

# Process Compensated Resonance Testing = PCRT

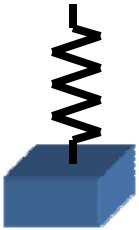


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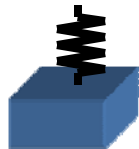
[www.VibrantNDT.com](http://www.VibrantNDT.com)



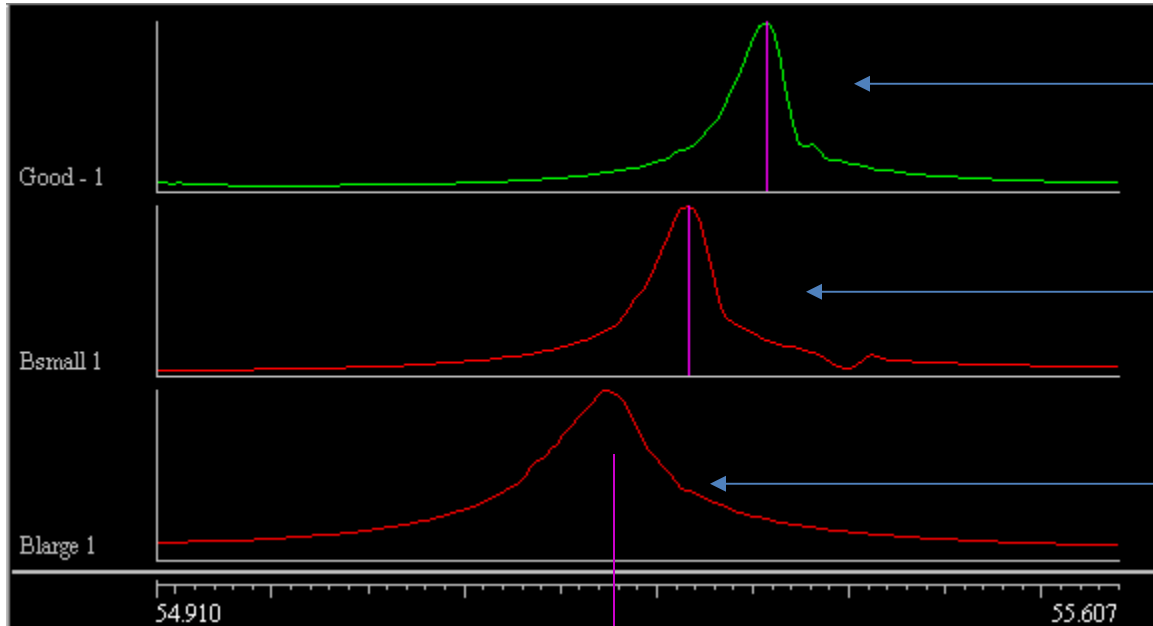
Resonant Inspection is an ideal NDT method because the measurement correlates directly to part strength



- Resonant Frequencies determined by dimensions and material properties of “whole part”
  - $f_r \sim \sqrt{(k/m)}$ 
    - $f_r$  = resonant frequency
    - $k$  = stiffness (elastic properties e.g., Young’s Modulus)
    - $m$  = mass (dimensions, density)



- *Structural Defect* = Strength reduction caused by degraded material properties or dimensional variation
  - Degree of resonant frequency change is proportional to the severity of defects
- Covered under ASTM E2534 and E2001-98



