

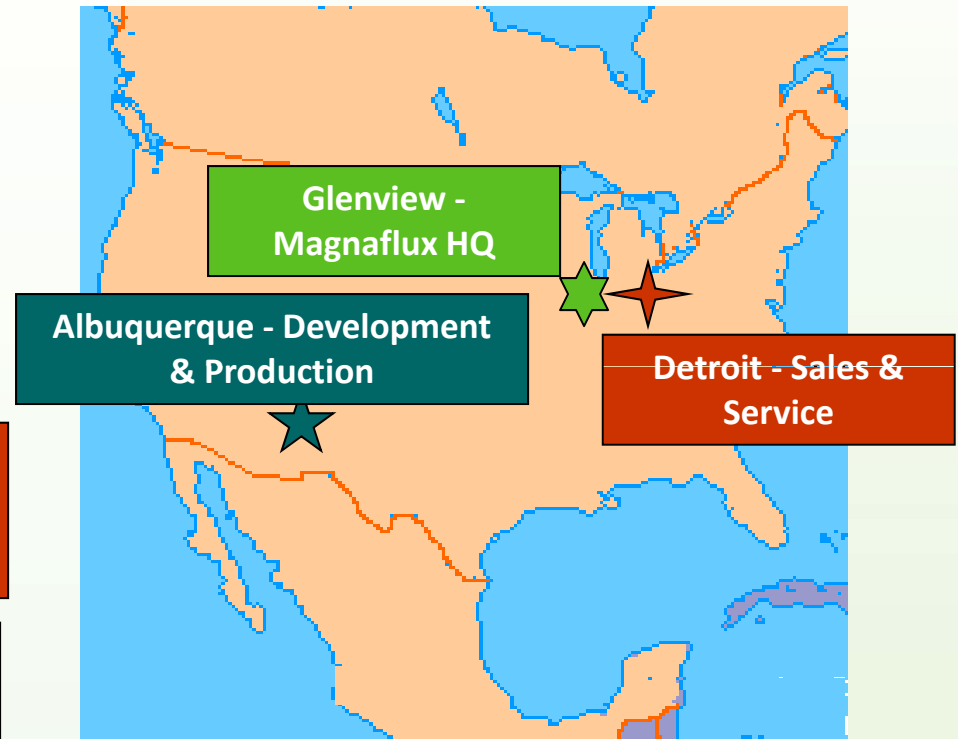
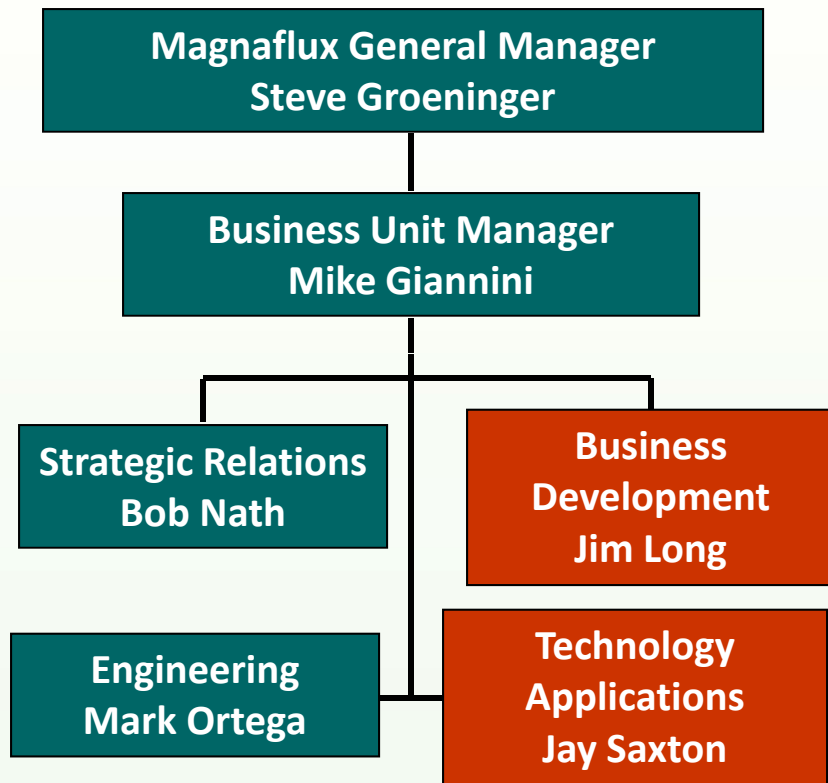


Magnaflux Quasar Systems Overview

Agenda

- **Magnaflux Quasar Background**
- **Quasar PCRI Message**
- **Quasar PCRI Method**
- **Application Examples**

