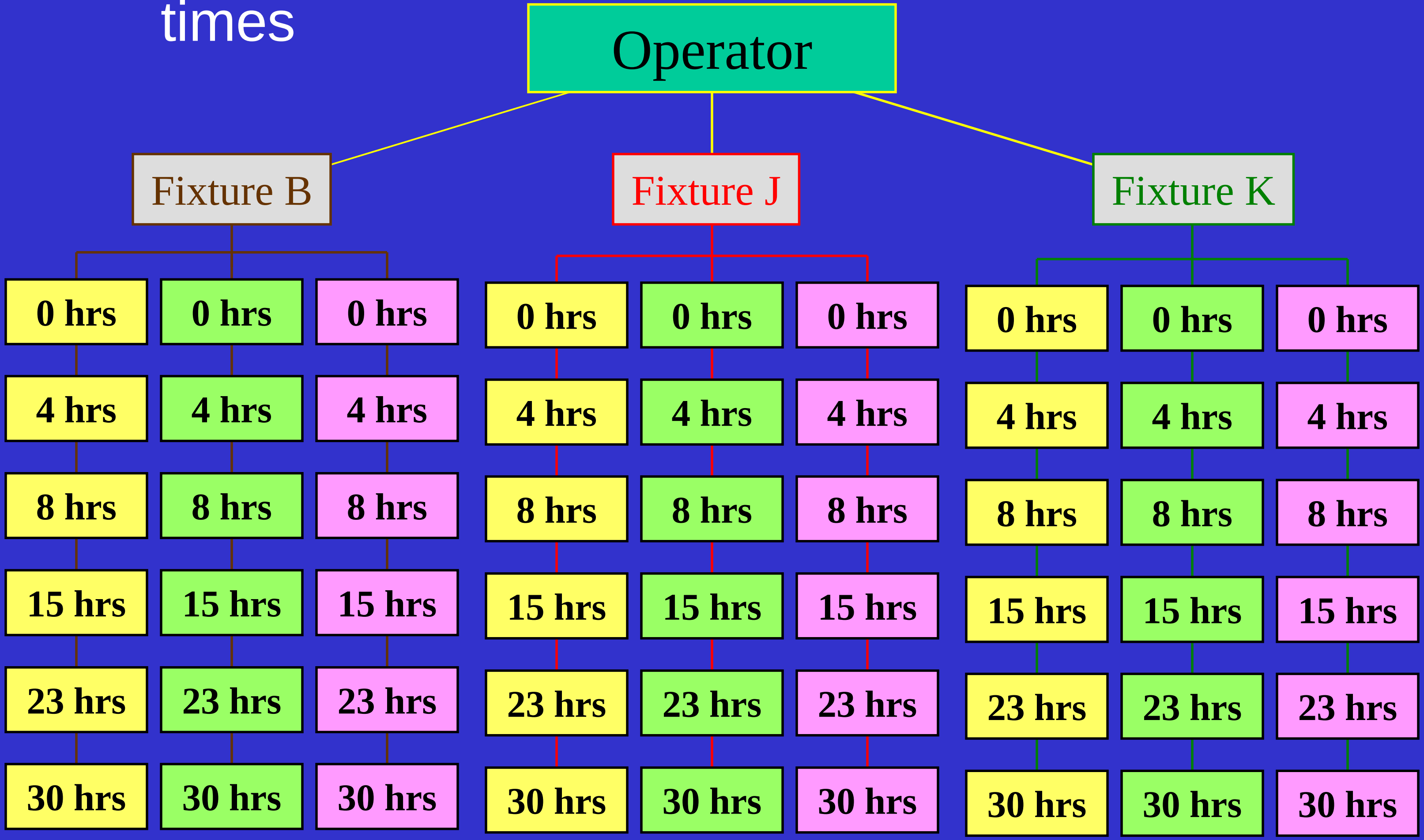
- Operator bias traced to temperature dependence
  - Loading, testing in climate-controlled room
  - Sufficient time to reach equilibrium
- Relaxation rate in tension > relaxation rate in bending

Additional Results



Test Reliability

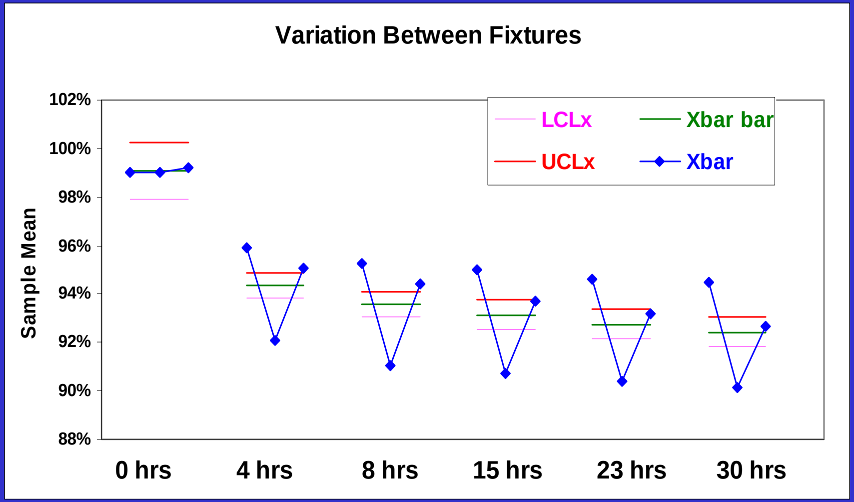
- Coefficient of variation study
  - One operator, 3 fixtures, one test condition
  - Measurements at 6 time increments, repeated 3 times

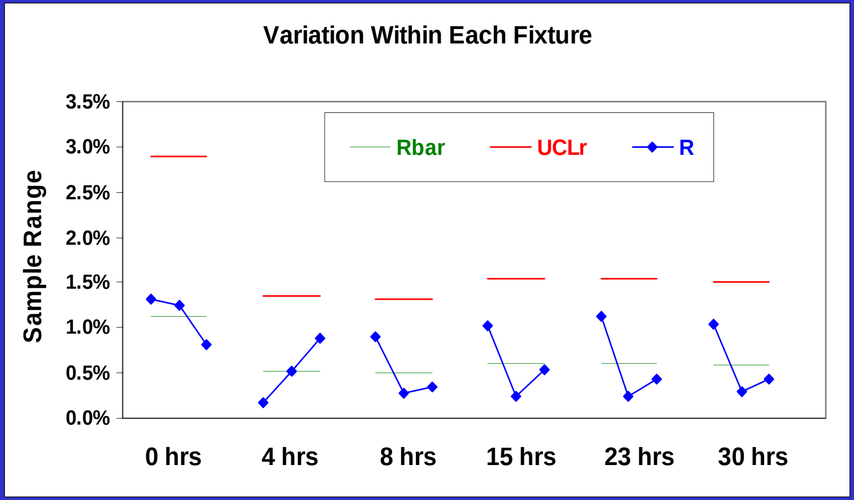


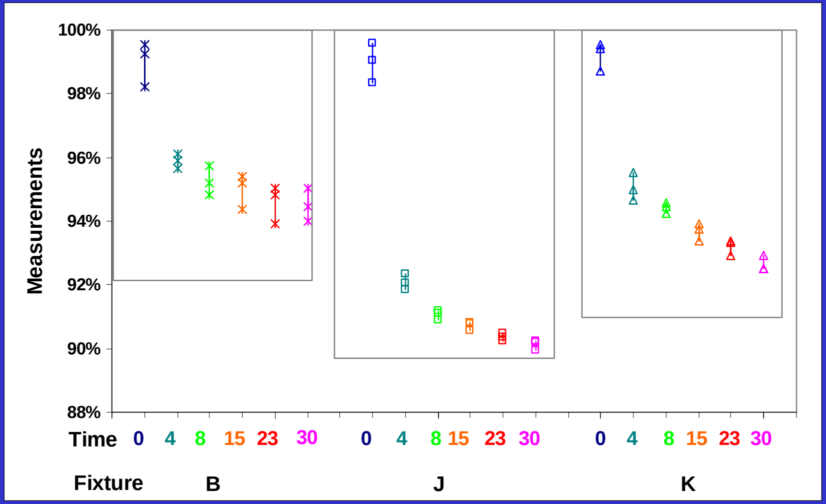
Operator

Fixture B			Fixture J			Fixture K		
0 hrs	0 hrs	0 hrs	0 hrs	0 hrs	0 hrs	0 hrs	0 hrs	0 hrs
4 hrs	4 hrs	4 hrs	4 hrs	4 hrs	4 hrs	4 hrs	4 hrs	4 hrs
8 hrs	8 hrs	8 hrs	8 hrs	8 hrs	8 hrs	8 hrs	8 hrs	8 hrs
15 hrs	15 hrs	15 hrs	15 hrs	15 hrs	15 hrs	15 hrs	15 hrs	15 hrs
23 hrs	23 hrs	23 hrs	23 hrs	23 hrs	23 hrs	23 hrs	23 hrs	23 hrs
30 hrs	30 hrs	30 hrs	30 hrs	30 hrs	30 hrs	30 hrs	30 hrs	30 hrs

Coefficient of Variation Study







Summary

- Results within each fixture are repeatable
- Most of the variation exists between fixtures

- Next steps
  - Work with supplier of fixtures to determine cause of between-fixture variation
  - Eliminate variation or mathematically compensate

Controlling Test Cell Contact Resistance With Non-destructive Conditioning Practices

2004 Burn-in and Test Socket Workshop

March 7 - 10, 2004

Jerry Broz, Ph.D. and Gene Humphrey

International Test Solutions

1475 Terminal Way, Ste. D

Reno, Nevada 89523

Overview

- Introduction
  - Background
  - Costs of Test Cell Cleaning
- Conditioning Technology
- Methodology Development
- Characterization
- Summary

Background

- Approximation for Contact Resistance (R. Holm, 1967)

$$C_{RES} = \frac{\rho}{4}\sqrt{\frac{\pi H}{F}} + \frac{\sigma_{film} H}{F} + R_{bulk}$$

  - Constriction resistance is affected by the number and size of the “a-Spots” at the deformed asperities at the interface.
  - Film resistance is affected by film conductivity, composition, structure, thickness, and breakdown voltage.
  - Film composition = absorbed materials various oxides and compounds, and miscellaneous contaminants.
- Film resistance results in variable and unstable behavior.

Introduction

- High and unstable contact resistance (C_{RES}) is one of the biggest factors in reduced test yields.
- C_{RES} is entirely attributable to the interfacial phenomena across the contact area and with any adherent contaminant.
- C_{RES} instability is caused by debris accumulation and a build-up of adherent contamination on the contacting surface.
- High C_{RES} values result in low performance rating and can lead to unacceptably high reject ratios.

The Need for Contactor Cleaning?

- Common causes of contact degradation
  - Debris on contacts and in socket bed
  - Material transfer and intermetallic formation
  - Mechanical wear
  - Localized material loss
  - Plating related issues
  - Oxidation
- Regularly scheduled cleaning operations are critical to control C_{RES} and maximize contactor electrical performance.

Contactor Cleaning Methods

- No cleaning … just replace it !

- Contact methods
  - Manual brush: inconsistent and can damage contactors.
  - Abrasives: remove material and can damage contactors, platings, or base metals; do not address debris and may add debris.

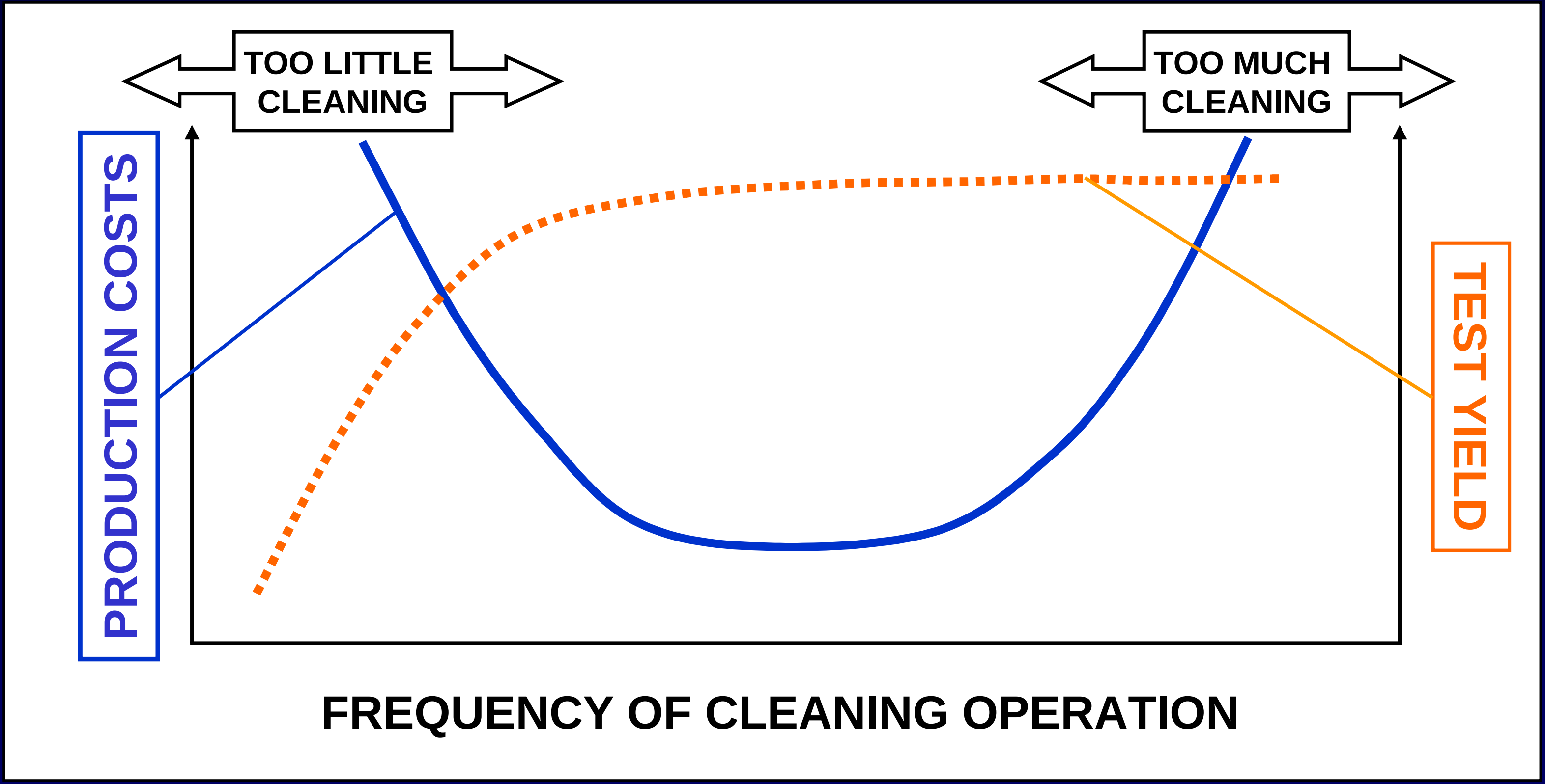
- Non-contact methods
  - Compressed air or inert gas (e.g., N_2, Ar, etc…) blow-off: "Where does the debris go?"
  - Chemical: often toxic and can affect the surface characteristics of contactor, platings, or base metals.
  - Ultrasonic: effective for loose debris, but does not remove transferred metals.