Acceptable Part

Small Introduced Defect

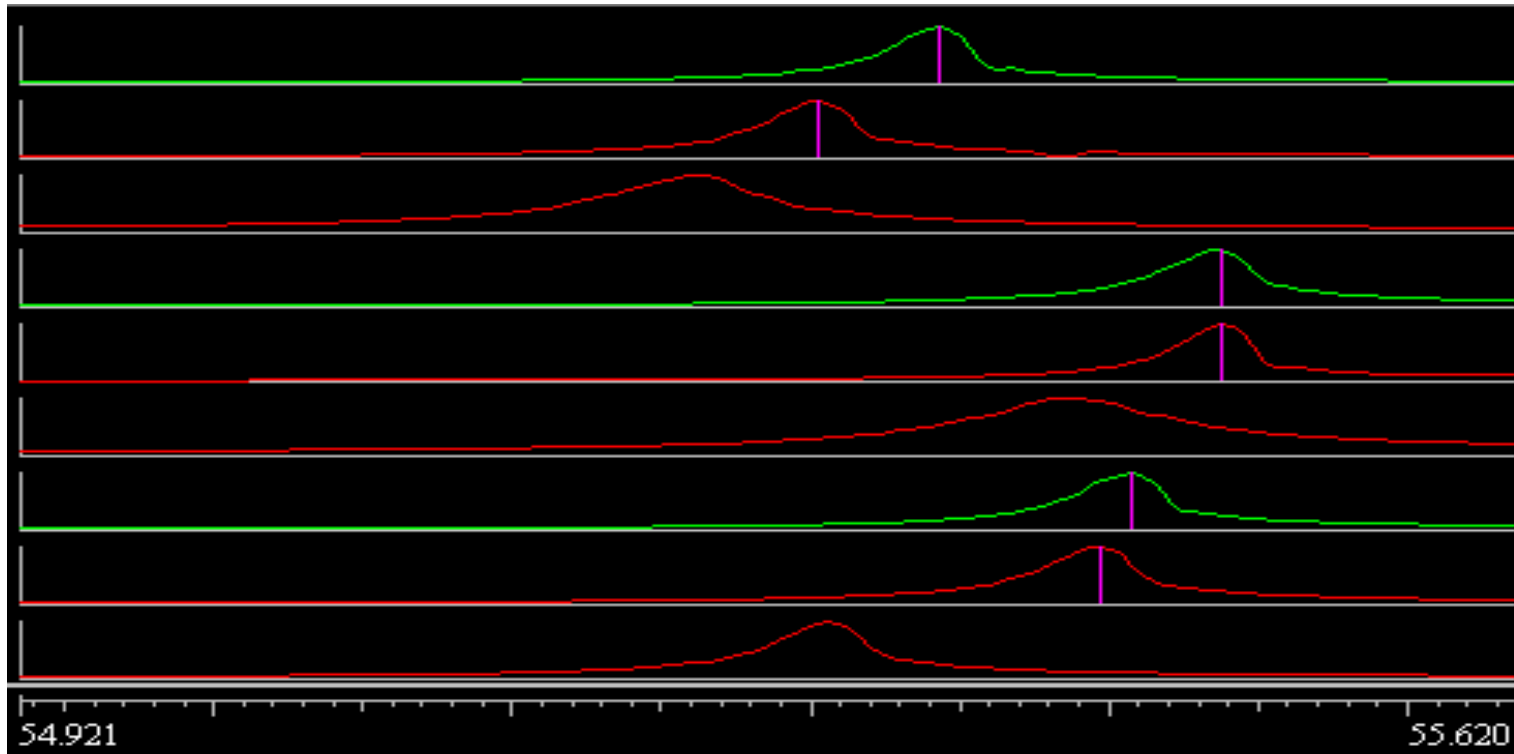
Shift = 0.9%

Larger Introduced Defect

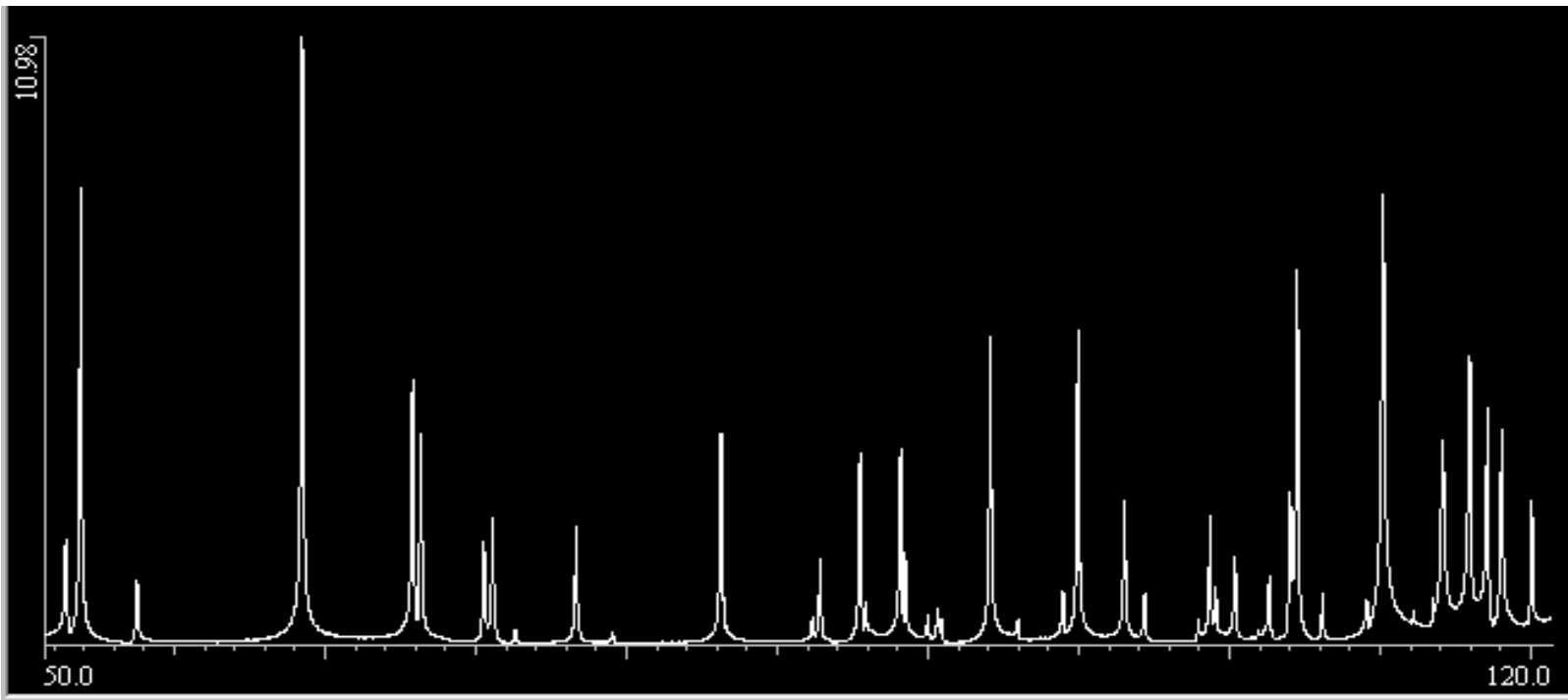
Shift = 1.5%