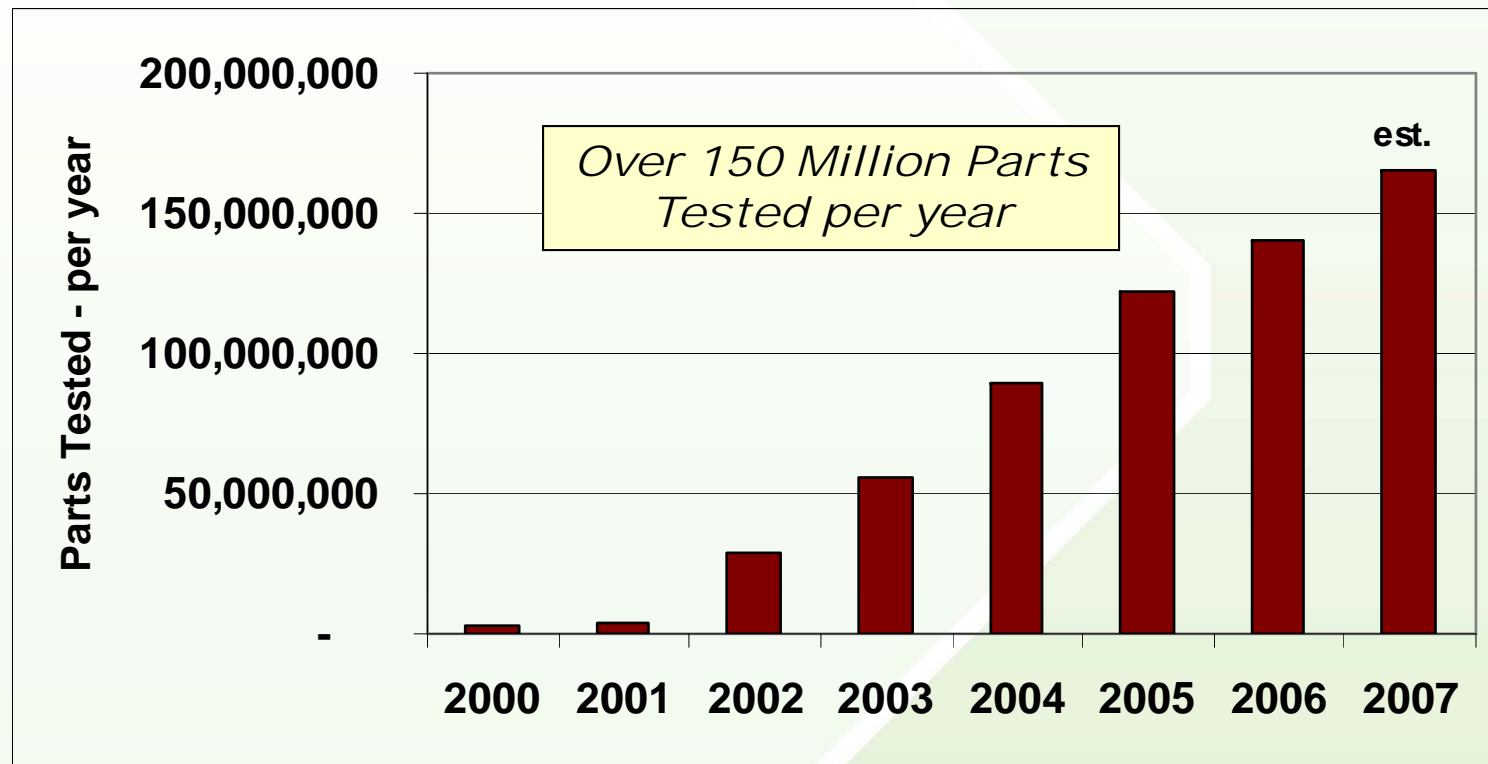
Magnaflux Quasar Systems Organization



VARs (Value Added Resellers)

- Europe – Hesselmann & Köhler Prozessautomation GmbH
- Japan—Toray Engineering Co. Ltd.
- Korea—Kyungdo Enterprises, Ltd.
- United Kingdom—Vibrant NDT UK, Ltd.
- United States—Vibrant NDT, Inc.

Quasar PCRI Has Achieved Industry Acceptance



Quasar PCRI: 21st Century NDT Technology

Quasar PCRI – Production NDT Benefits

- **Lower Risk**
 - Lower probability of shipping defective parts
 - *Proper use reduces the risk of containment*
- **Lower Cost**
 - Reduced NDT Cost
 - Limits scrapping acceptable parts
 - Reduces engineering & marketing costs associated with “quality spills”

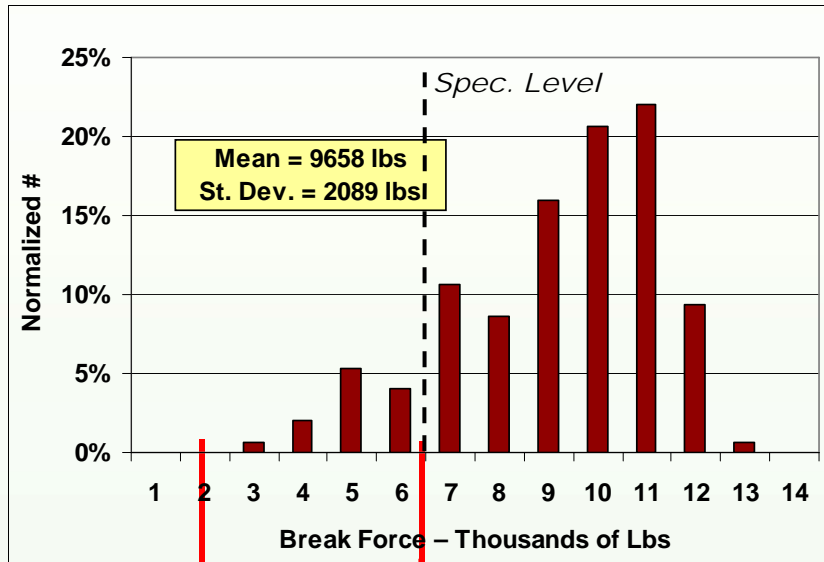
Why is Quasar PCRI Better?

- **Other NDT methods detect defect “indications” that are weakly correlated to part performance**
 - Some defects produce no indication (false accepts)
 - Most indications are only cosmetic (false rejects)
- **Resonance measurements are based on part’s material properties**
 - Material properties determine field performance
 - But normal process variation fools simple resonance measurements
- **Magnaflux invented PCRI – Process Compensated Resonant Inspection - a structural test, not a visual inspection**
- **A single Quasar PCRI test detects all of a part’s structural defects, wherever they are located**

Quasar PCRI Works! – Proven by research conducted by OEMs, Suppliers & Industry Consortium

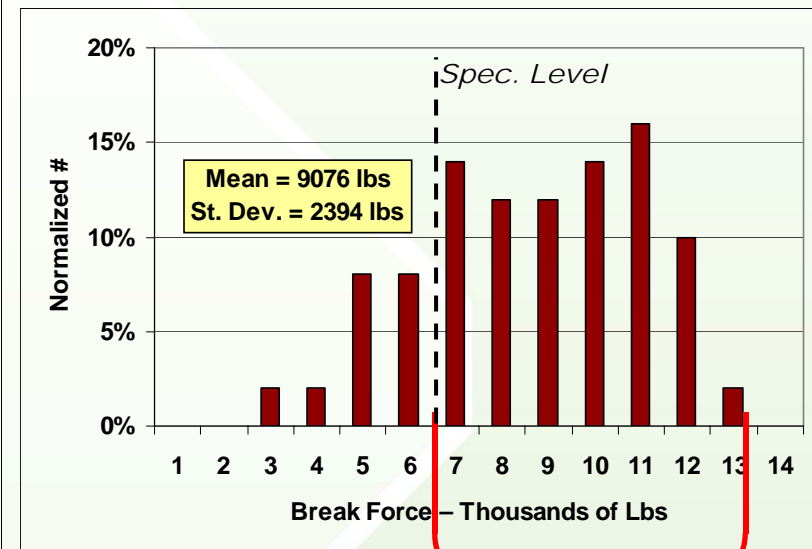
OEM Test - Performance of X-ray Inspection

200 Suspension Links



Failure Distribution for 150 Links that **Passed** X-ray (and Ultrasound)

- 12% Failed Below Spec (False Accepts)