Cleaning Economics - OEE

- OEE (Overall Equipment Effectiveness) quantifies overall machine performance with three metrics …
  - Availability (*Average Up-Time*): amount of time the machine was actually running as a proportion of time it could have been running.
  - Machine Effectiveness (*Capacity*): actual machine output as a percentage of theoretical output running at rated speed and actual runtime.
  - Output Quality (*Yield*): amount of good output as a proportion of total output.

Cost of Ownership Model

- Frequent cleaning operations impact the OEE.
  - A set-up break is required for the cleaning operation.



Industry Requirements

- Achieve stable and accurate test results
- Contactor Conditioning
  - Debris collection and removal
  - Effective removal of embedded or bonded contaminants without wear
  - Contactor shape maintenance without damage
  - Environmental safety
- Economics
  - Cost effective
  - Increase overall throughput
  - Minimize machine “down” time

Wafer Level Test - Parallelism

- Debris and adherent material accumulation are major contributors to C_{RES} instability during wafer level test.

Probes after Touchdowns on Bond Pads
(Mag: 150X)

Non-destructive Cleaning Solution

- Non-Abrasive, Highly Cross-linked Polymer
  - Loose debris collected by polymeric material
    - Attractive forces of material “pull” adherent debris
  - Non-conductive and non-corrosive
    - Leaves no residue on contact surface
    - FTIR and XPS analysis do not detect any residuals
  - -50°C to 200°C Operating Temperature

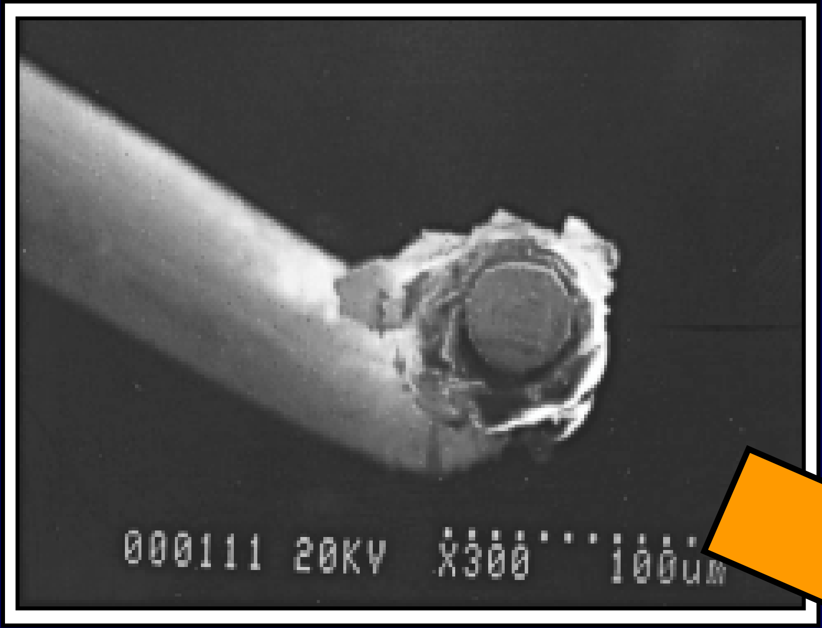
- Extends the life of the probe needle “contactor”
  - No abrasive material removal from probe contacts
  - No lateral forces are applied during cleaning operation

Wafer Level Test – Debris Removal

- Sort floors utilize non-destructive cleaning materials to collect debris and remove adherent material from various probe technologies.

Probes after Non-destructive Cleaning
(Mag: 150X)

Wafer Level Test – Debris Removal



Cantilevered Probe Adherent Debris

Tip Polishing and Debris Collection

Wafer Level Test – Debris Removal

Debris Collection on Cleaning Material Surface and within the Polymer Layer

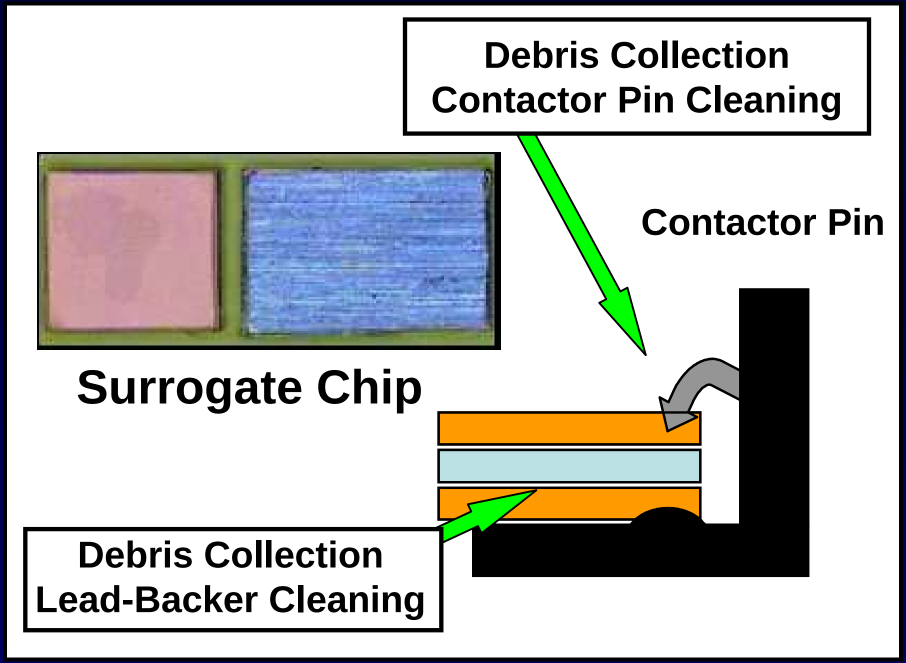
Contactor and Socket Conditioning

- Non-destructive cleaning materials can be adapted and utilized for test socket applications.
- Effective cleaning and maintenance of the contactor without breaking the setup during high volume production or damaging the contactor surface or socket materials.
- Yield loss due to adherent contamination is reduced, thus maximizing socket life and performance.

Test Cell Conditioning Technology

- IC chip “surrogate” test cell conditioning chip
  - Fits with any IC test socket
  - Pick & Place and Gravity-Feed handler compatible
- Highly cross-linked polymeric material layer
  - Non-abrasive polymer: removes and collects loose debris
  - “In suspension” abrasive particulates: remove bonded and embedded contaminants combined with loose debris collection.
- Environmentally safe for all test environments
  - Non-toxic and environmentally inert
  - Traps heavy metal particulates and debris for proper disposal

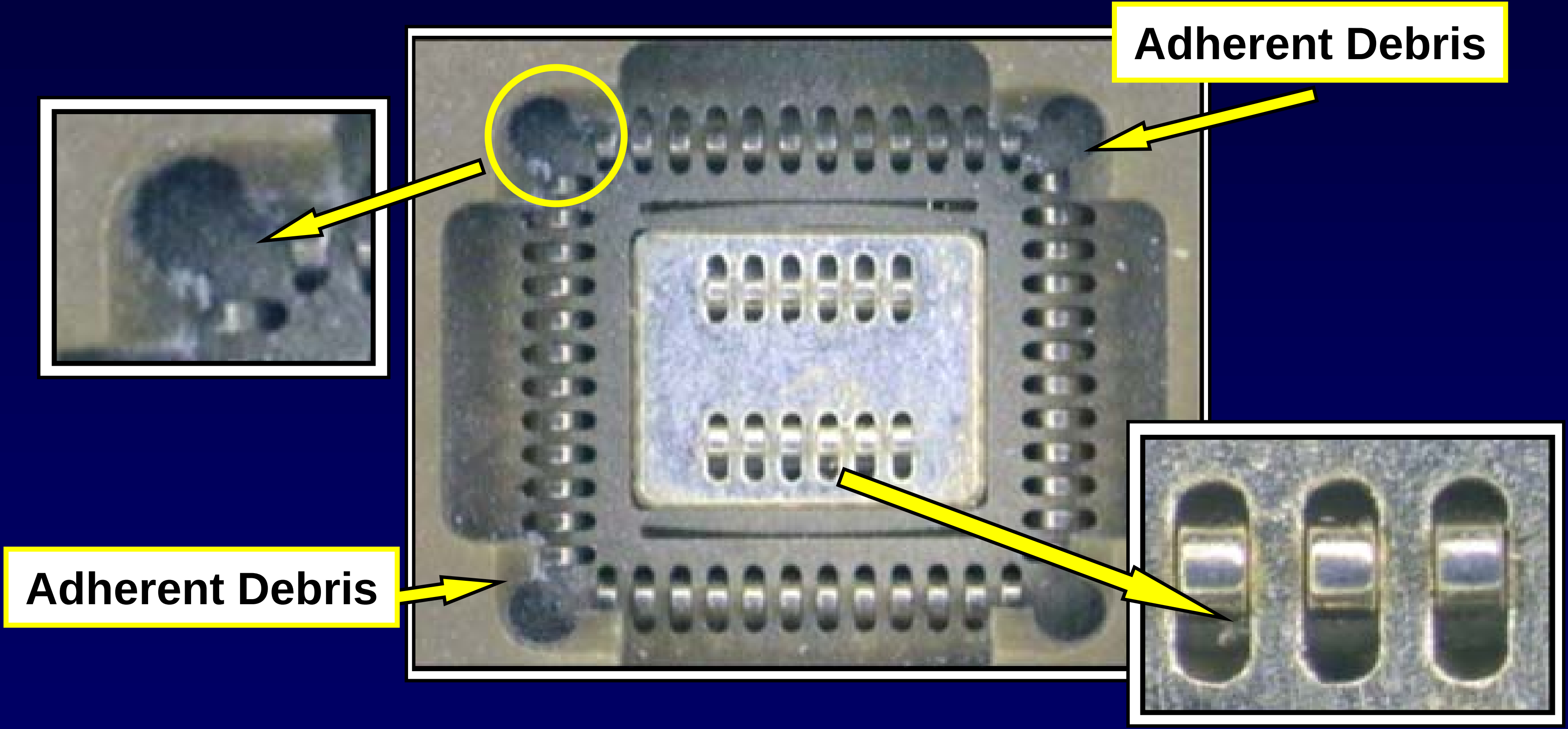
"Surrogate" Conditioning Chip



- "Bottom side" polymer layer
  - Attracts and holds loose debris from socket interior and bed.
  - Removes adherent contaminants from lead-backer.
- "Top side" polymer layer
  - Attracts and holds loose debris from between pins.
  - Removes adherent contaminants from contacts.
- Abrasive particles can be added to the polymer
  - "Tack" and abrasive "loading" can be modified to clean adherent debris and oxides.

Field Application

- 5 x 5 mm Contactor with 1 mm contacts
  - Debris accumulation after 4000 insertions