**A structural defect reduces the stiffness of the part and causes a proportional shift in the resonant frequency**

# Defect Masking

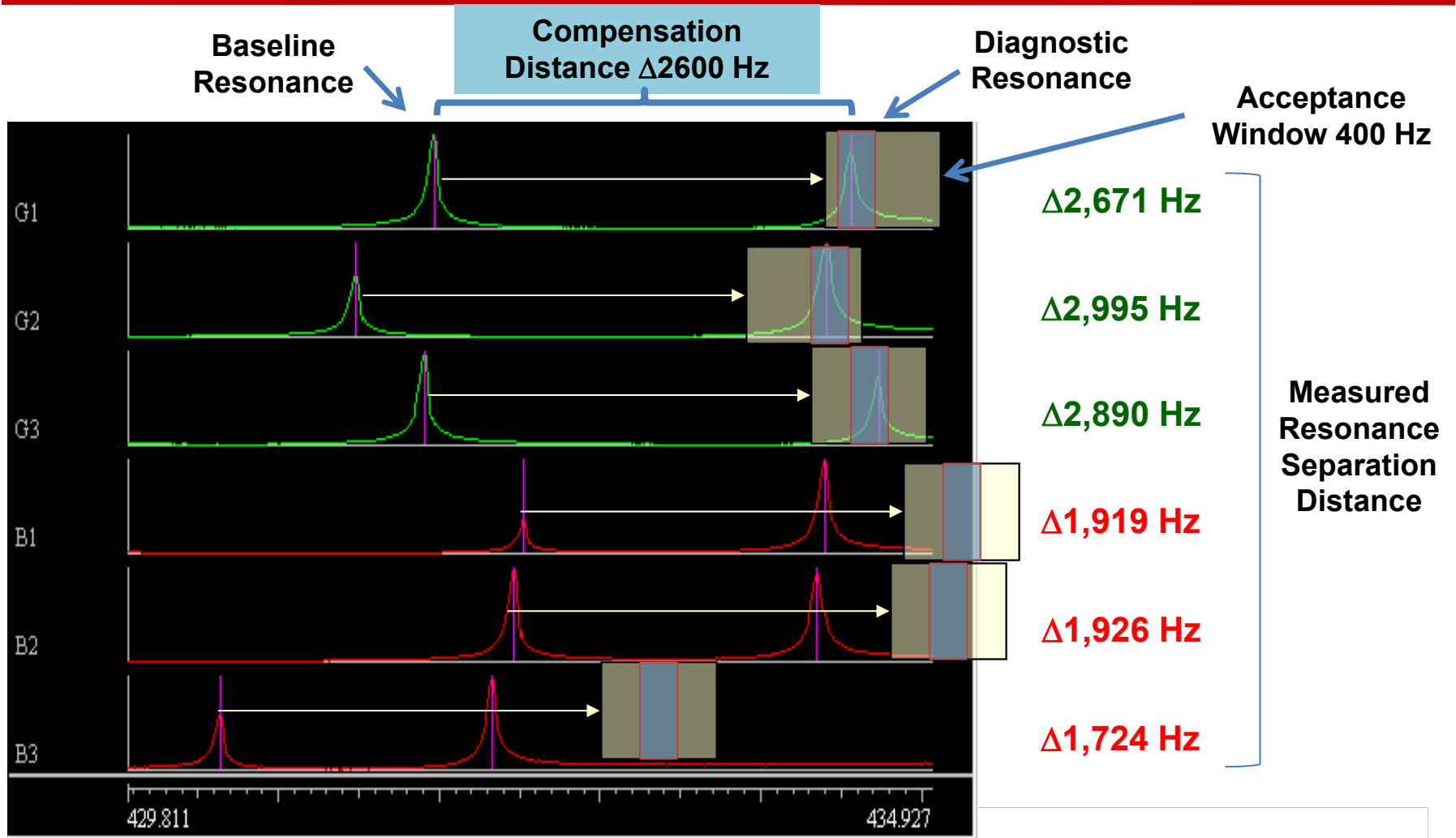


Simple resonance analysis is insufficient for defect detection since unacceptable and acceptable patterns are interlaced



The PCRT System uses a subset of the spectra for pattern recognition of acceptable and unacceptable parts