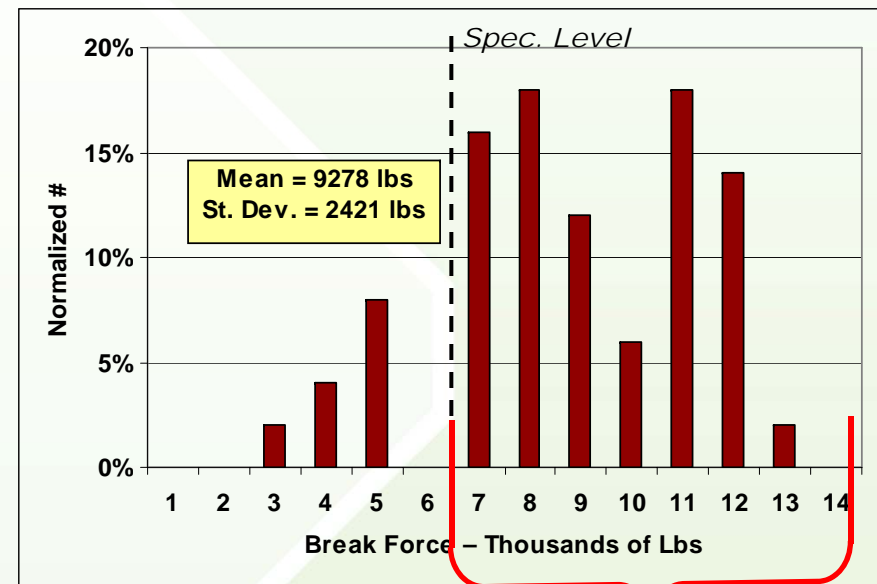
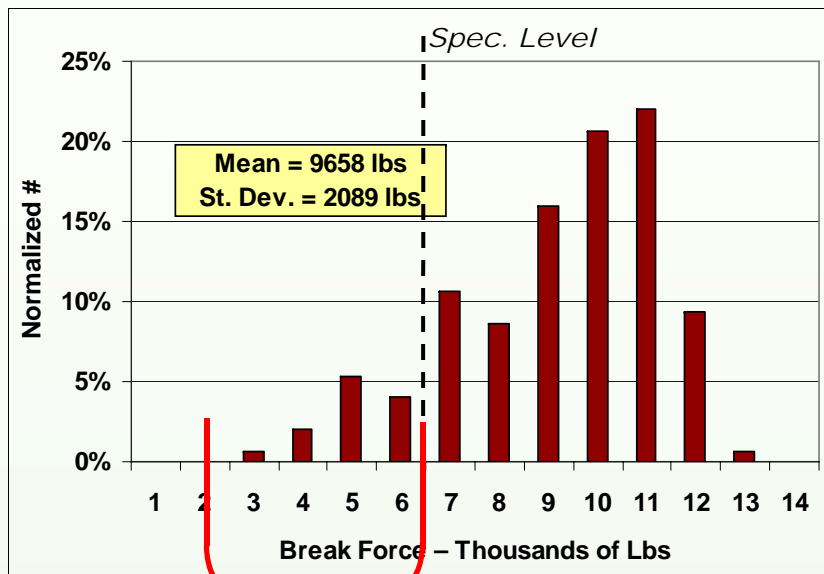
Failure Distribution for 50 Links that **Failed** X-ray

- 86% Failed Above Spec (False Rejects)

Conclusion: X-ray is not capable of detecting all defective parts (oxides)

OEM Test - Performance of Ultrasound Inspection

200 Suspension Links



Failure Distribution for 150 Links that **Passed** Ultrasound (and X-ray)

- 12% Failed Below Spec (False Accepts)

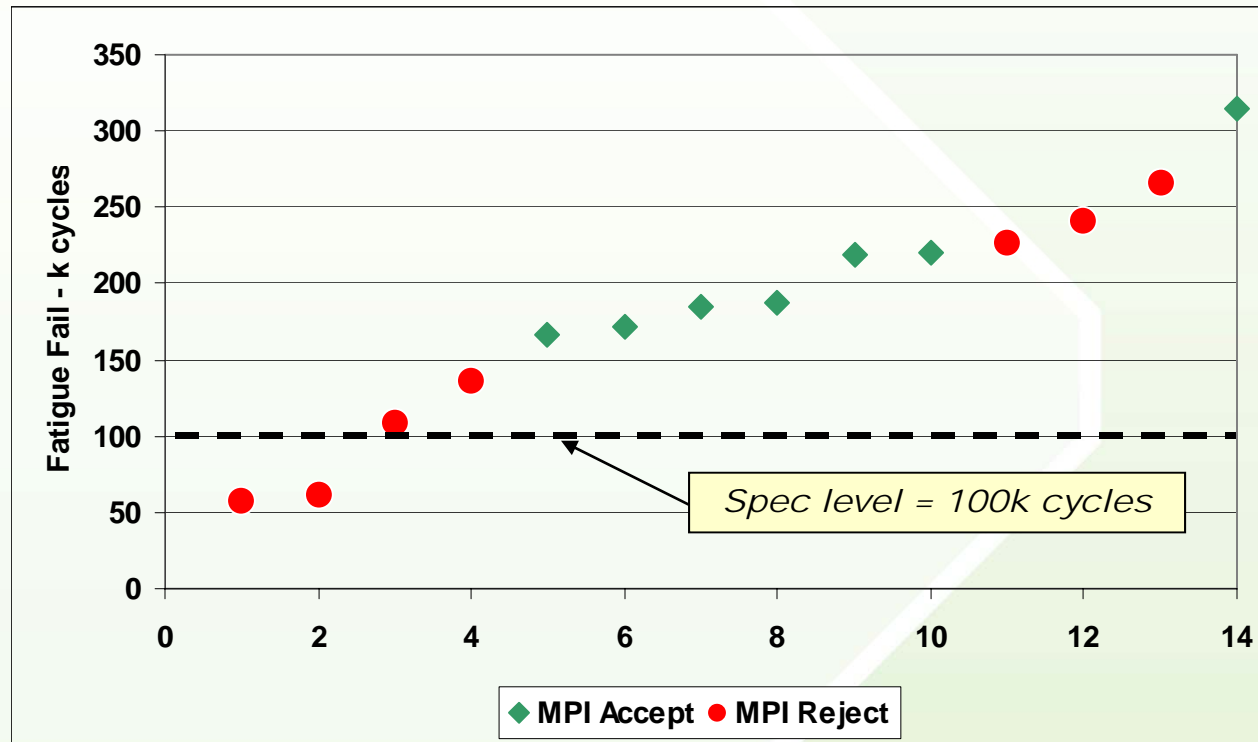
Failure Distribution for 50 Links that **Failed** Ultrasound

- 80% Failed Above Spec (False Rejects)

Conclusion: Ultrasound is not capable of detecting all defective parts (oxides)

Supplier Test - Performance of MPI

PM Clutch Plates - Fatigue Tested to Destruction



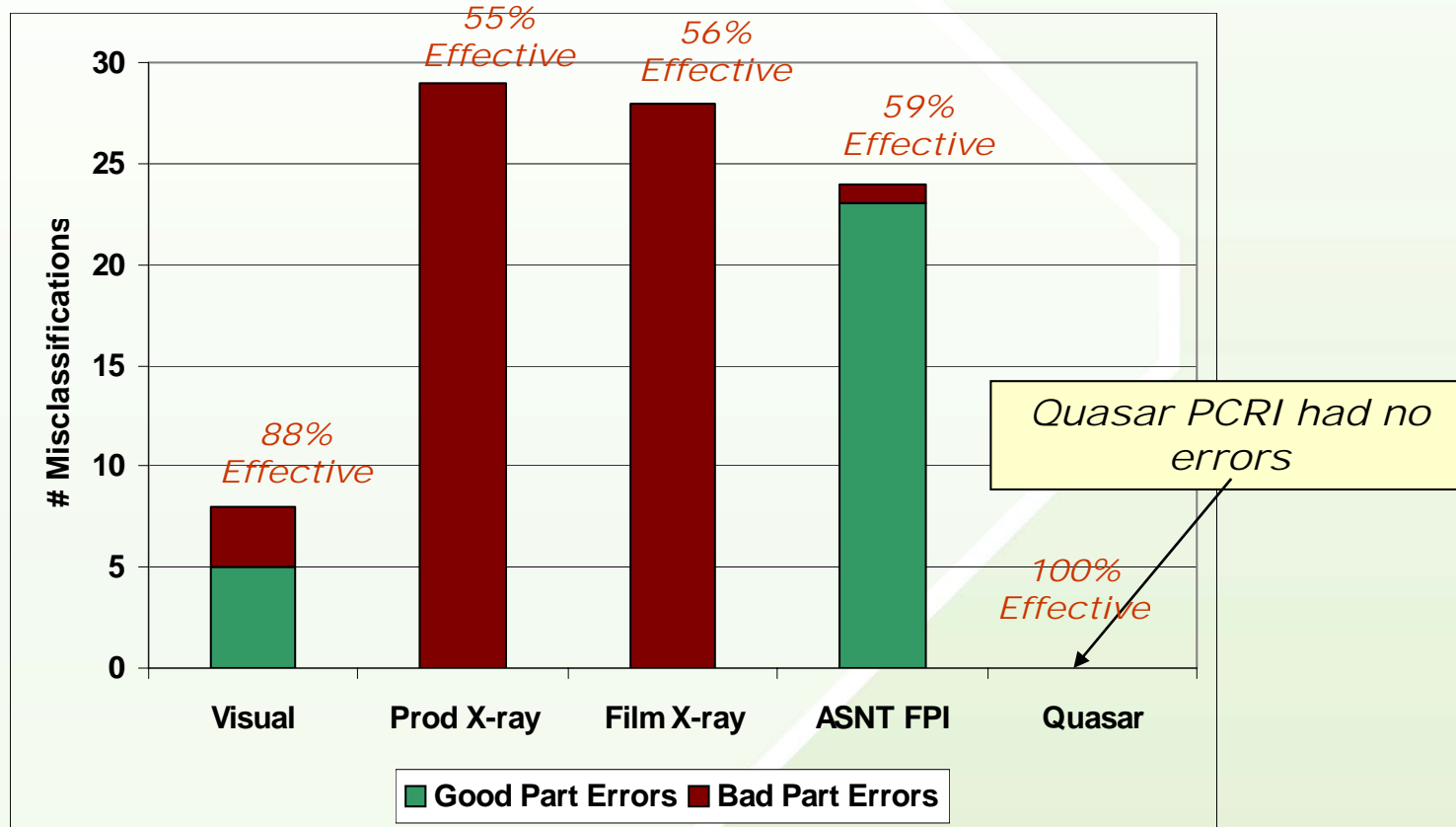
■ 0% of Accepts Failed Below Spec
(False Accepts)