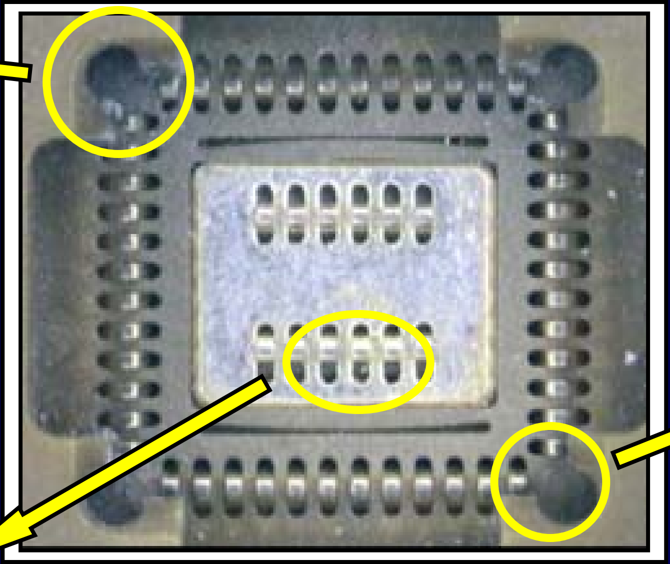
Adherent Debris

Adherent Debris

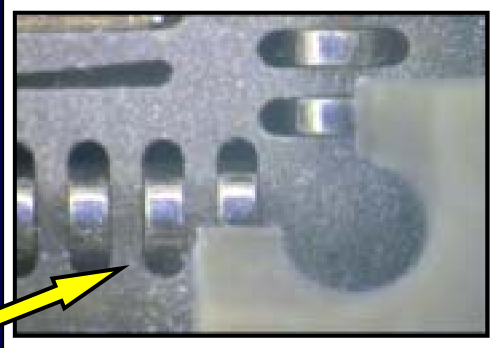
Contactor Conditioning

- 20 Cleaning insertions performed

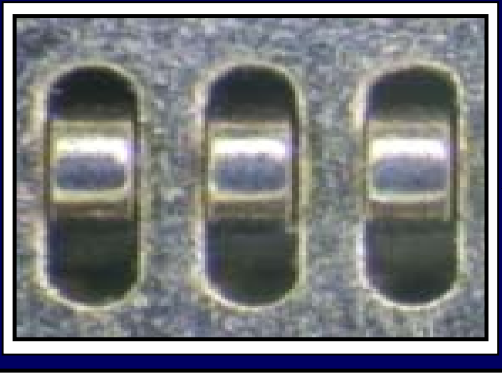
After Conditioning



Before Conditioning



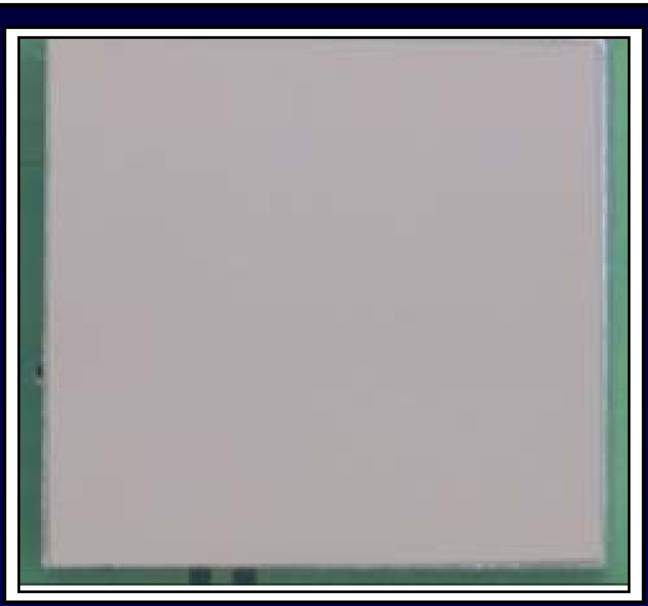
After Conditioning



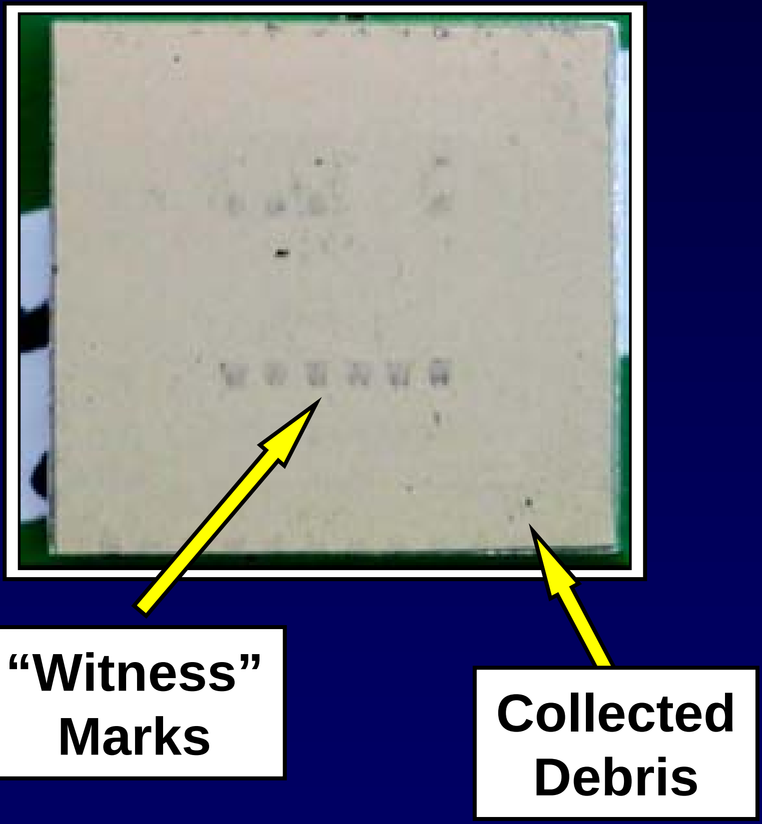
After Conditioning

Debris Removal and Collection

Before Cleaning Insertions



After 20 Cleaning Insertions



“Witness” Marks

Collected Debris

Performance Data

- Socket Performance versus Insertions
  - Yield improvement with periodic test cell conditioning

Capt. Edward A. Murphy
Air Force Project MX981

Summary

- Non-destructive cleaning technologies used during wafer level test were adapted for test socket applications.
  - Wafer sort floors utilize advanced cleaning to remove adherent materials from “fragile” probe technologies.

- Adherent particulates and debris were easily removed and collected by the polymeric cleaning material.
  - Socket malfunctions due to debris accumulation will decrease dramatically; thus, increasing throughput and production yields.

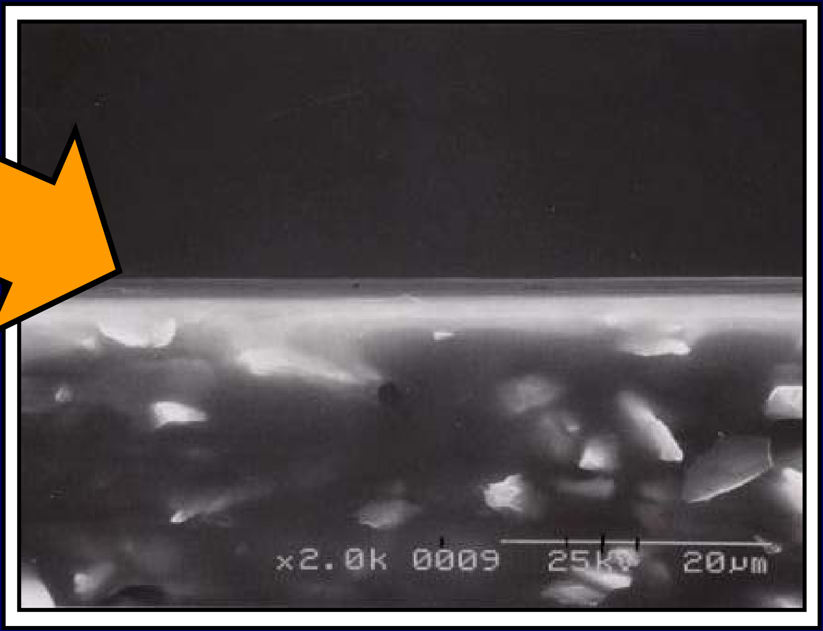
Summary

- “Surrogate” IC chip form-factor facilitates frequent on-line test cell conditioning without a “set-up break”
  - Cleaning frequency will be dictated by the testing conditions and the amount of debris accumulation.
- Non-destructive properties of the polymeric materials maximize socket life and performance.
  - Debris and contaminants are removed without the risk of damage to the contactors, base metal, or surface plating.

Future Work – TCC Optimization

Highly cross-linked polymeric material

Spatially Distributed Abrasive Particles



BiTS – 2004

Thank you for your attention

Questions ???

BRUSHWELLMAN
ENGINEERED MATERIALS

A New Finite Element Analysis Technique for Modeling Stress Relaxation of Electro-Mechanical Spring Contacts Made Using Copper Beryllium Strip

By

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BiTS

Presentation Outline

- Traditional vs.New Approach for predicting stress relaxation behavior.
- New testing methodology for measuring stress relaxation.
- FEA modeling results
- Validation study using BiTS application
    - Enplas Validation –Individual Pin samples
    - Intel Validation – Socket samples
- Conclusions
- Next Steps

Traditional Approach

Available stress relaxation data (time vs. remaining stress)

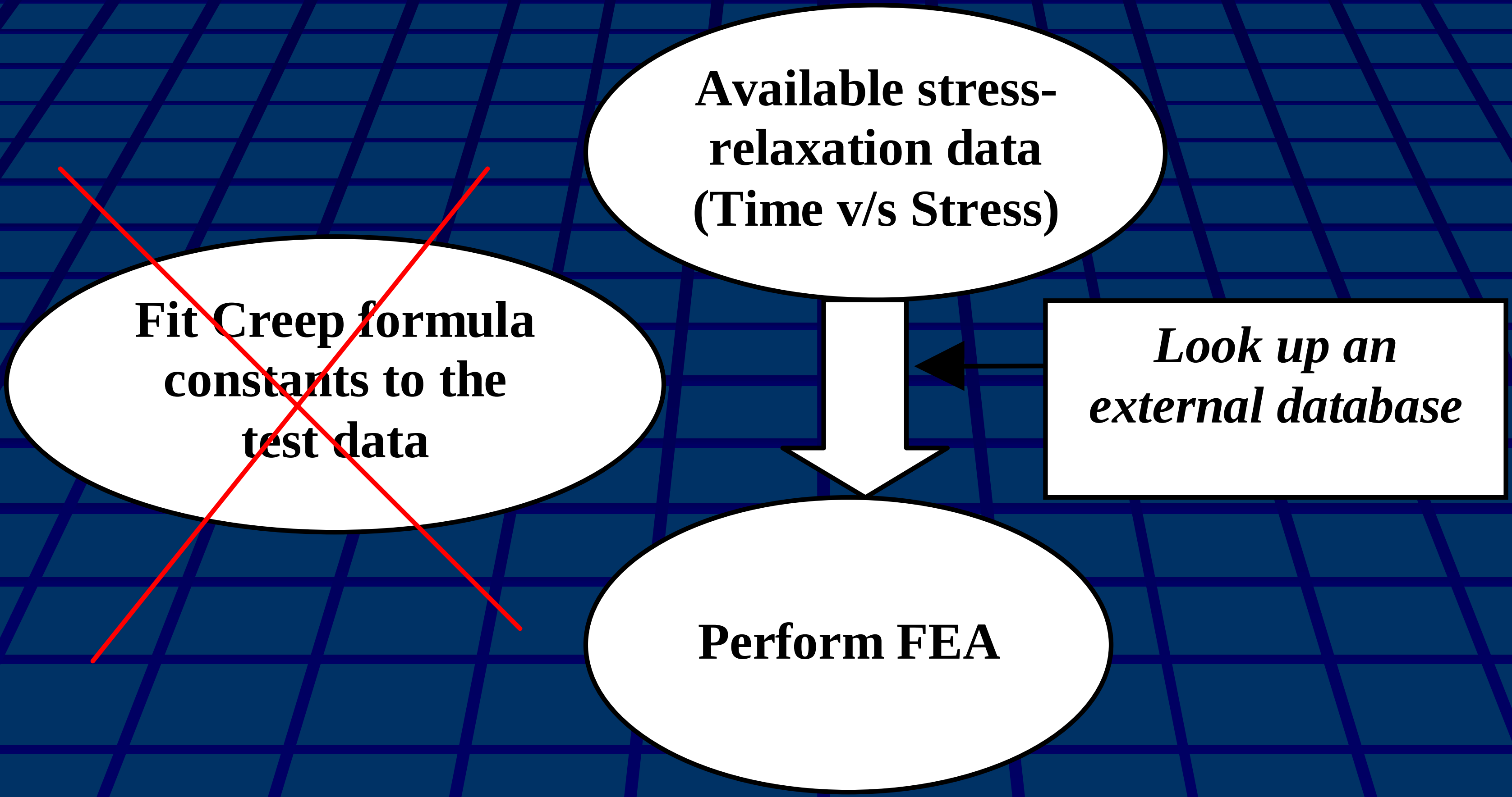
Convert stress relaxation data into creep strains and fit power law

Perform FEA

Traditional Approach Test Method

Stress Relaxation Bending Stress Test

New Approach



Available stress-relaxation data (Time v/s Stress)