# 2D Compensation



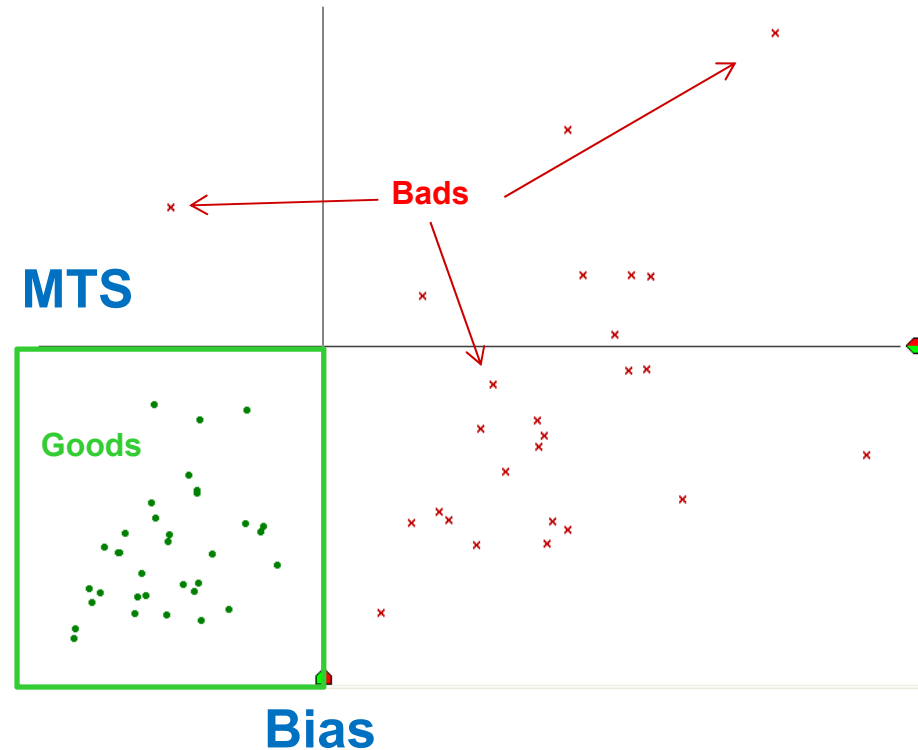
# Two Items Critical to PCRT

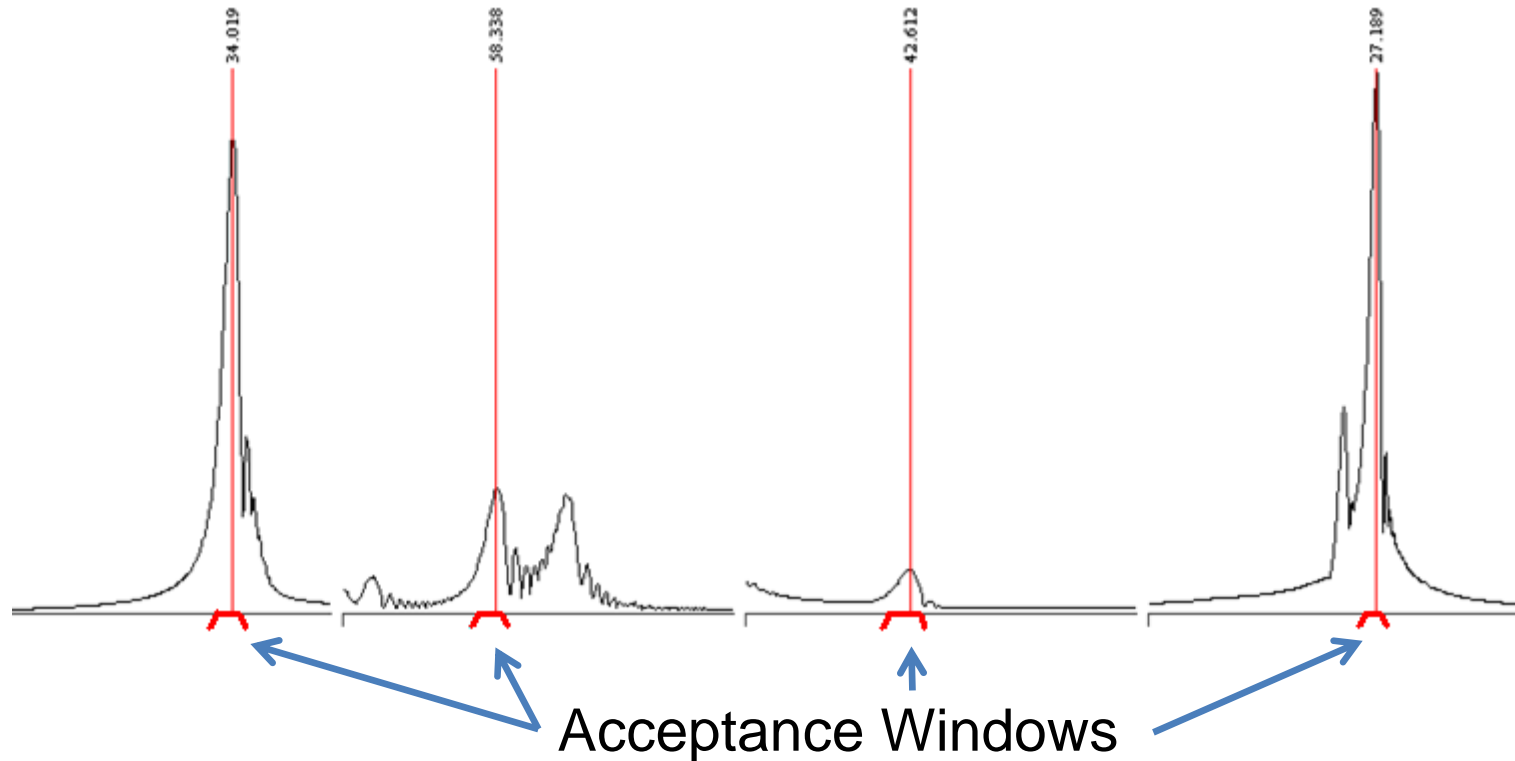
## ■ Teaching Set

- Collection of acceptable and unacceptable parts to characterize the pattern of resonances
- MTS (Mahalanobis-Taguchi System) characterizes acceptable parts & variation
- Bias score characterizes unacceptable parts