■ 71% of Rejects Failed Above Spec
(False Rejects)

Conclusion: Majority of MPI rejects are acceptable parts

Consortium Test – Comparison of Several NDT Methods

Fatigue Test of 64 Aluminum Knuckles



Conclusion: Only Quasar PCRI was 100% Reliable

Examples of Quasar PCRI Applications

<i>ABS Pump Bodies</i>	<i>Engine Mounts</i>
<i>ABS Rings</i>	<i>Flywheels</i>
<i>Bearing Caps</i>	<i>Gears</i>
<i>Brake Anchors</i>	<i>Knuckles</i>
<i>Bearing Hubs & Races</i>	<i>King Pins</i>
<i>Brake Calipers</i>	<i>Links</i>
<i>Master Cylinders</i>	<i>Oxygen Sensors</i>
<i>Cam Caps</i>	<i>Pump Housings & Rotors</i>
<i>Cam Shafts</i>	<i>Rocker Arms</i>
<i>Clutch & Pressure Plates</i>	<i>Steering Racks</i>
<i>Connecting Rods</i>	<i>Sprockets</i>
<i>Control Arms</i>	<i>Synchronizers</i>
<i>Dampener Forks</i>	<i>Timing Rings & Gears</i>
<i>Differential Carriers</i>	<i>Transmission Shafts</i>
<i>Cylinder Heads</i>	<i>Wheels</i>
<i>Engine Blocks</i>	<i>Yokes</i>

Quasar PCRI Rejects Parts with Significant Structural Defects

Common Defects – All Processes

Cracks, Inclusions, Chemistry, Missing Features, Non-fill, Dimensions

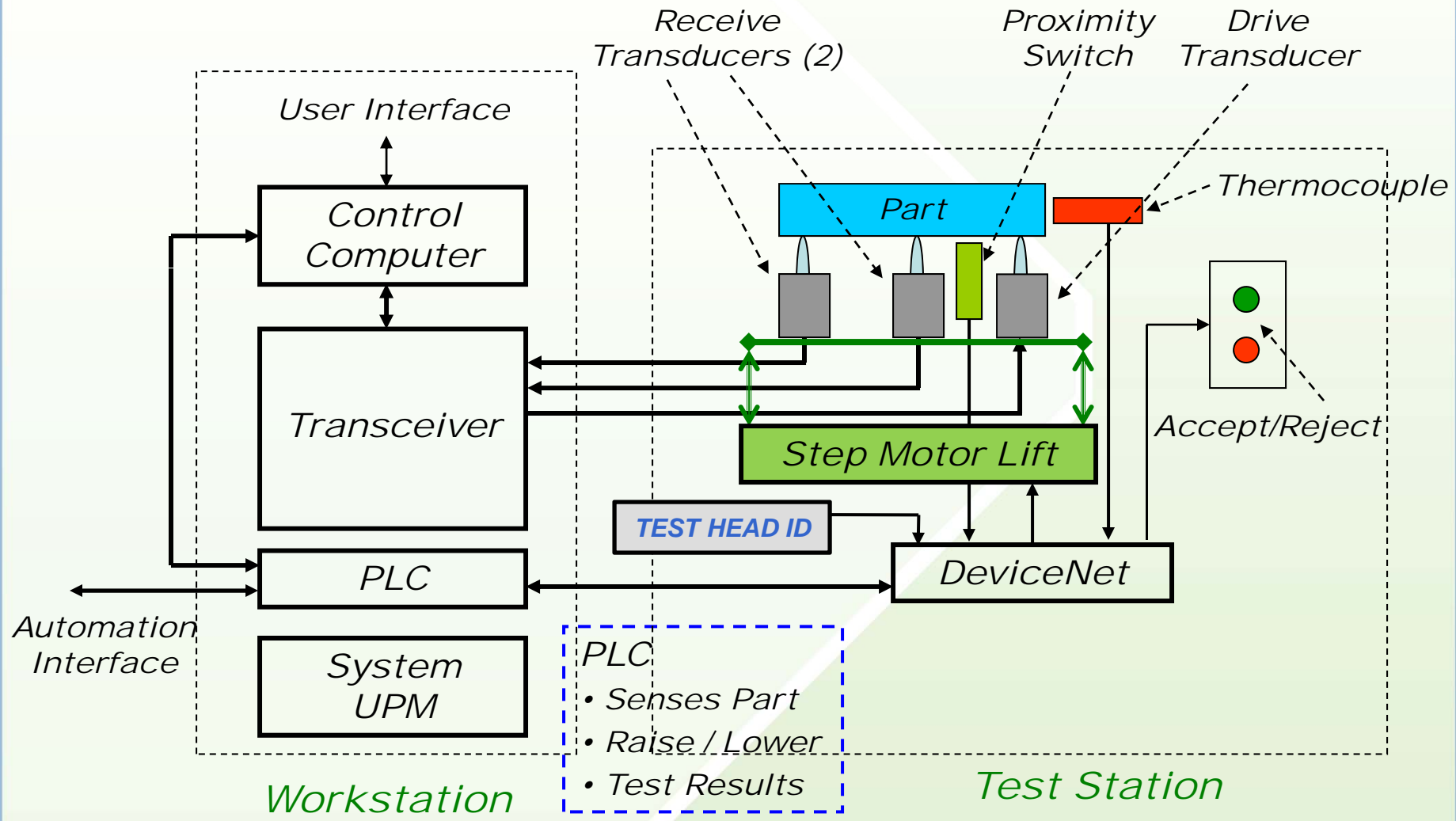
<u>Process-Specific Defects</u>			
<u>Al Cast</u>	<u>Fe Cast</u>	<u>PM</u>	<u>Forge</u>
Oxides	Oxides	Oxides	Bar Ends
Cold Shuts	Cold Laps	Chipped Teeth	Double Strikes
Shrink Porosity	Shrink Porosity	Porosity	Laps (folds)
Blow Holes	Nodularity	Sintering	Water quench
Elongation	Heat Treat	Coining	Wrong material
	Carbides	De-carb	