Look up an external database

Perform FEA

~~**Fit Creep formula constants to the test data**~~

Theory Behind Both Approaches

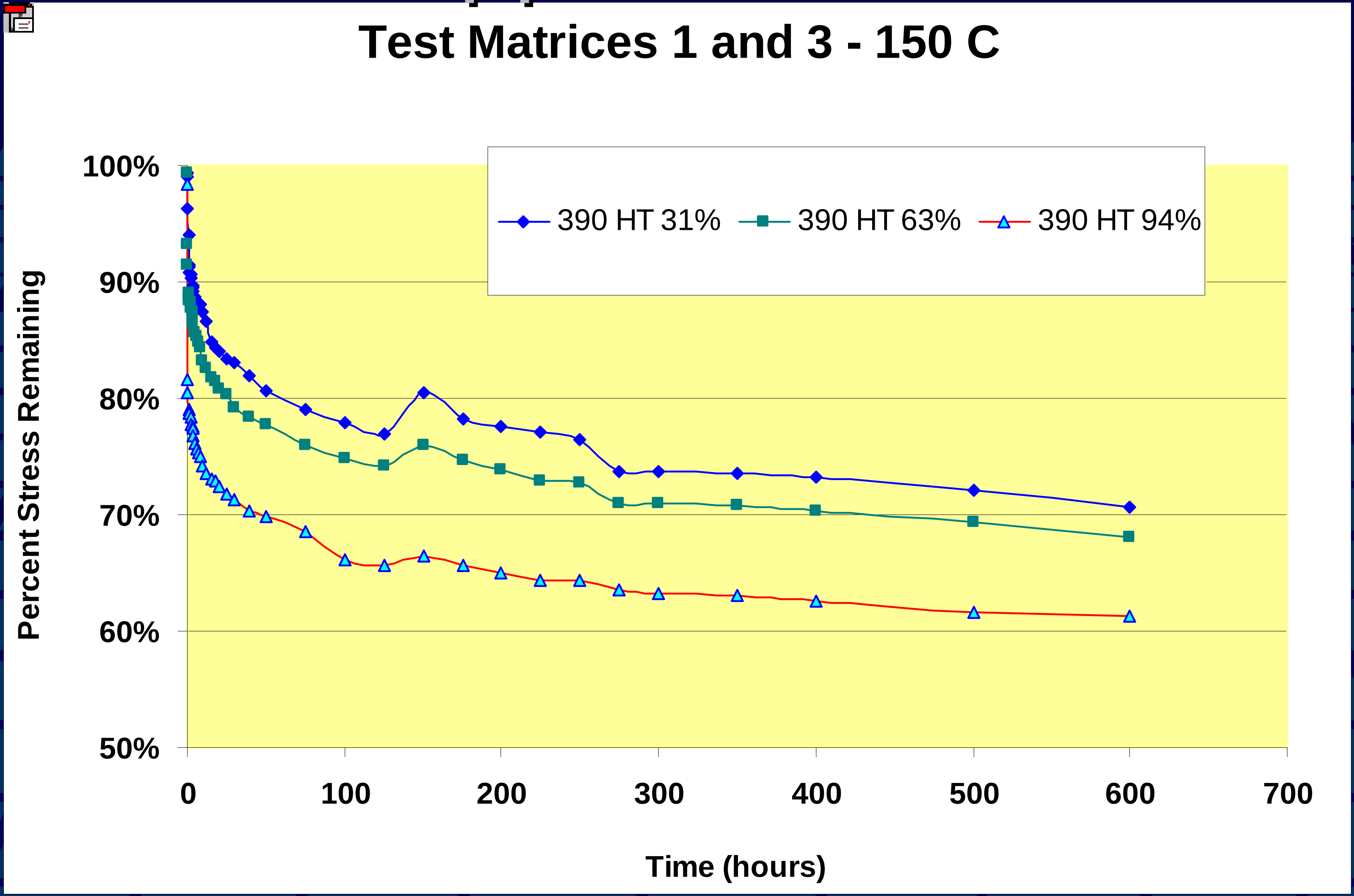
Non-uniform Stress

Uniform Stress

New Approach Test Method

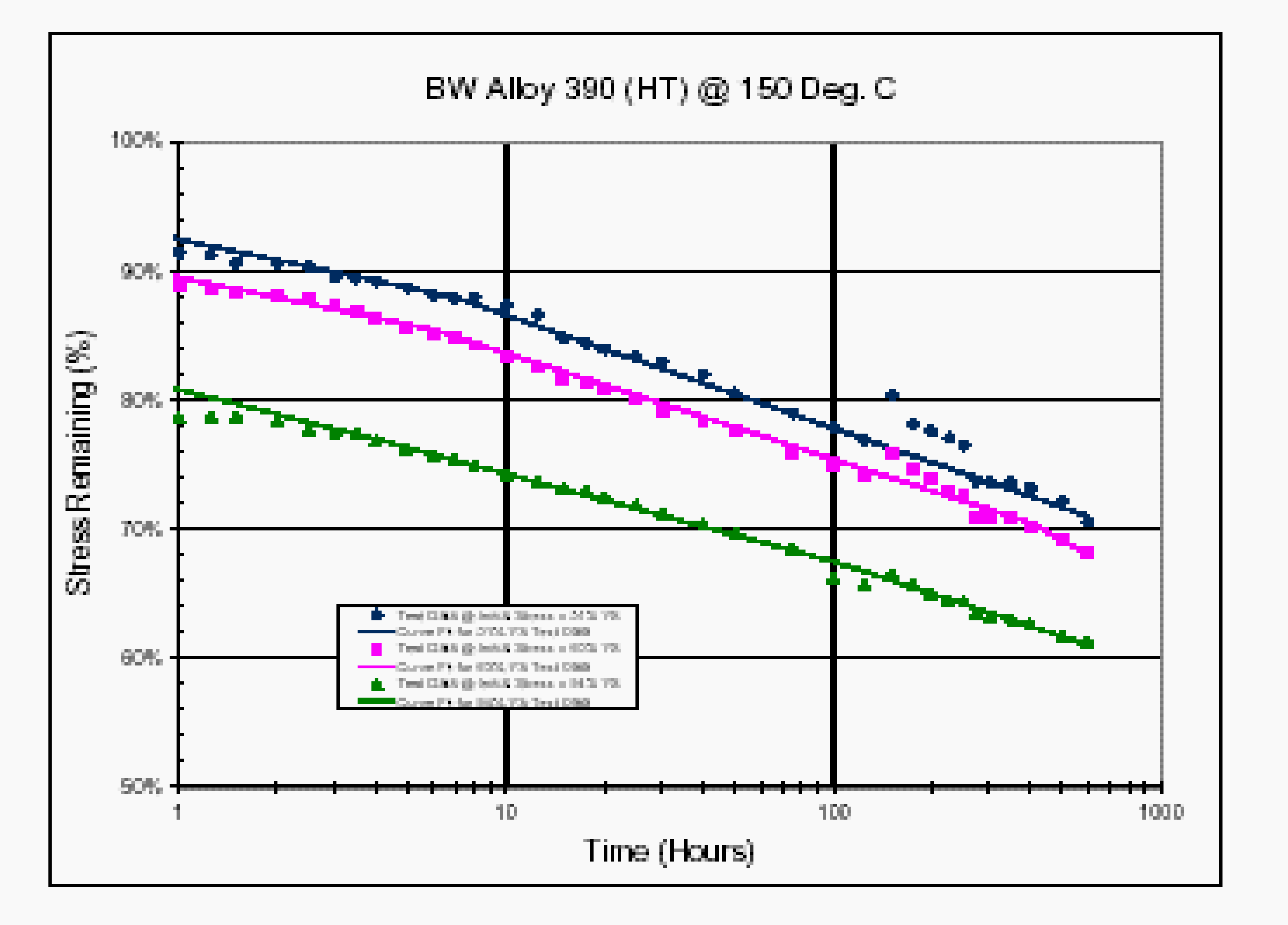
Stress Relaxation Tensile Stress Test

New Approach Results



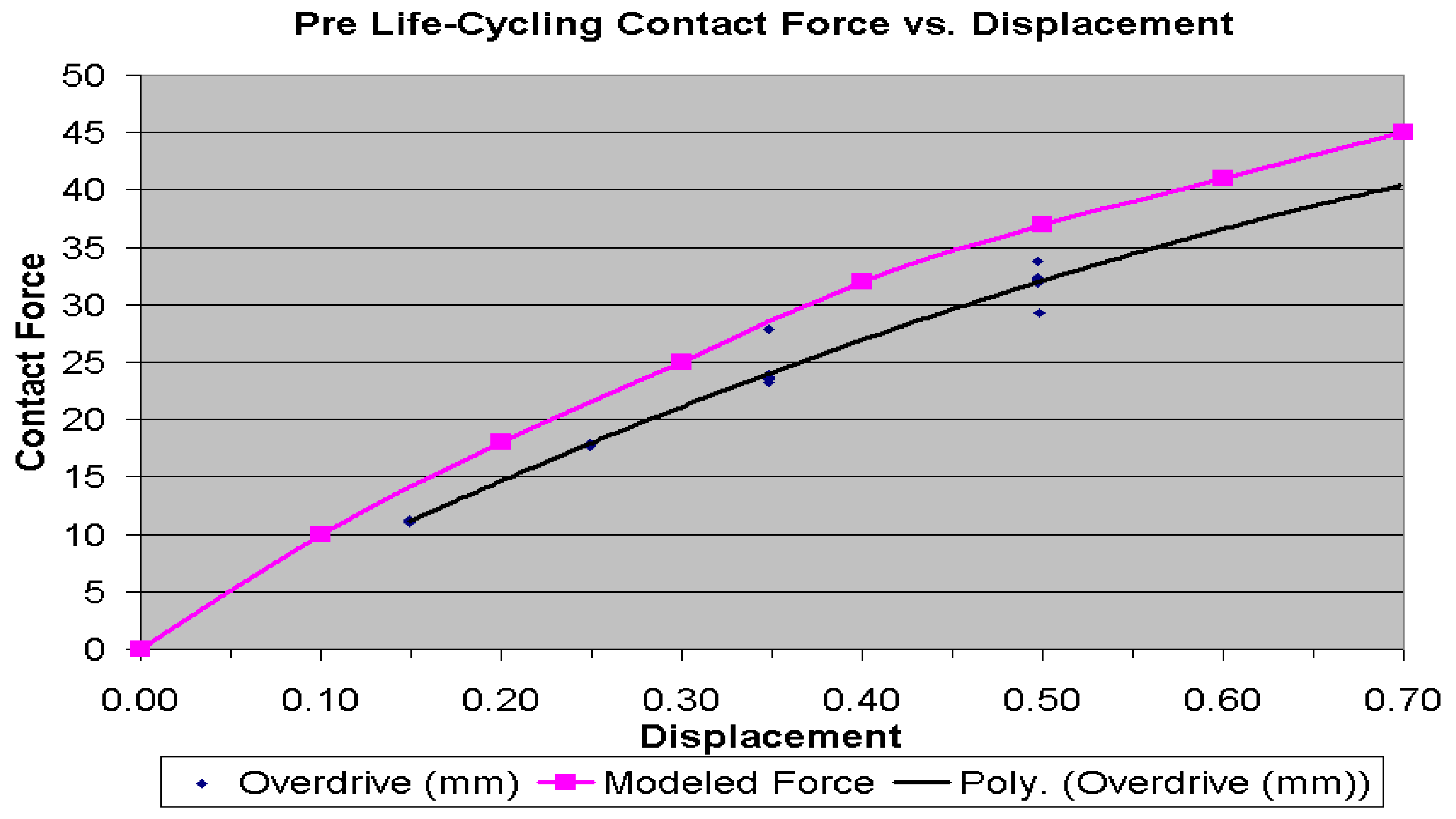
Stress Relaxation Tensile Stress
Test Results

New Approach Results



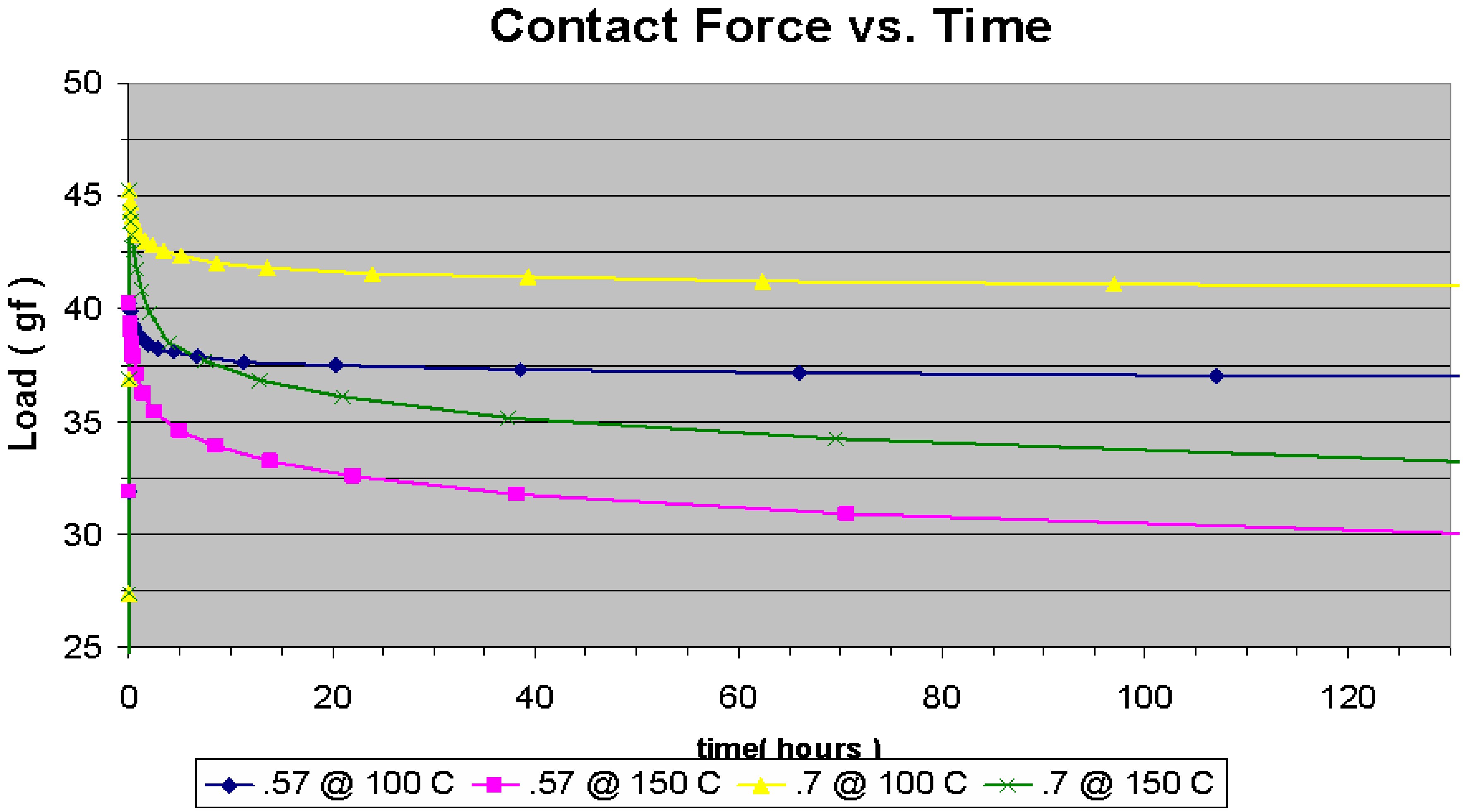
FEA Results

Normal Force vs Applied displacement @ t = 0 hrs.