## ■ Temperature Compensation

- Critical to precision measurements (Key performance variable to be controlled)
- Eliminates error of .015%-.025% per degree Celsius



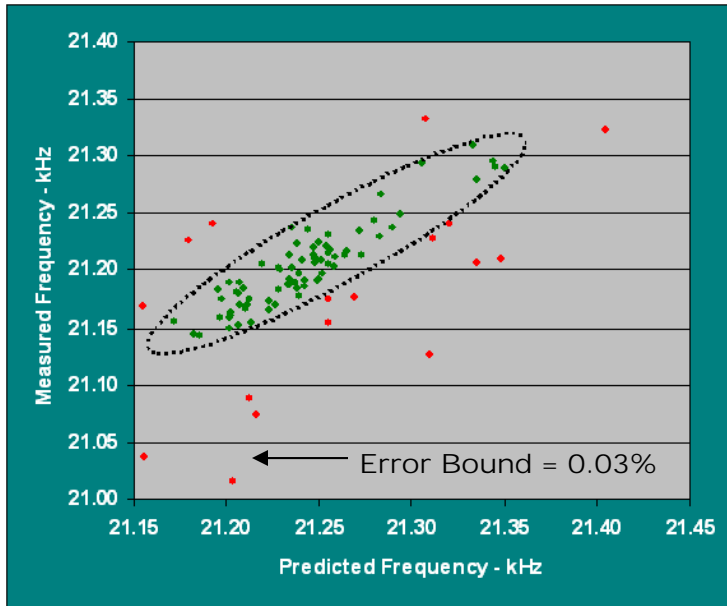


The PCRT System measures multiple resonances to develop its vibrational pattern recognition acceptance criteria