Other Processes – Welding, Ceramics, Composites

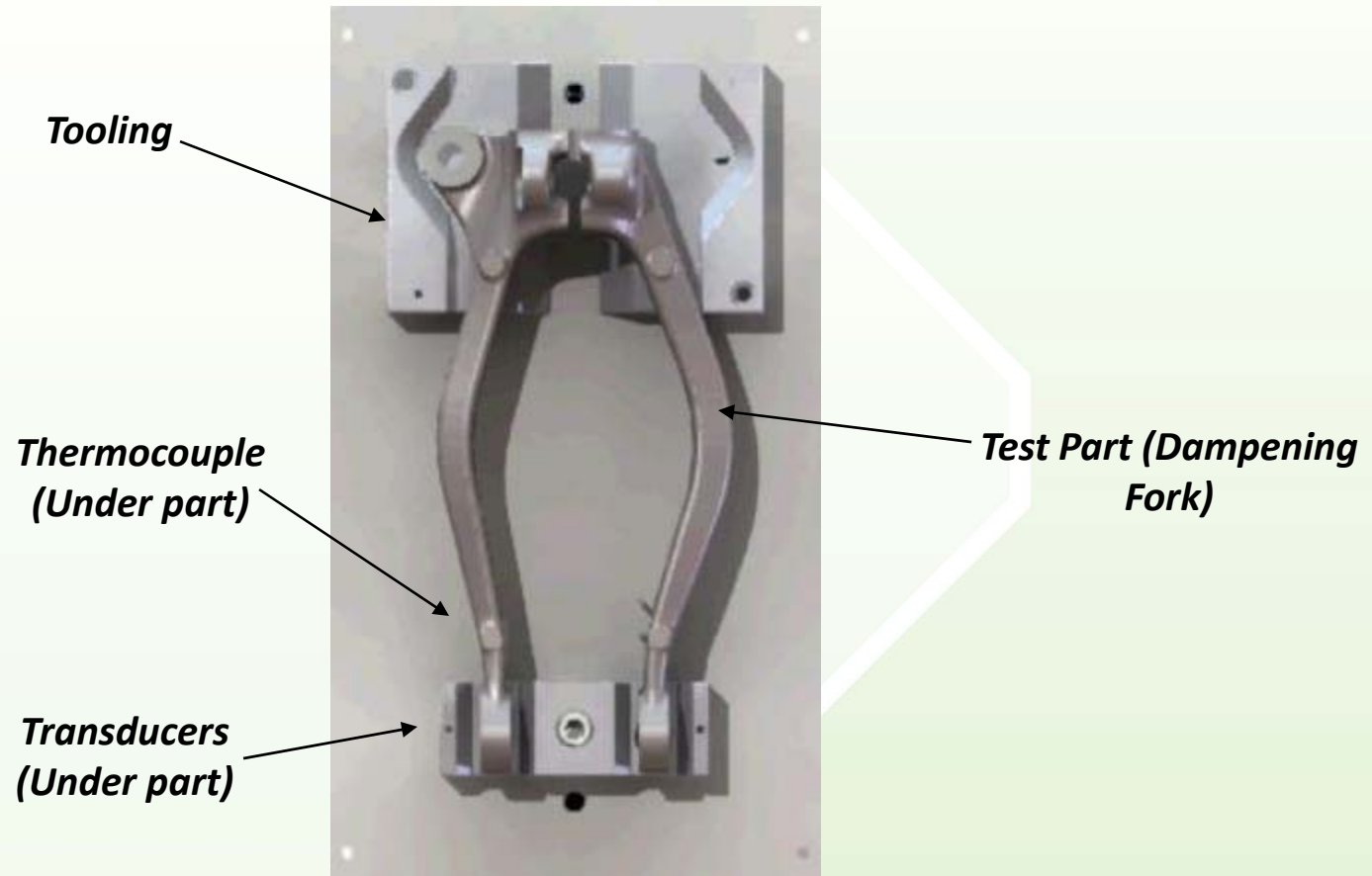
Quasar 4200 NDT System



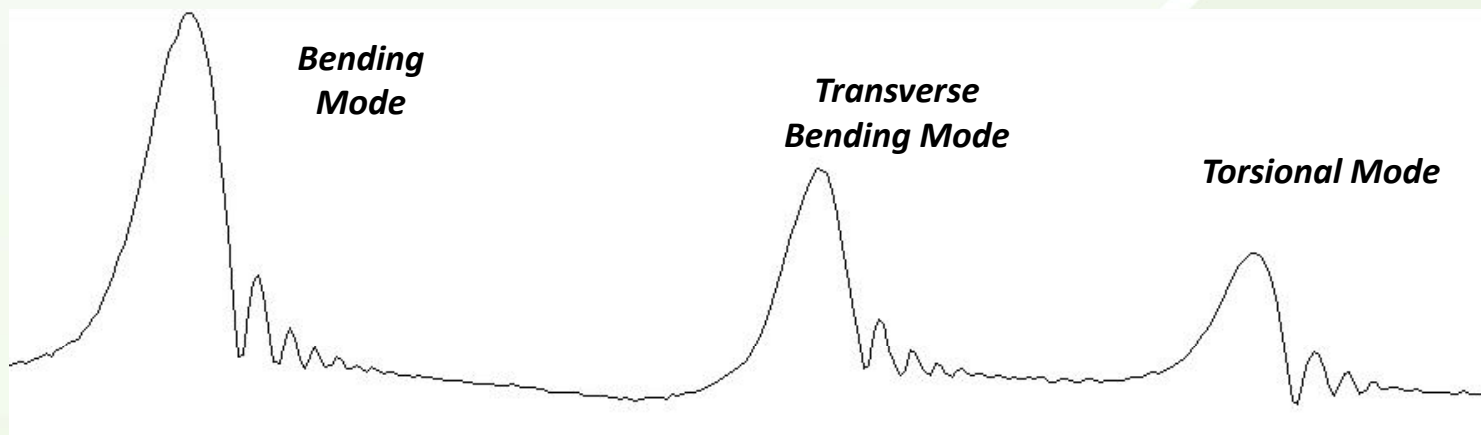
Quasar 4000 System Block Diagram



Quasar PCRI Part Test Sequence

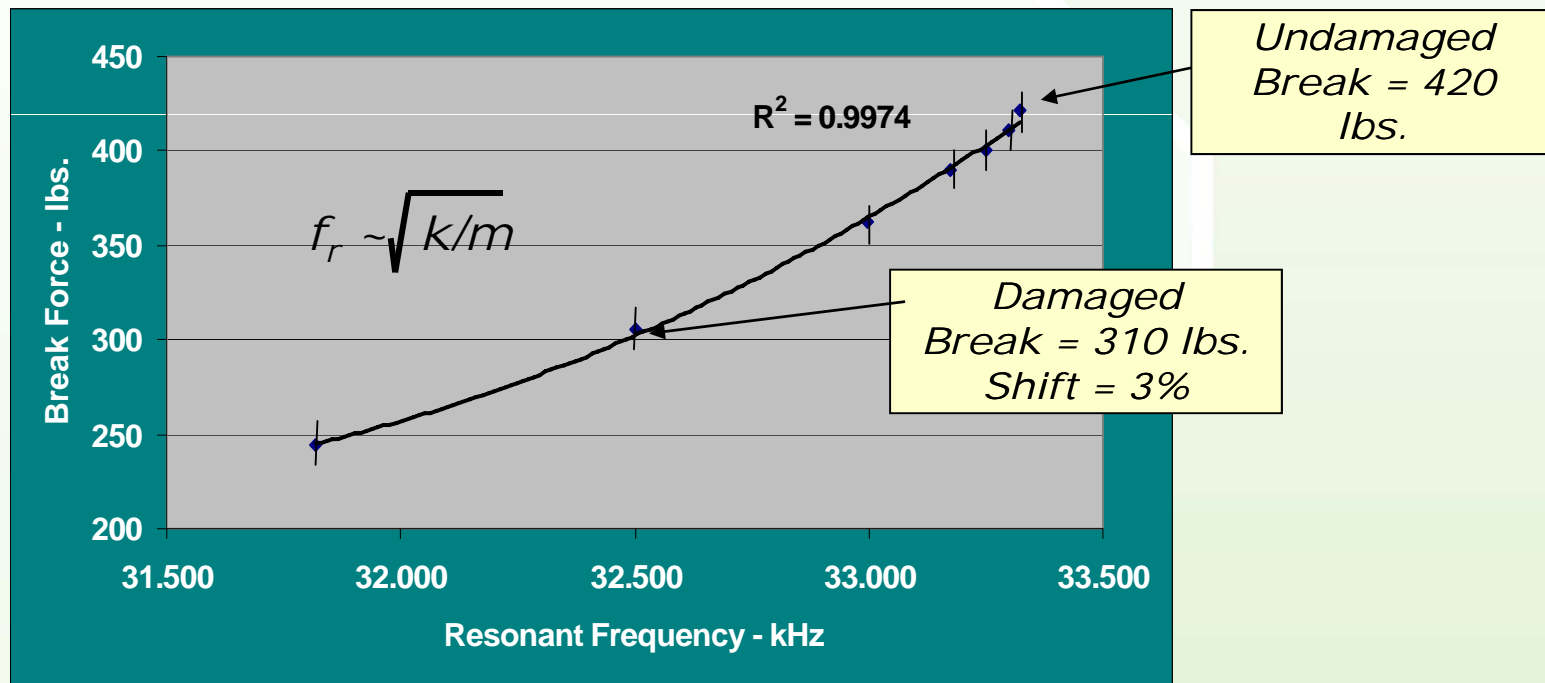


Exciting Resonant Modes



Resonant Frequency Correlates Directly to Break Strength

Break Force vs. Resonant Frequency for PM Exhaust Flange



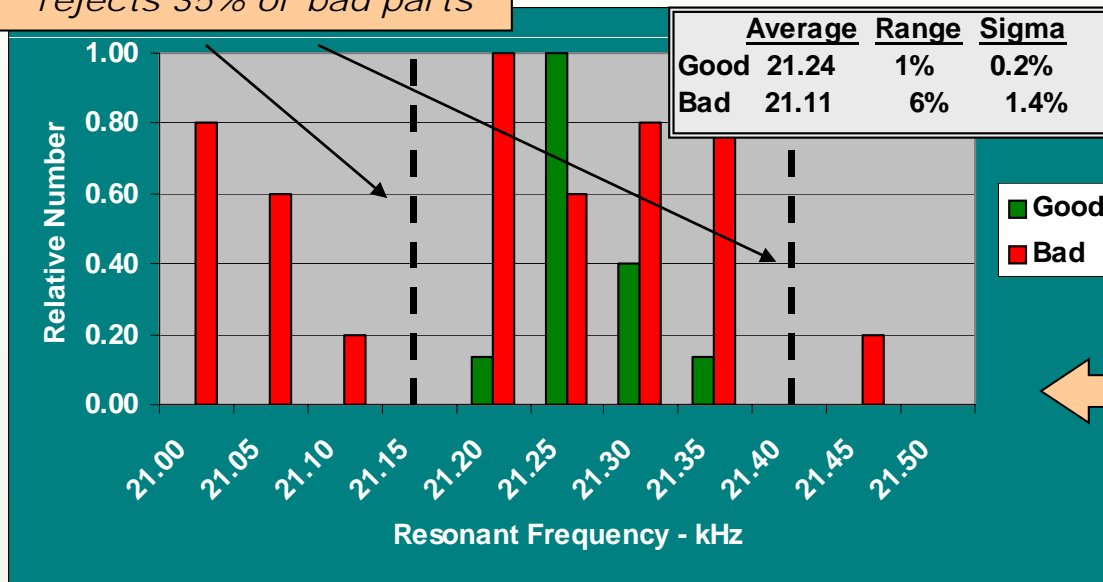
High correlation between performance degradation and an accurately measured parameter is the foundation of an effective NDT method

Defect Masking Effect

Resonance frequency is shifted by defects - but, acceptable process variations in dimensions and material properties produce frequency shifts that mask defects