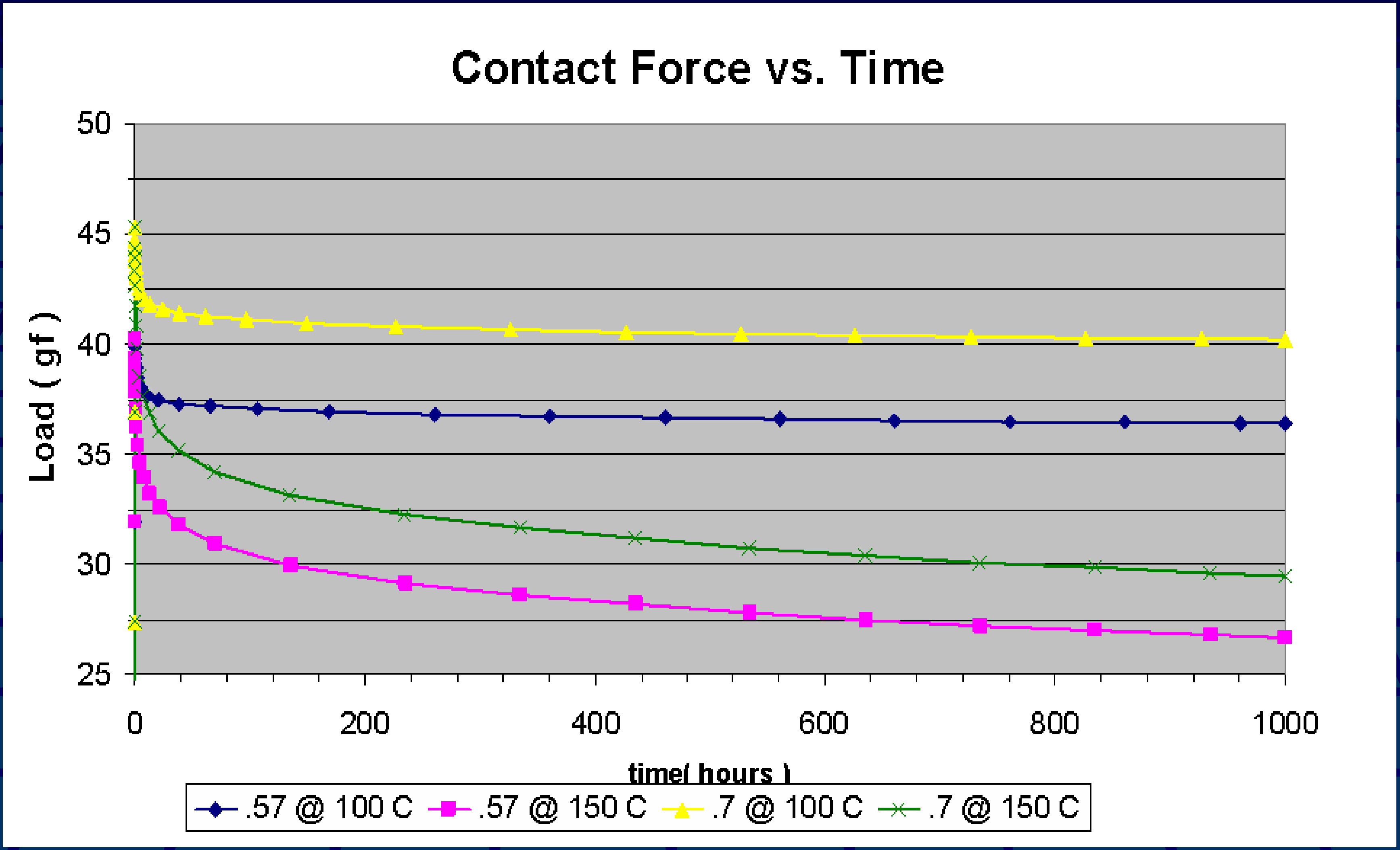
FEA Results

Normal Force vs @ t < 130 hrs.



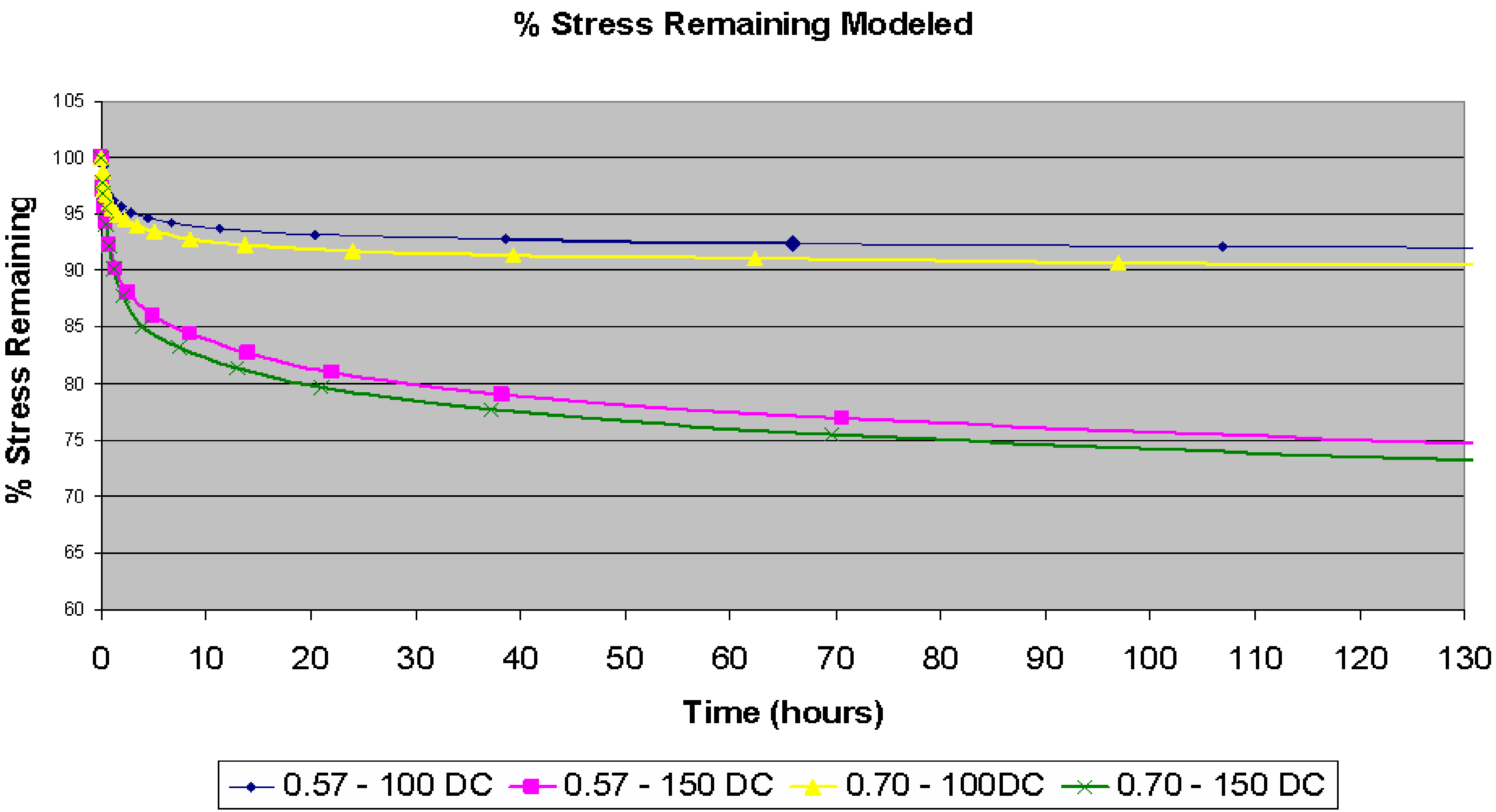
FEA Results

Normal Force vs @ t < 1000 hrs.



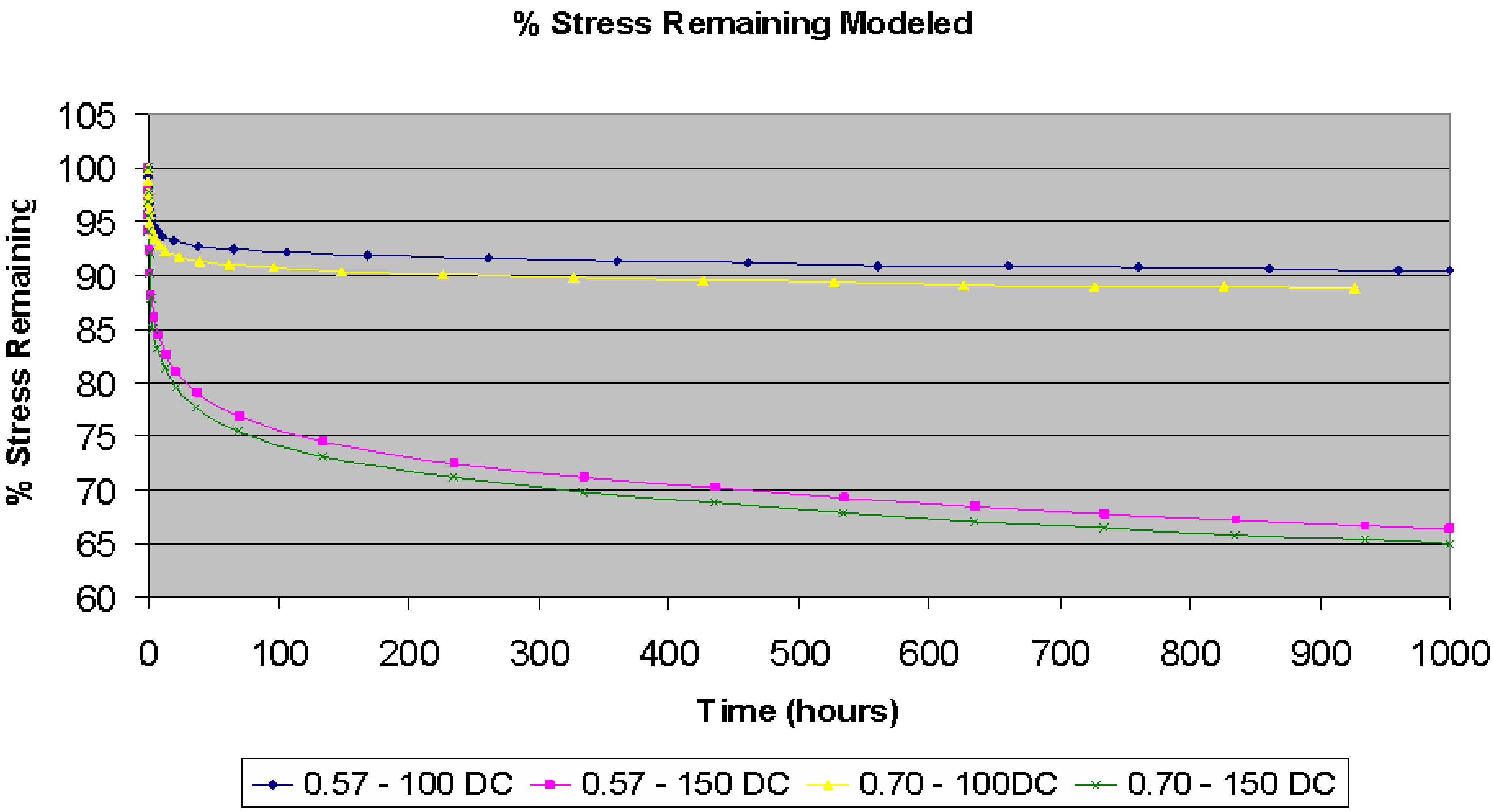
FEA Results

% Stress Remaining vs @ t < 130 hrs.



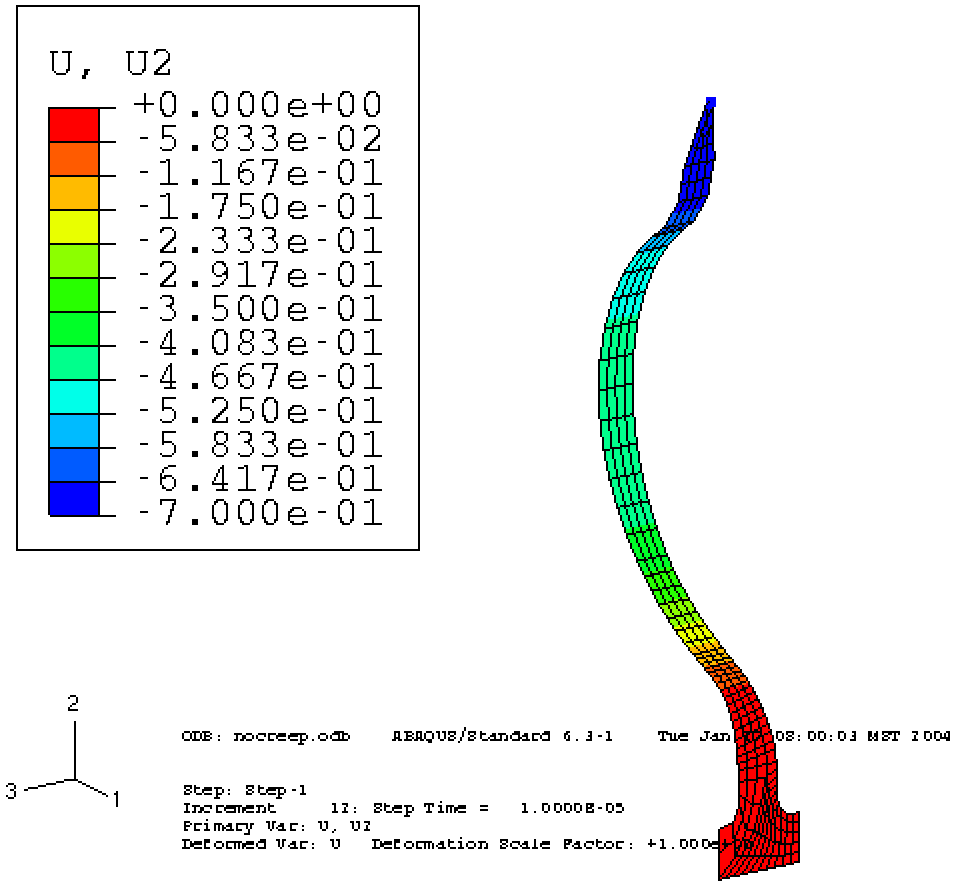
FEA Results

% Stress Remaining vs @ t < 1000 hrs.