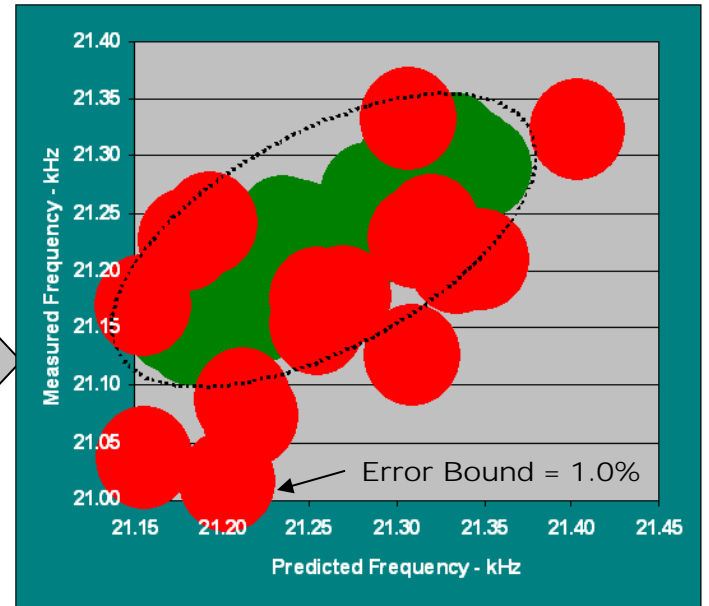




# The PCRT Advantage



Measurement Error = 0.03%  
Parts Can Be Sorted

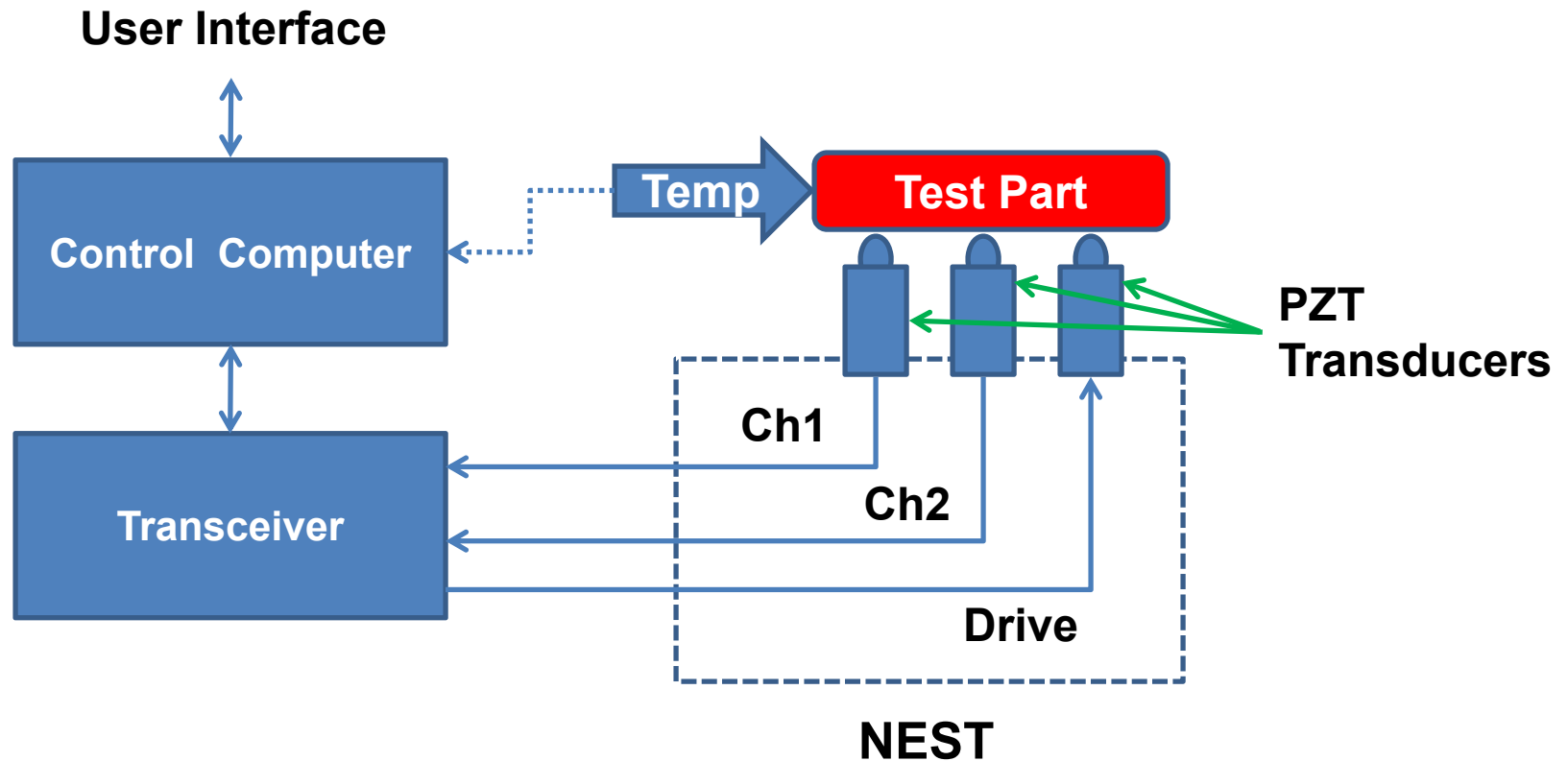


Measurement Error = 1%  
Parts Cannot Be Sorted

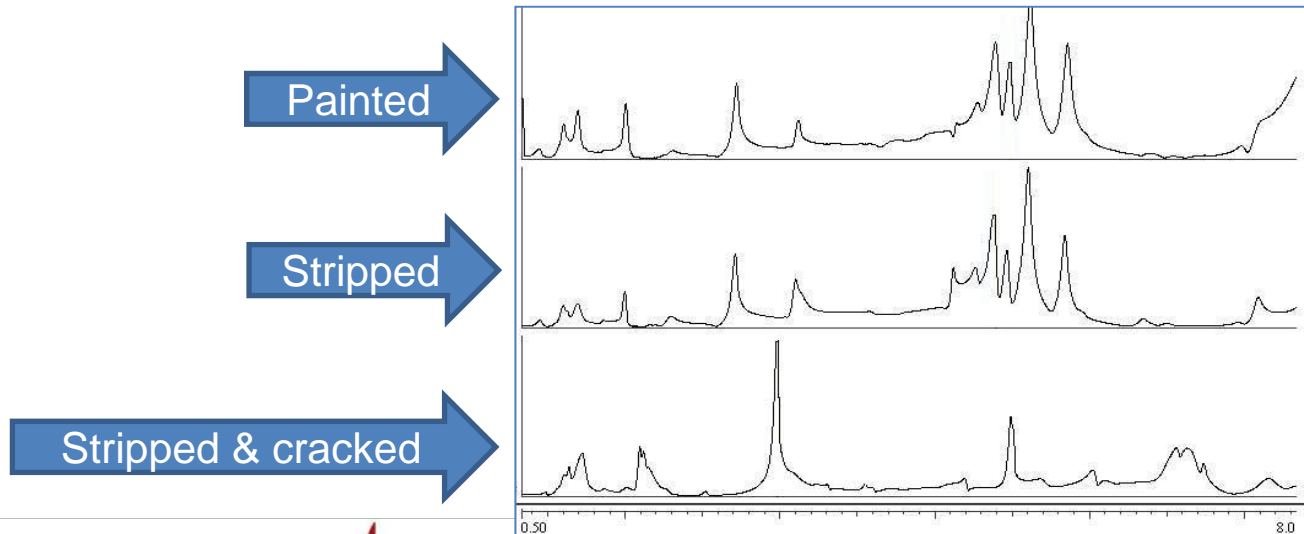
Performance Comparison  
Vibrant PCRT Method  
vs.  
Impulse Method (hammer & microphone)

	Vibrant	Impulse
Precision	0.001%	1%
Placement	0.005%	?
Temp Comp	0.015%	?
Total	0.03%	1+%

- PCRT System Hardware
  - Simple part interface, PZT transducers
  - Thermocouple to record part temperature
  - Precision spectrum analyzer & signal generator
  
- PCRT System Software
  - PC computing power
  - Statistical analysis with the Mahalanobis-Taguchi System
  - Vibrational pattern recognition algorithms
  - Digital storage of spectra



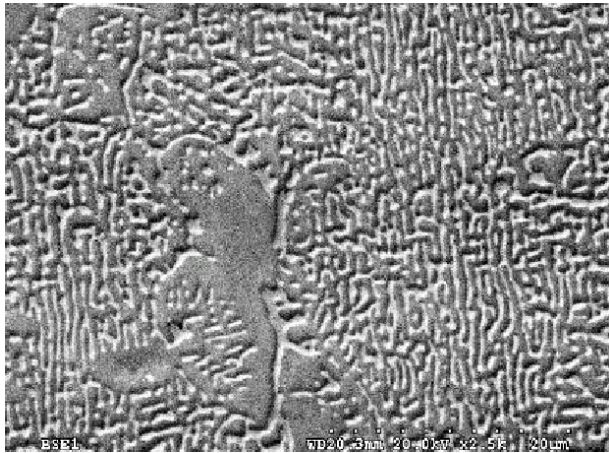
- Insensitive to paint and coatings
- Minimal part preparation
  - Parts do not have to be chemically prepared, minimal waste stream.



# Detectable Defects

## Common Defects

Cracks, Inclusions, Chemistry, Geometry, Heat-treatment, Cold Shuts, Porosity



Rafting Detectable with PCRT

## Process Specific Defects

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

# ***PCRT Strengths***

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- Rigid, Hard Components
- Characterizing Mature, Well-Controlled Manufacturing Processes
- Sorting for Structural Integrity
- Single, Whole Body Test for Multiple Defect Sources
- Elimination of Operator Error
- Digital Historical Record of Resonant Spectra for Life-of-Part Surveillance

- PCRT System uses resonance spectra and complex algorithms to correctly sort acceptable from unacceptable parts.
  - Detects structural defects
- PCRT System has many advantages
  - Few disadvantages