- Bad part frequency distribution overlaps good part distribution
- Some defects increase resonant frequency (e.g., reduced mass)

Acceptance window rejects 35% of bad parts



*Poor Basis for
Sorting*

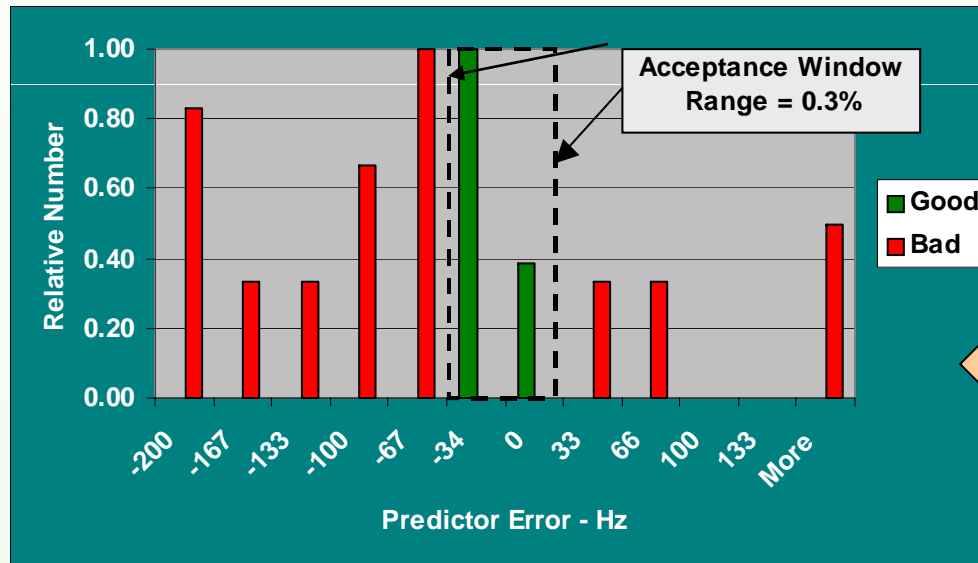
*Good and Bad Parts
overlap*

Distribution of resonances for 200 master cylinder bodies

Result: Uncompensated Resonance Testing Limited to Detecting Gross Defects

Quasar PCRI Uses Pattern Recognition to Predict Resonant Frequency

- Predictor Error separates Good and Bad parts
 - No overlap of Good & Bad Distributions
- Parts outside Acceptance Window are rejected