FEA - Permanent Deflection

0.7 mm vertical displacement



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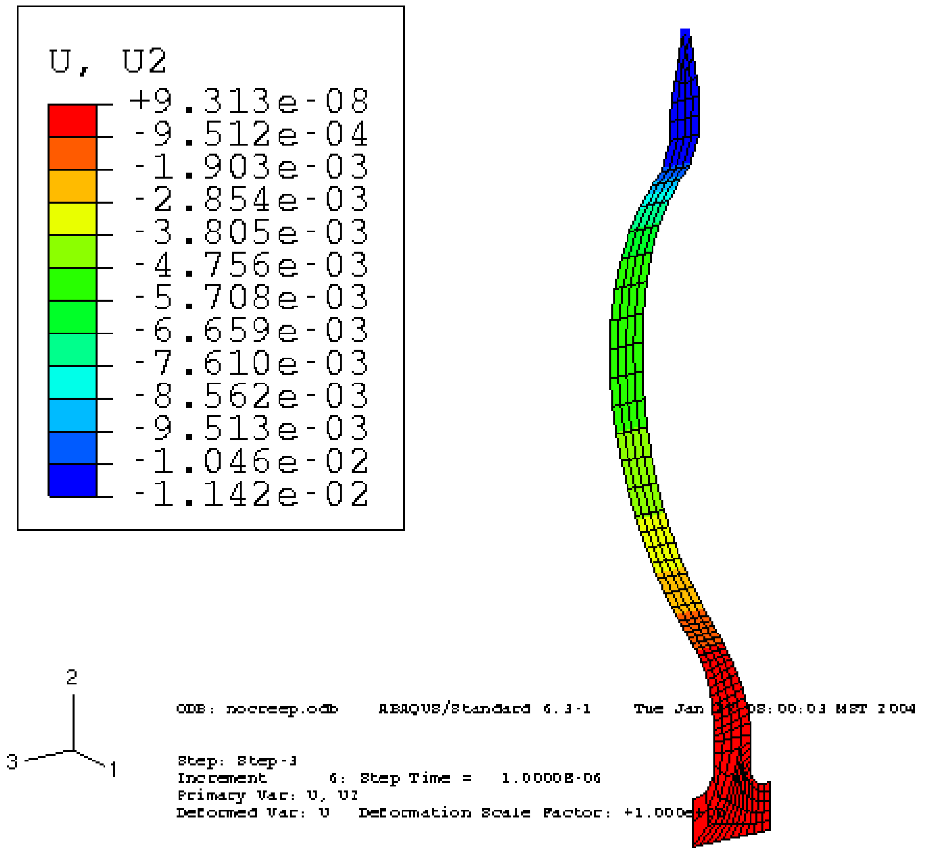
ODB: nocreep.odb    ABAQUS/Standard 6.3-1    Tue Jan    08:00:03 MST 2004

Step: Step-1
Increment     12: Step Time =   1.0000E-05
Primary Var: U, U2
Deformed Var: U   Deformation Scale Factor: +1.000e+00
```

After Displacement removal post 100 hours Bake @150 °C



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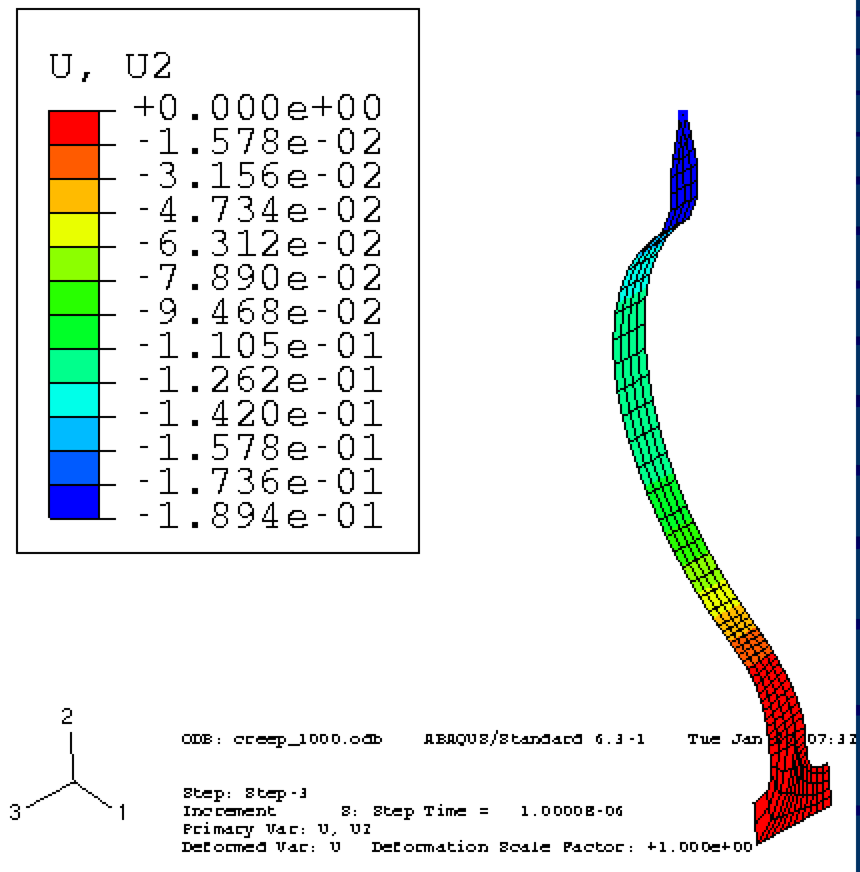
Step: Step-3
Increment      6: Step Time =   1.0000E-06
Primary Var: U, U2
Deformed Var: U   Deformation Scale Factor: +1.000e+00
```

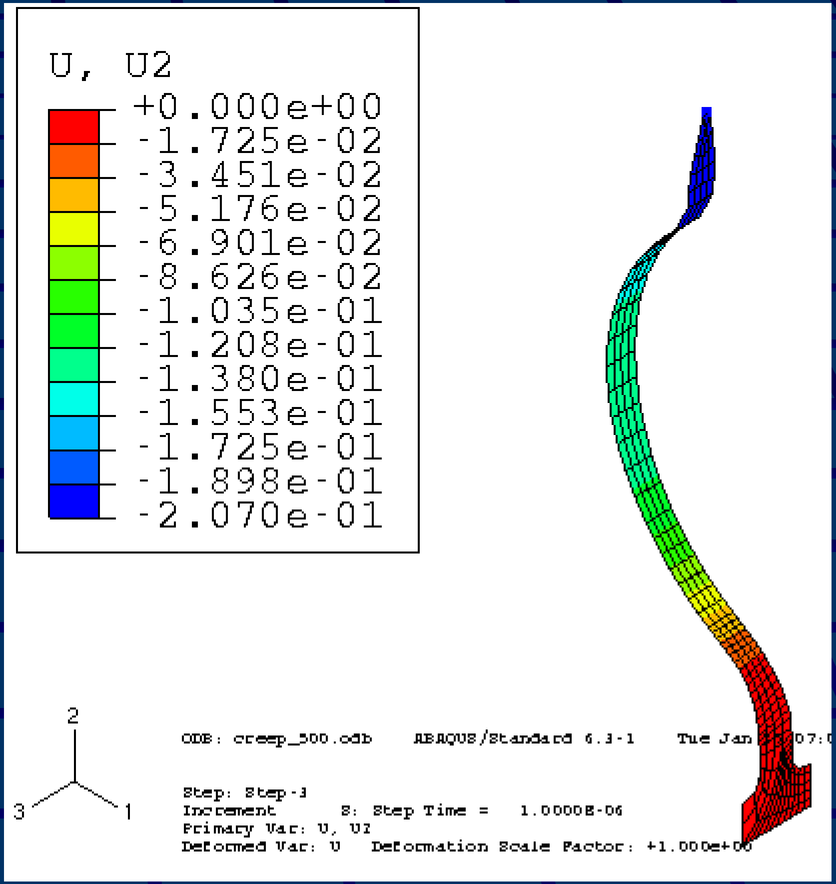
Units = mm

FEA - Permanent Deflection

After Displacement removal post 250 hours Bake @150 °C

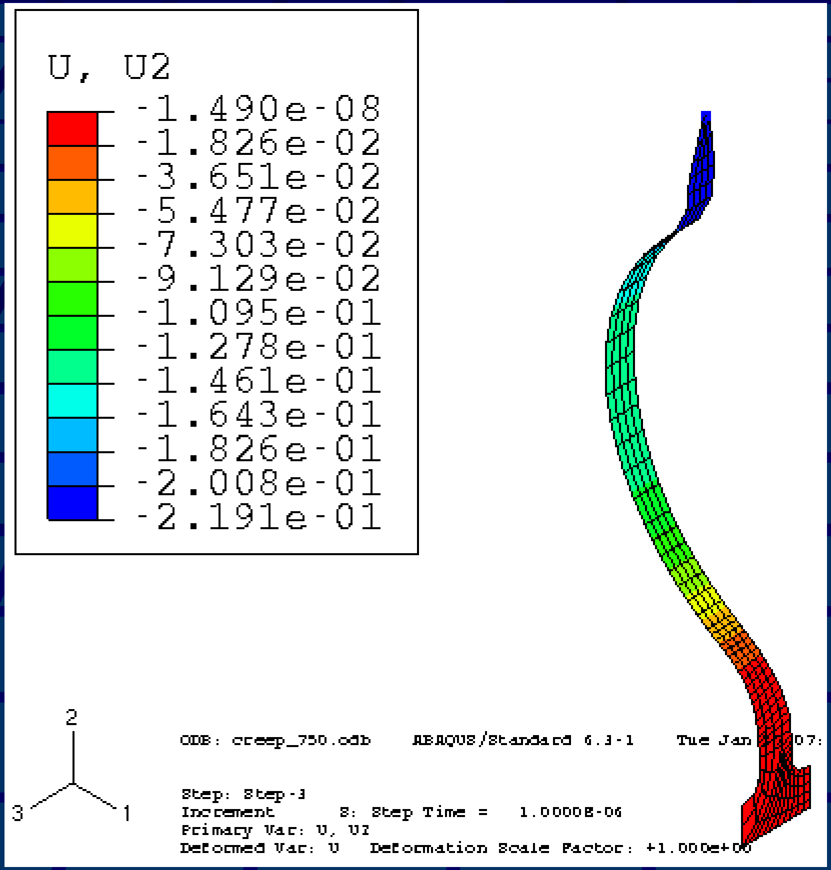


After Displacement removal post 500 hours Bake @150 °C



FEA - Permanent Deflection

After Displacement removal post 750 hours Bake @150 °C

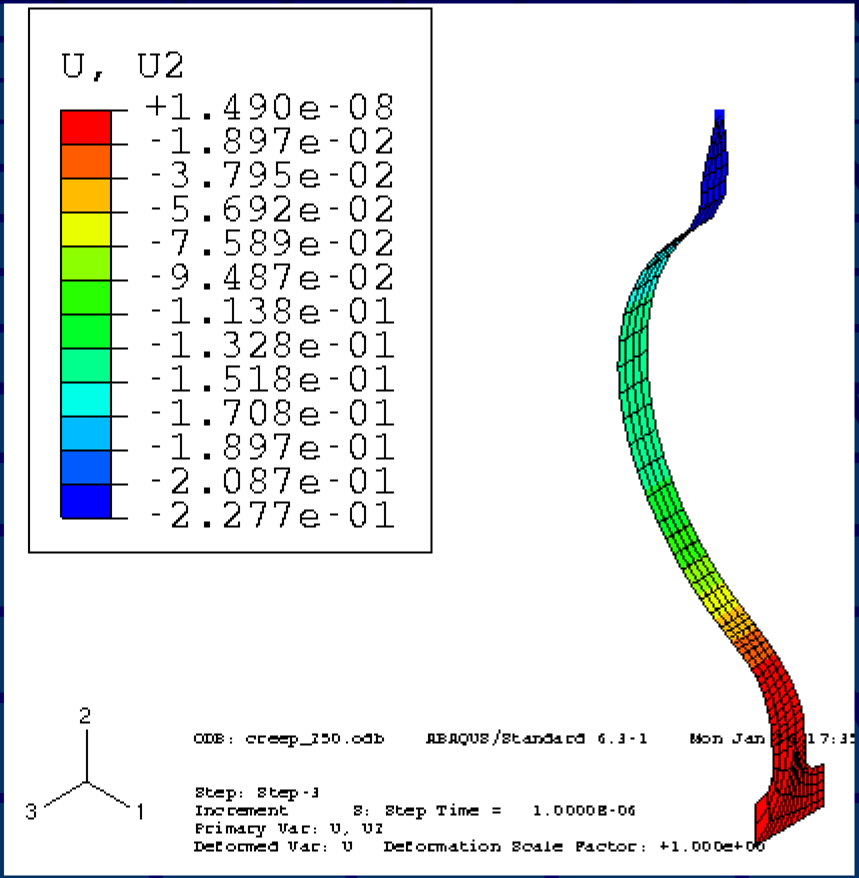


U, U2
-1.490e-08
-1.826e-02
-3.651e-02
-5.477e-02
-7.303e-02
-9.129e-02
-1.095e-01
-1.278e-01
-1.461e-01
-1.643e-01
-1.826e-01
-2.008e-01
-2.191e-01

```
ODB: creep_750.odb    ABAQUS/Standard 6.3-1    Tue Jan 07:

Step: Step-3
Increment      8: Step Time =   1.0000E-06
Primary Var: U, U2
Deformed Var: U   Deformation Scale Factor: +1.000e+00
```