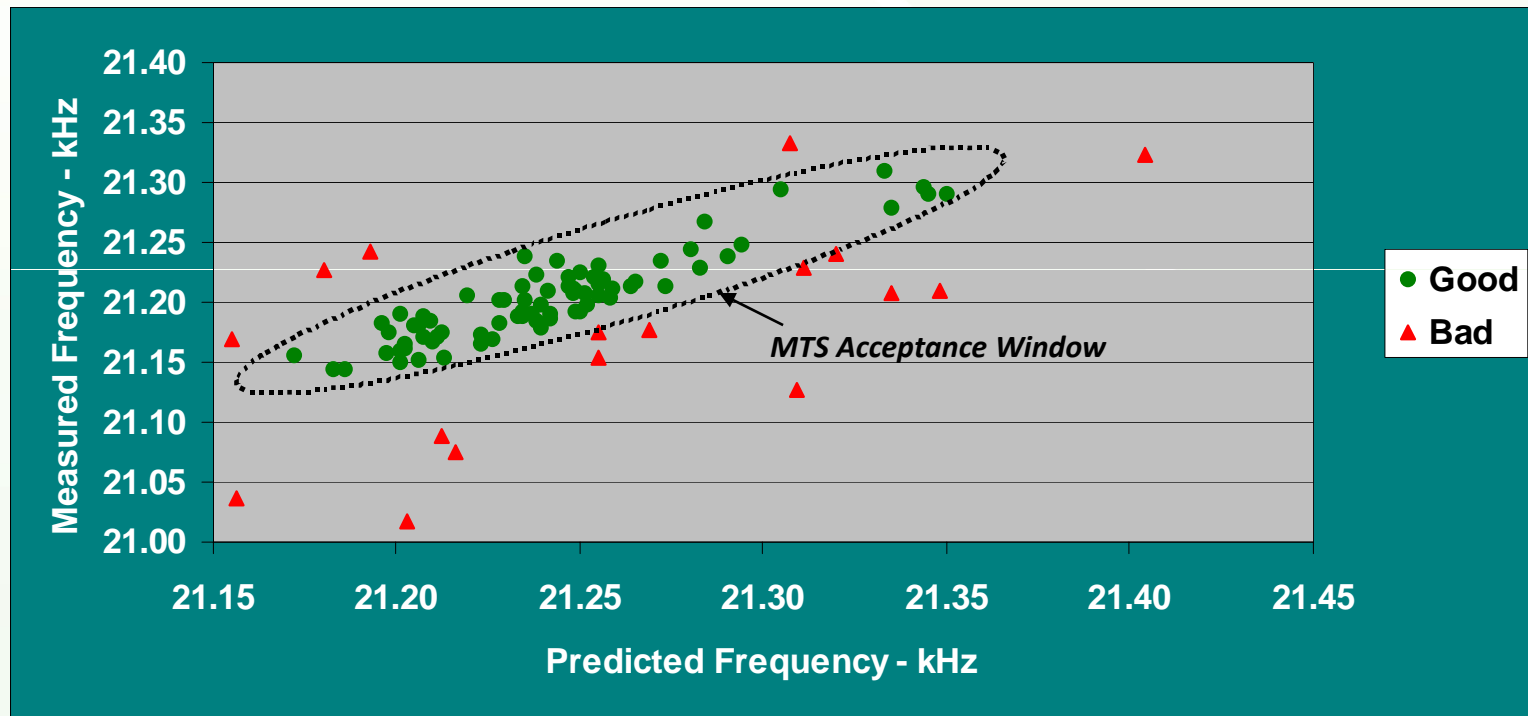
Perfect Sorting
All Good parts accepted
All Bad parts rejected

Distribution of Predictor Error for 200 Aluminum Master Cylinders

Process compensation "sees through" process variation to provide effective sorting

Quasar PCRI Uses MTS Pattern Recognition

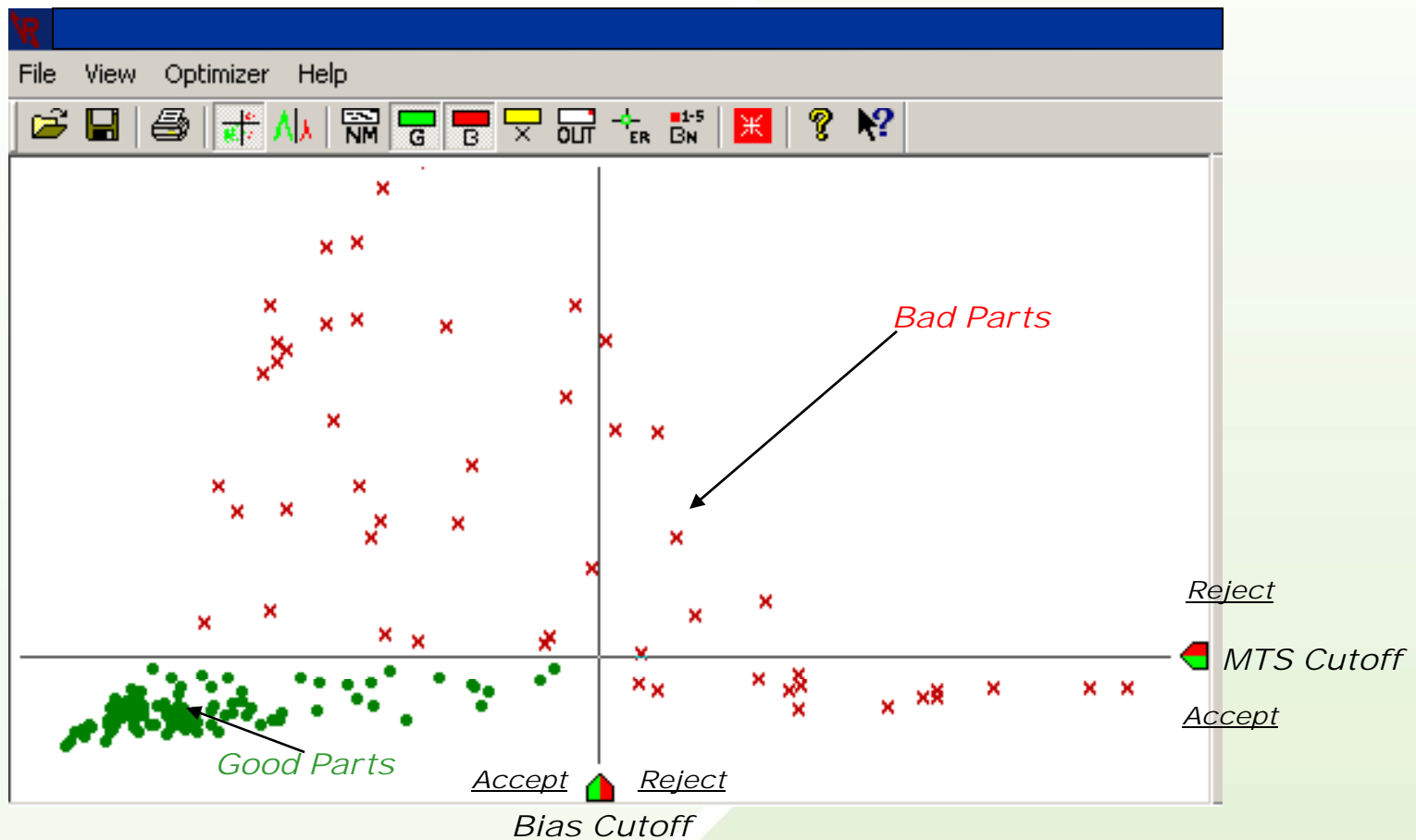
MTS = Mahalanobis Taguchi System



Measured & Predicted Resonant Frequencies for 200 Aluminum Master Cylinder Bodies

***MTS uses the resonance pattern that best separates Good from Bad parts.
MTS score is the statistical distance from the center of the Good parts distribution.***

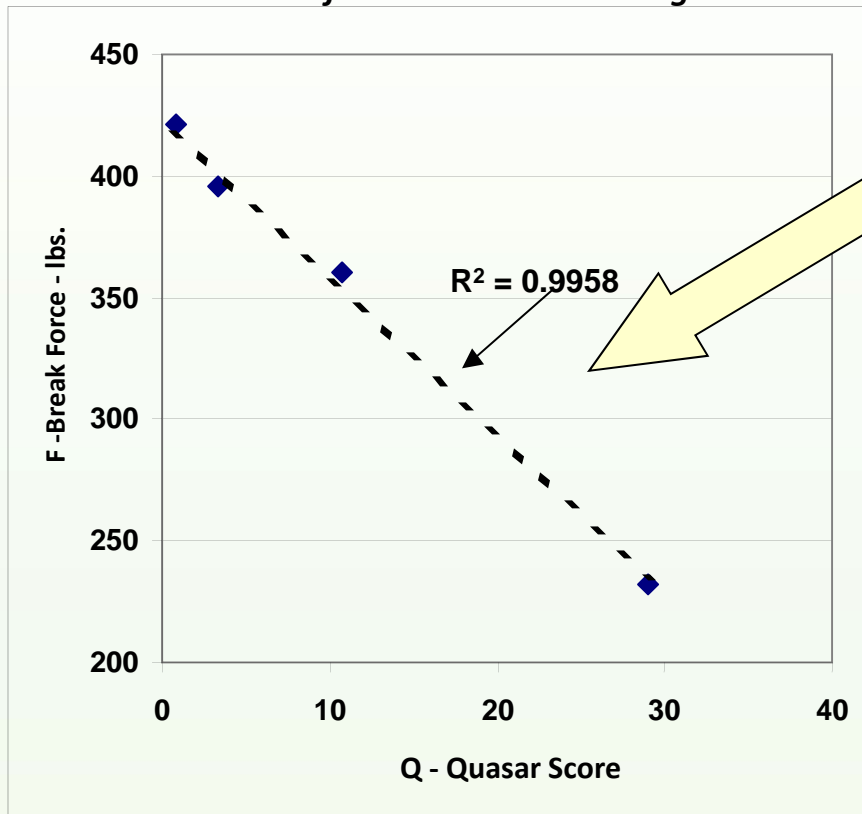
VIPR – Pattern Recognition Program



VIPR computes the MTS (good part characteristics) and Bias (bad part characteristics) equations

Quasar PCRI Score Predicts Performance

Break Force for Powder Metal Flanges



*Magnaflux Quasar PCRI Score (Q)
predicts Break Force (F)
 $F = - 6.6 * Q + 424$*

Correlation is perfect because:

- *Quasar score is determined by part strength*
- *Defect size and orientation are controlled*

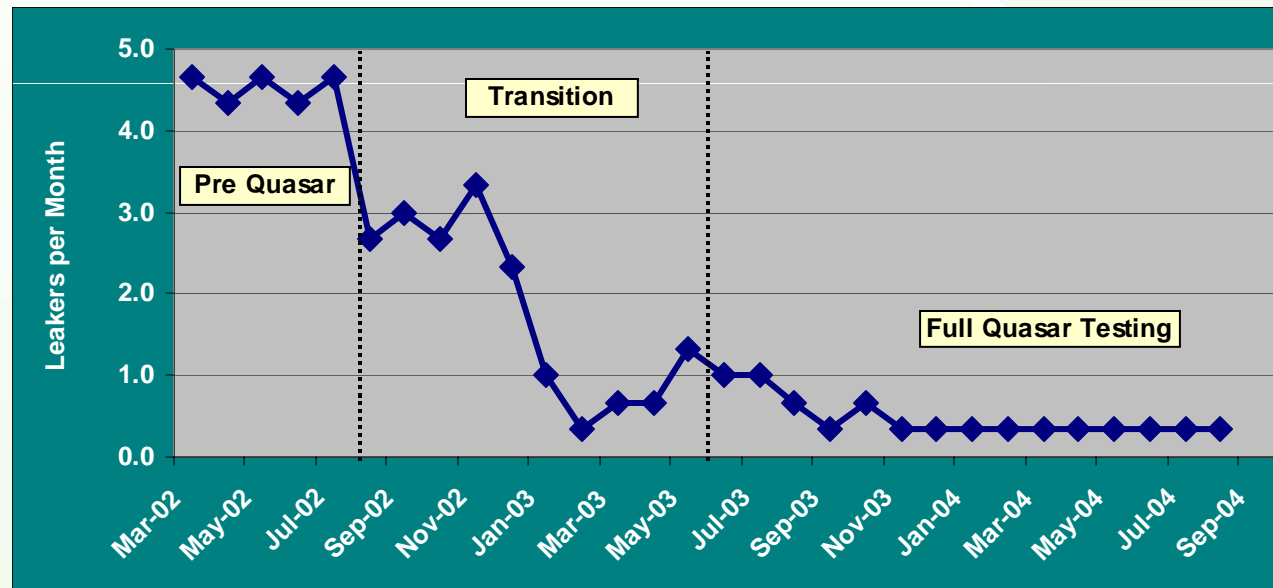
Perfect correlation is impossible for other NDT Methods because they do not measure parameters associated with Part Strength

Application Example

2 year Production Log

Cast Aluminum Master Cylinders

2 suppliers – 12 million parts



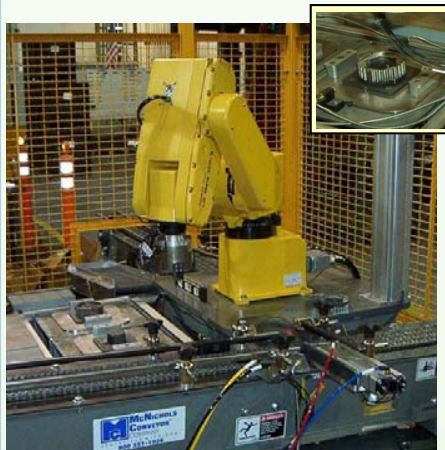
Leakers occur when aluminum oxides provide a channel from bore to surface

Result: Significantly Better NDT

Customized Quasar Systems



Quasar systems are customized for part size, color, automation and special features



Magnaflux Quasar Systems

The Next Step in NDT

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