After Displacement removal post 1000 hours Bake @150 °C



U, U2
+1.490e-08
-1.897e-02
-3.795e-02
-5.692e-02
-7.589e-02
-9.487e-02
-1.138e-01
-1.328e-01
-1.518e-01
-1.708e-01
-1.897e-01
-2.087e-01
-2.277e-01

```
ODB: creep_150.odb    ABAQUS/Standard 6.3-1    Mon Jan 17:35

Step: Step-3
Increment      8: Step Time =   1.0000E-06
Primary Var: U, U2
Deformed Var: U   Deformation Scale Factor: +1.000e+00
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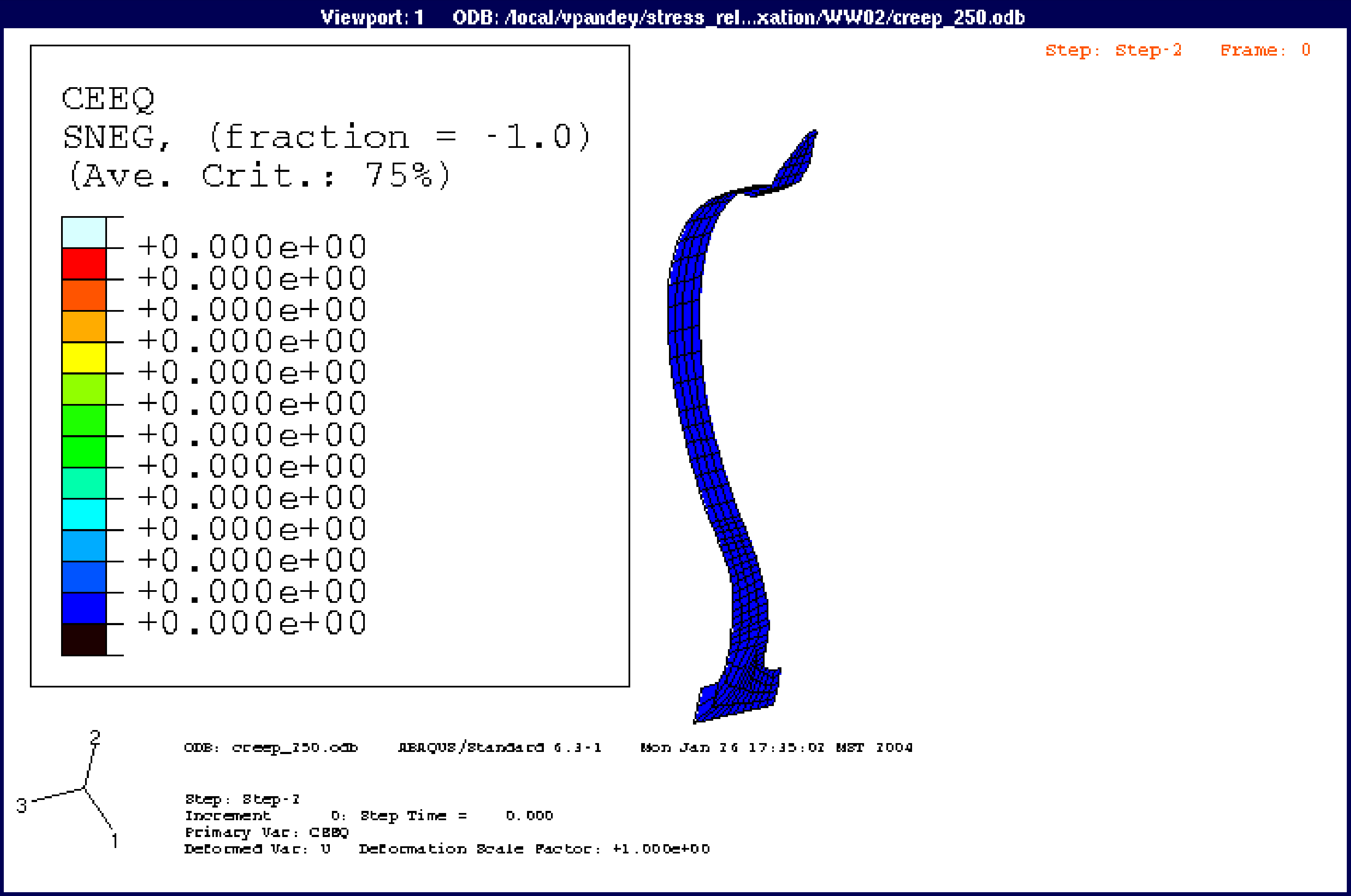
Stress Relaxation Simulation



Viewport: 1 ODB: /local/vpandey/stress_rel...xation/WW02/creep_250.odb

Step: Step-2 Frame: 0

CEEQ
SNEG, (fraction = -1.0)
(Ave. Crit.: 75%)

+0.000e+00
+0.000e+00
+0.000e+00
+0.000e+00
+0.000e+00
+0.000e+00
+0.000e+00
+0.000e+00
+0.000e+00
+0.000e+00
+0.000e+00
+0.000e+00
+0.000e+00

ODB: creep_250.odb ABAQUS/Standard 6.3-1 Mon Jan 26 17:35:02 MST 2004

Step: Step-2
Increment 0: Step Time = 0.000
Primary Var: CEEQ
Deformed Var: U Deformation Scale Factor: +1.000e+00

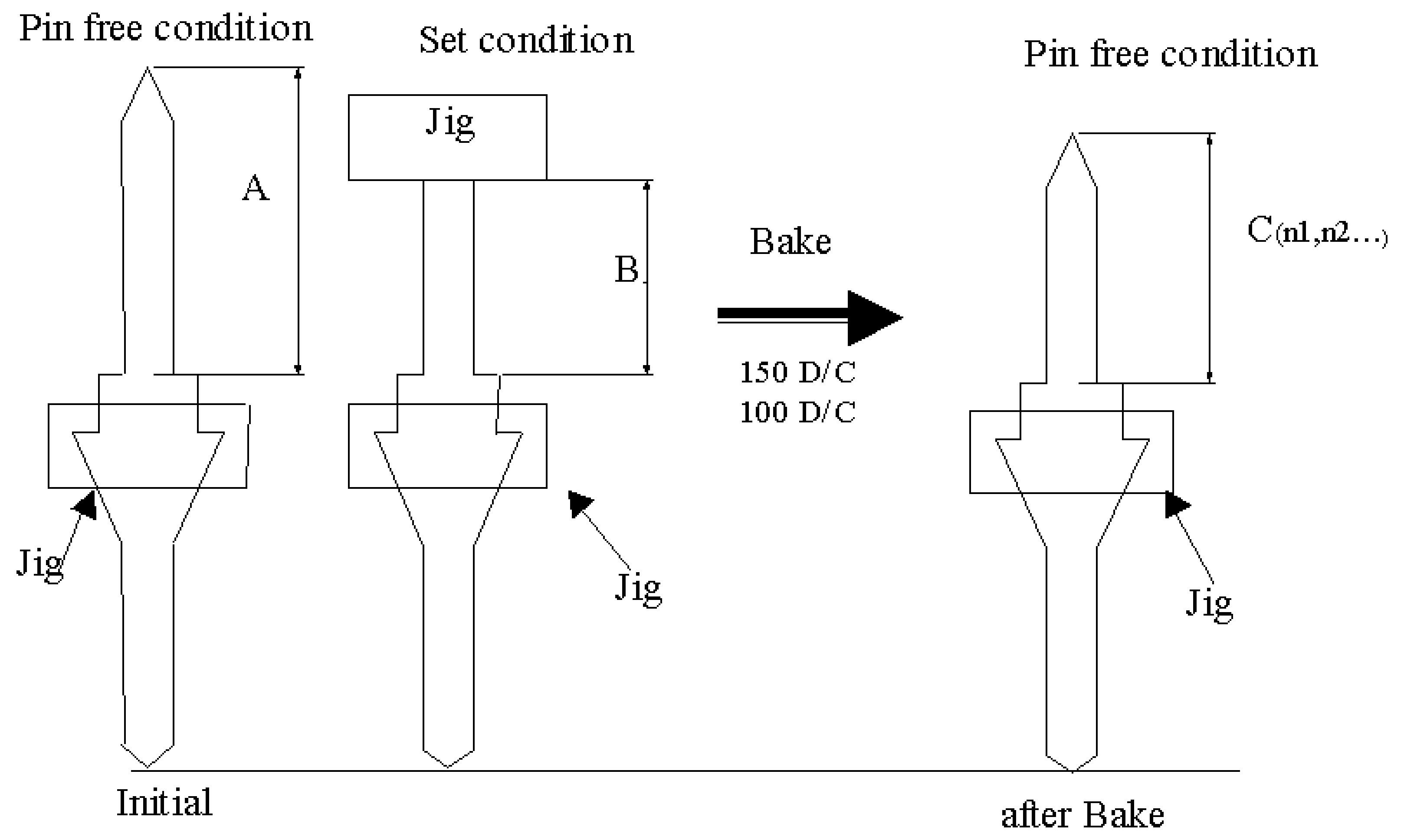
Enplas Validation Test

Test Parameters:

CP Material Brush 390 (Yield Strength 95.9kgf/mm2)

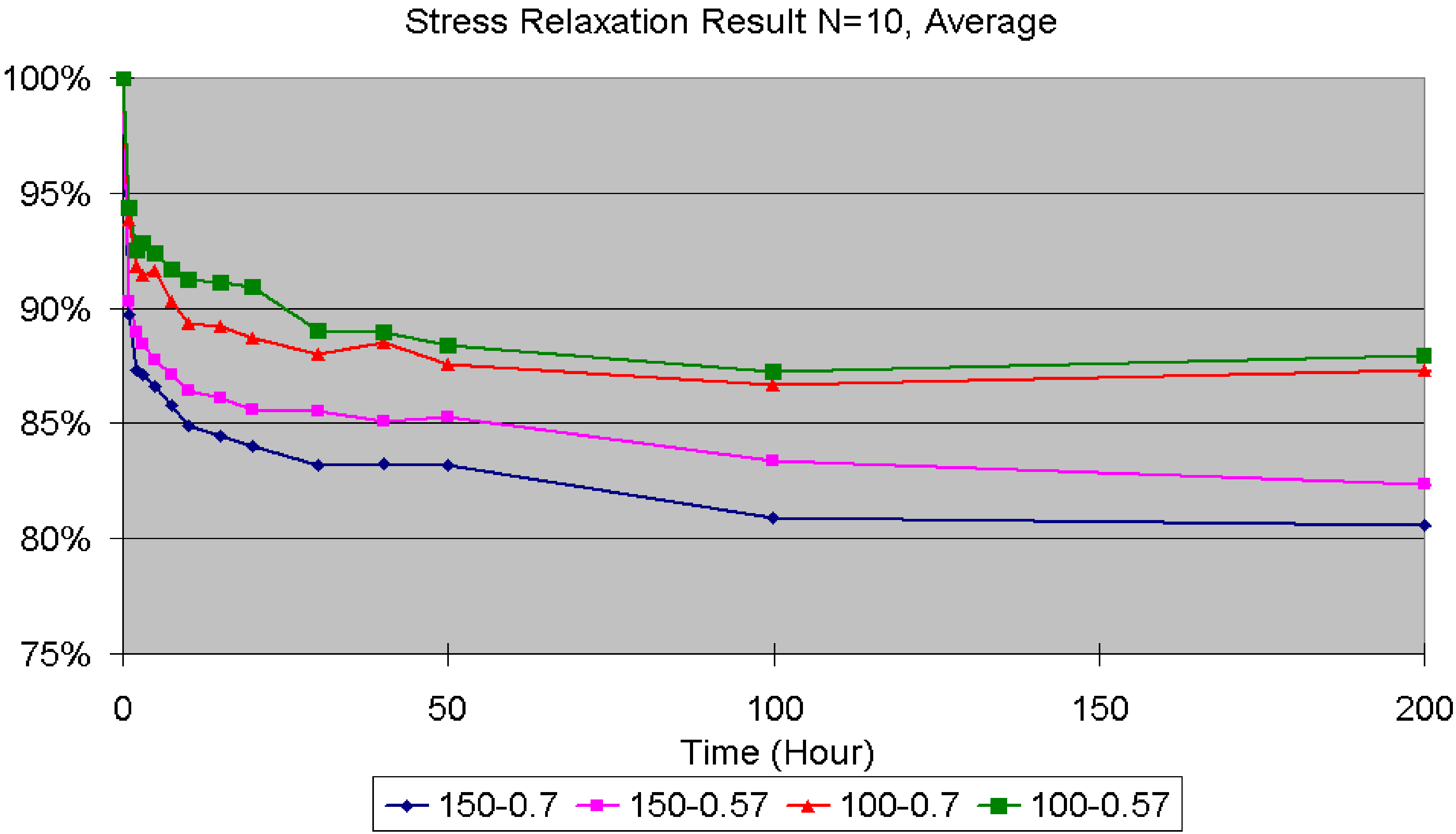
- Sample size : n=10
- Test Temperature : 100degreeC
  : 150 degree C
- Contact pin travel distance
  : 0.57mm(% Stress:77%)
  : 0.70mm (% Stress: 94%)
- Measurement Interval(unit:hour)
  1,2,3,5,7.5,10,15,20,30,40,50,100,200,…, 1000 hours

Enplas Validation Test

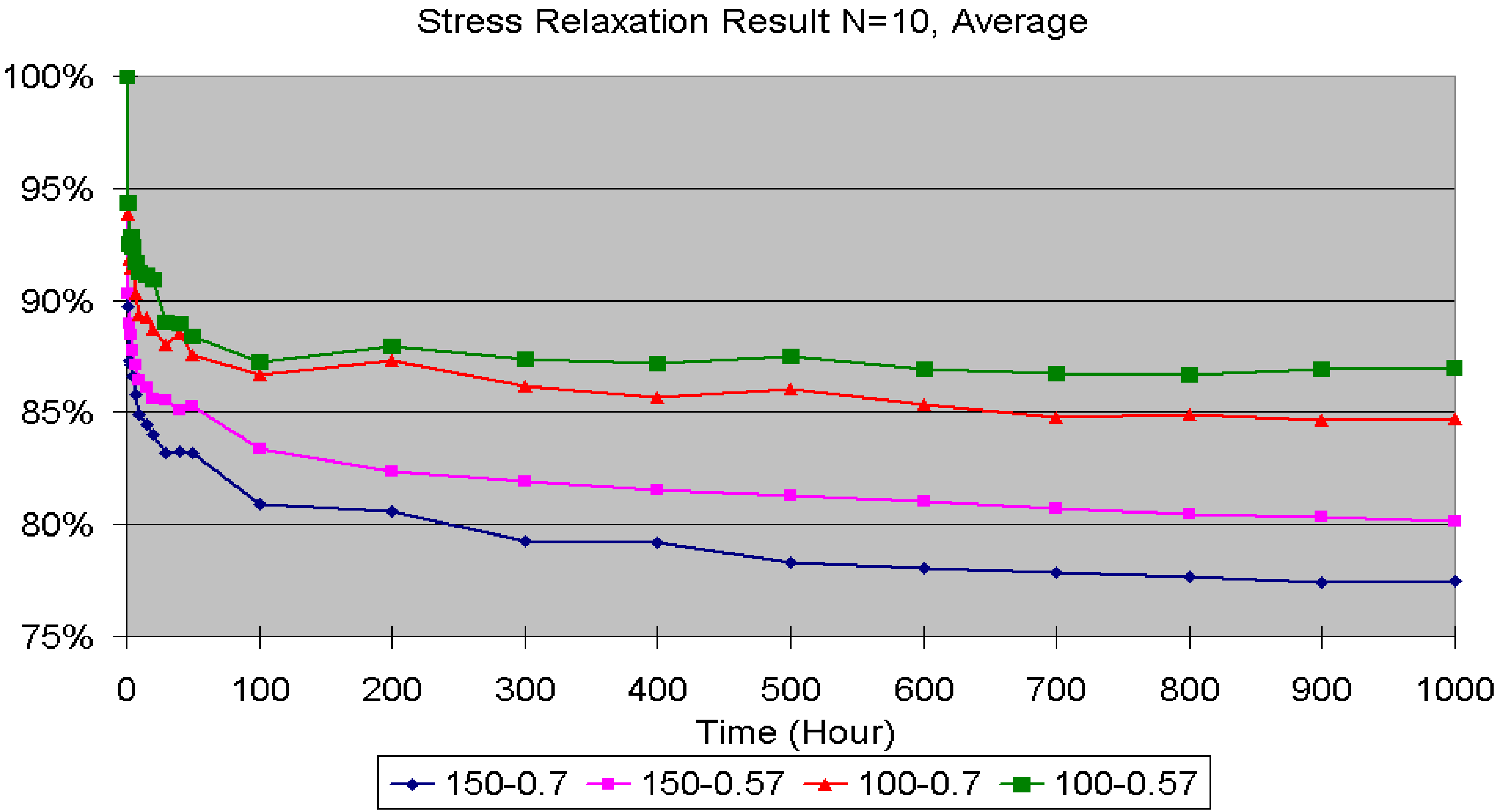


Stress Relaxation[%] = [1 – (A-Cn1…) / (A-B)] * 100(*A-B: Initial Deflection

Enplas Validation Test



Enplas Validation Test



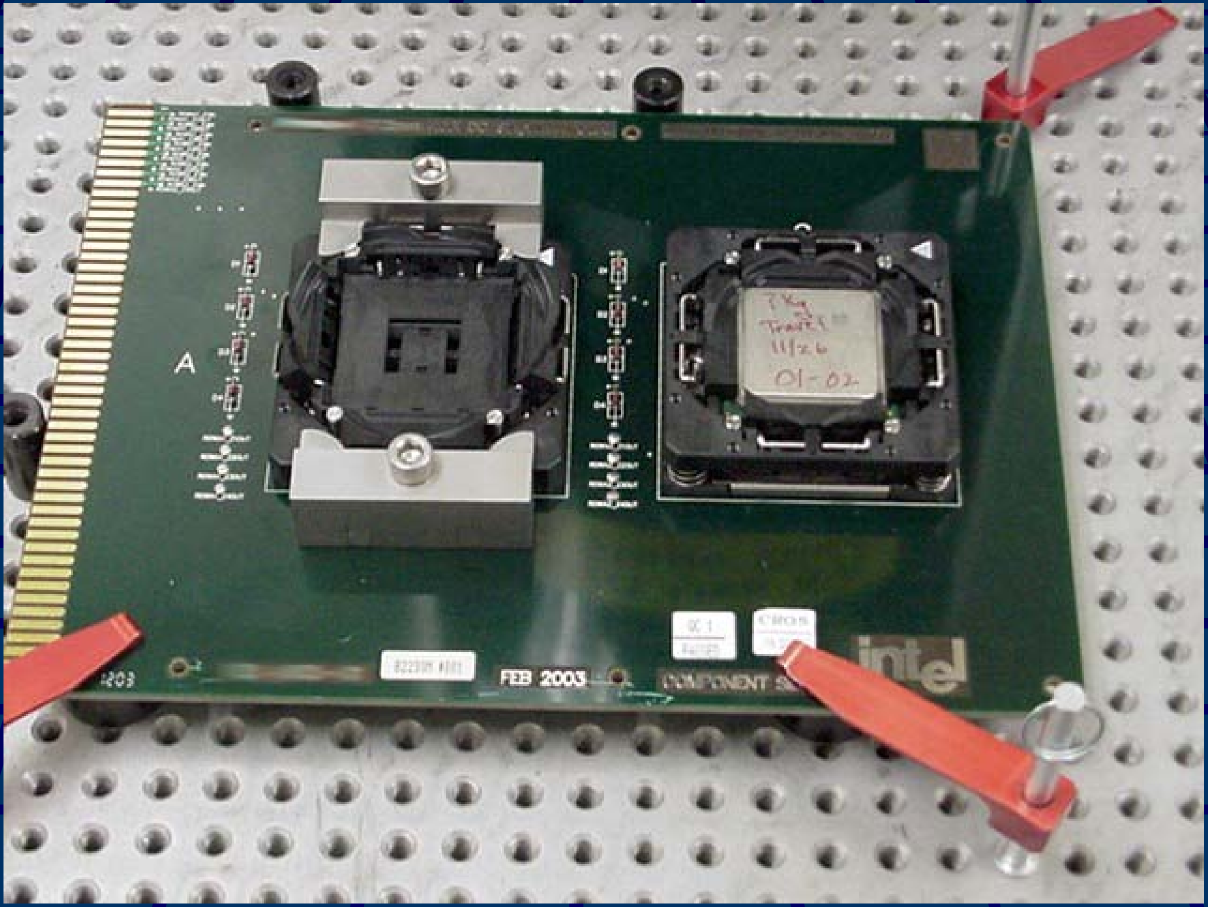
Intel Validation Test

Test Parameters:

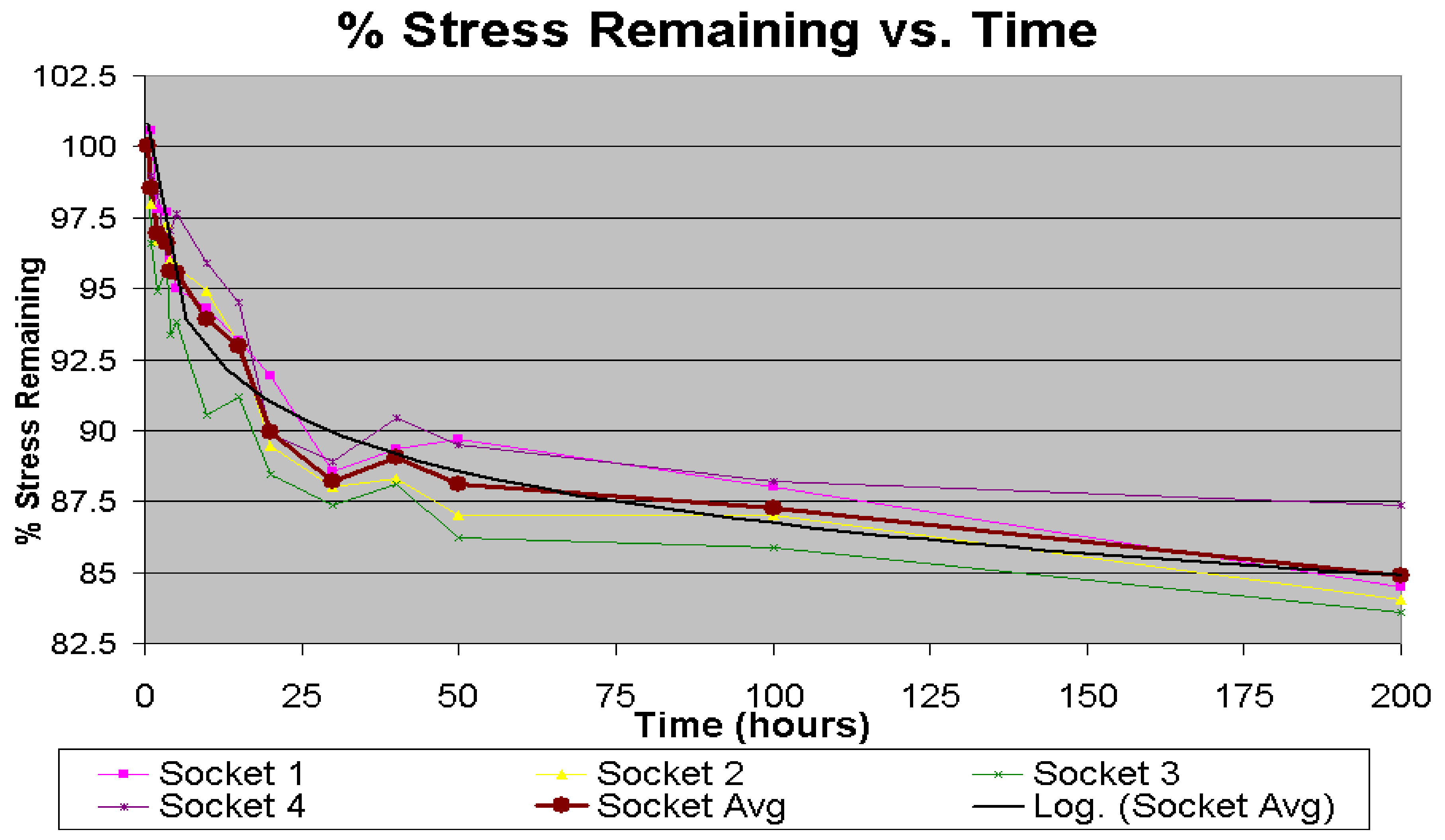
- CP Material Brush 390 (Yield Strength 95.9kgf/mm2)
- Sample size : 4 sockets
  : 45 pins/socket
- Test Temperature : 150 degree C
- Contact pin travel distance
  : 0.48mm(% Stress:64%)
- Measurement Interval(unit:hour)
  1,2,3,5,7.5,10,15,20,30,40,50,100,200,…., 1000 hours

Intel Validation Test

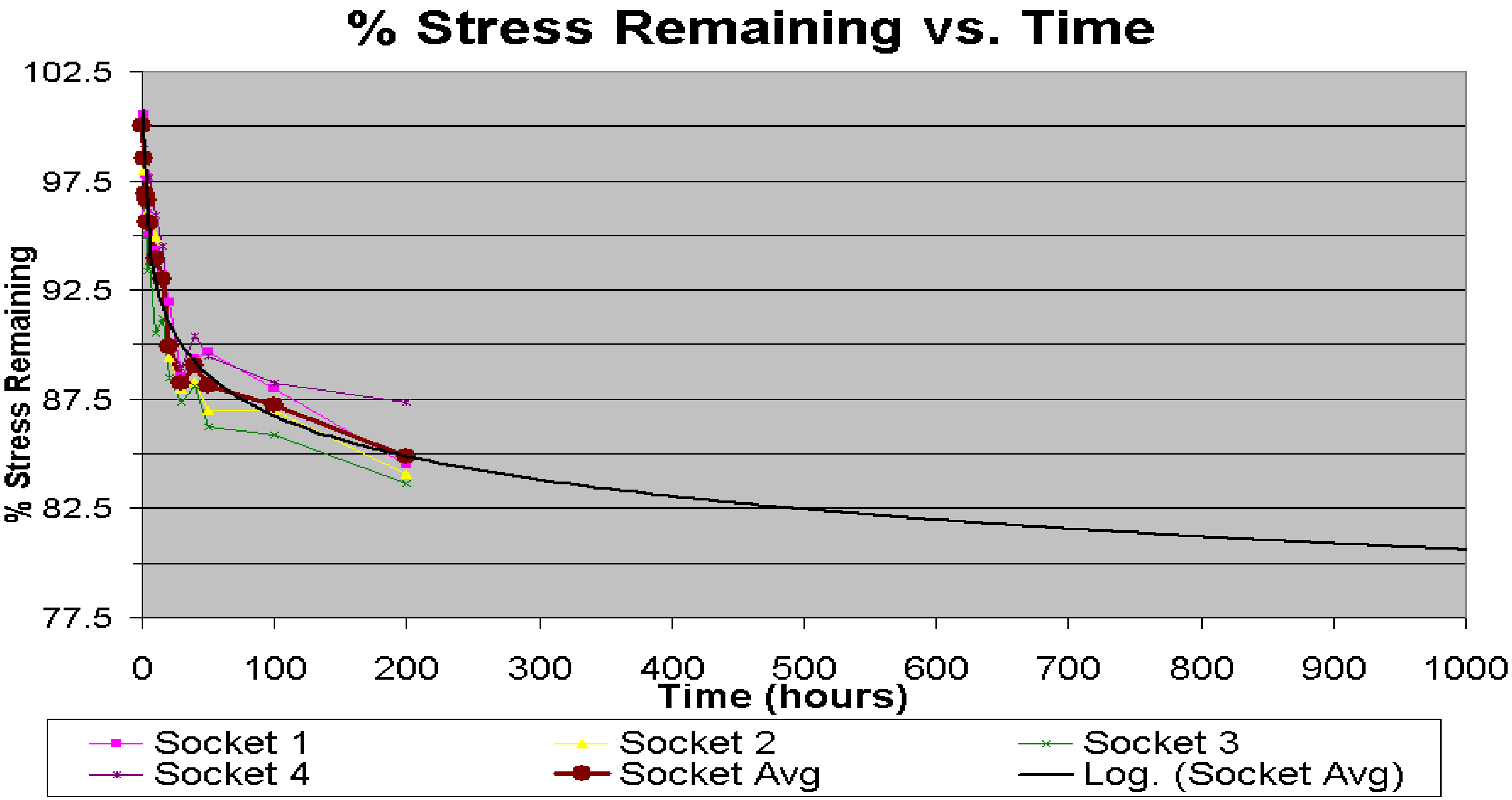
Pin Height and Pkg Displacement Measurement



Intel Validation Test



Intel Validation Test



Conclusions

- The agreement between predicted and measured stress relaxation at 100 hrs was
  - Model %
    - 150 dc @ 0.57 = 76%   100 dc @ 0.57 = 92%
    - 150 dc @ 0.70 = 74%   100 dc @ 0.70 = 91%
  - Enplas data
    - 150 dc @ 0.57 = 83%   100 dc @ 0.57 = 87%
    - 150 dc @ 0.70 = 81%   100 dc @ 0.70 = 86%
  - Intel Data
    - 150 dc @ 0.48 mm = 87%

Conclusions

- The agreement between predicted and measured stress relaxation at 600 hrs was
  - Model %
    - 150 dc @ 0.57 = 68%	100 dc @ 0.57 = 91%
    - 150 dc @ 0.70 = 67%	100 dc @ 0.70 = 89%
  - Enplas data
    - 150 dc @ 0.57 = 81%	100 dc @ 0.57 = 87%
    - 150 dc @ 0.70 = 78%	100 dc @ 0.70 = 85%
  - Intel Data
    - 150 dc @ 0.48 mm = ~82%

Conclusions Cont.

- FEA model is conservative model. Intel and Enplas’ data is consistent over the longer duration with similar displacements.
- Additional work is needed to build the stress relaxation data base and improve the predictive model.
- The feasibility of predicting stress relaxation behavior using FEA models was successfully proven.

Next Steps

- A measurement system analysis should be completed to understand the variability of the testing method and to make improvements where needed.

- Additional data should be collected and added to the stress relaxation data base to improve on the modeling accuracy.

- Further validate FEA predictions of stress relaxation with other connector designs. Knowledge gained should be used to refine the subroutines and modeling procedures.