NDT-RAM™

THE MODAL SHOP INC.
A P C B GROUP CO.

| ◎ Excellent ◑ Fair ● Poor | ET | MT/PT | UT | RT | RAM |
|---|---|---|---|---|---|
| **Defect Type** | Eddy Current | Magnetic Particle | Ultrasonic | Radiography | Resonant Acoustic |
| Cracks/chips/porosity/voids | ◎ | ◎ | ◎ | ◎ / ● | ◎ |
| Missed processes/operations | ◎ / ● | ● | ◎ / ● | ◎ / ● | ◎ |
| Material property | ◎ / ● | ● | ● | ● | ◎ |
| Structurally significant | ◎ | ◎ | ◎ | ◎ | ◎ |
| Product lot variations | ◎ / ● | ◎ | ◎ | ◎ | ◎ / ● |
| **Defect Location** | | | | | |
| Surface (external) | ◎ | ◎ | ◎ | ● | ◎ |
| Internal | ● | ● | ◎ | ◎ | ◎ |
| Brazing/bonding/welding | ● | ● | ◎ / ● | ◎ / ● | ◎ |
| **Speed/Training/Cost** | | | | | |
| Part throughput | ◑ | ● | ◎ | ● | ◎ |
| Training requirements | ● | ● | ◑ | ● | ◎ |
| Overall inspection costs | ◑ | ◑ | ● | ● | ◎ |
| **Automation Capacity** | | | | | |
| Quantitative results | ◎ / ● | ● | ◎ / ● | ● | ◎ |
| Automation requirements | ◑ | N/A | ● | ● | ◎ |
| Automation cost | ◑ | N/A | ● | ● | ◎ / ◑ |

Traditional NDT technique comparison

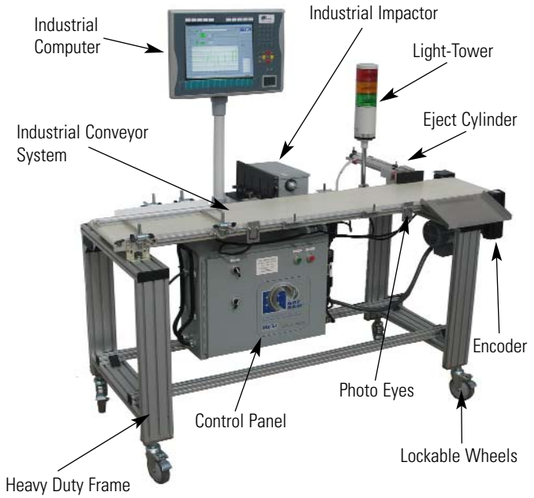
## NDT-RAM Systems

- Ideal for in-line, automated, objective inspection
- In-line monitoring to improve process
- 100% inspection of every part prior to shipment
- Fast throughput - as fast as a part per second
- No operator intervention needed for inspection
- Customizable conveyor configurations
- Adaptable to existing process automation
- Portable units for spot checking in the field

**NDT-AUTO** Fully automated system for turnkey in-line 100% inspection

**NDT-SEMI** Semi-automated system for implementing in existing process

**NDT-MAN** Manual system for laboratory or spot checking use




| Major System Components | NDT-AUTO | NDT-SEMI | NDT-MAN |
|---|---|---|---|
| LanSharc Smart Digital Controller | √ | √ | √ |
| NDT-RAM Software | √ | √ | √ |
| Microphone and Preamplifier | √ | √ | √ |
| Statistical Analysis Software | √ | √ | √ |
| Industrial Electric Impact Hammer | √ | √ | |
| Handheld Instrumented Impact Hammer | | √ | √ |
| Industrial Computer | √ | √ | |
| Laptop Computer | | | √ |
| Turnkey Conveyor System | √ | | |
| Automation Accessories (photo eyes, PLC, ejector) | √ | | |



Helping you test, model, and modify the behavior of structures and processes.

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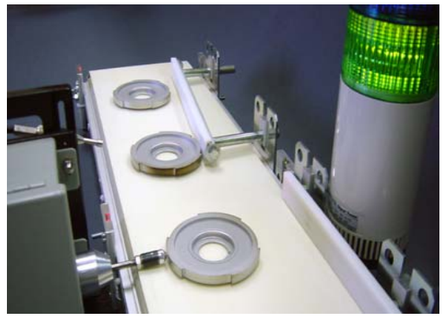
# Part Quality Inspection Application: Resonant Acoustic Method NDT

In the world of manufacturing today, the liability of shipping a defective part can be catastrophic for you, your customer, and the consumer. Resonant Acoustic Method NDT (RAM NDT) is designed to help you deliver fully inspected parts, economically and on time, giving you and your customer confidence in the quality of your parts.

The principle of resonant inspection is simple: every part has a unique resonant signature or pattern that reflects its structural integrity. A deviation from the expected signature or pattern can indicate the presence of a flaw. For example, a bell with a crack no longer has a clear ring or the ability to hold its tone.



The resonances of a structure are defined by its mass, stiffness and damping. These resonant frequencies can be measured in most rigid materials including most metals, ceramics, and composites. NDT-RAM systems detect frequency shifts which can be caused by imperfections such as cracks, porosity and voids, as well as variances in nodularity, dimension, geometry, weight, density and manufacturing processes.

## TYPICAL USES:

- Production - In-Line Inspection
- Field Service - Troubleshooting
- Quality Control - Spot Checking
- Engineering - Development

## SUCCESSFUL APPLICATIONS:

- Powder Metal
- Iron Castings
- Forgings
- Metal Stampings
- Aluminum Foundry
- Ductile Metals
- Ceramics
- Composites

## BENEFITS:

- 100% inspection - ensures the confidence that every part is objectively tested
- No part preparation required for inspection
- High throughput - as fast as a part per second
- Simple to learn and use application software
- Reduces scrap costs associated with false rejects
- Greatly lowers operating expenses by eliminating consumables
- Industrial package - NEMA4 enclosure allows factory floor operation.
- Versatility - same system can test many different parts
- Eliminates quality recall/containment costs
- Financially justified - ROI analysis available

**CALL FOR FREE PARTS EVALUATION AND TEST REPORT**

**"Simplifying with Smart Sensing Solutions"**

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## Who needs NDT Resonant Inspection?

Manufacturers or users of metal parts that...

- have substantial inspection cost.
- require 100% parts inspection.
- desire to improve part quality.
- produce and/or use safety-critical parts.
- have customers demanding higher quality.
- have substantial scrap costs due to false rejects.

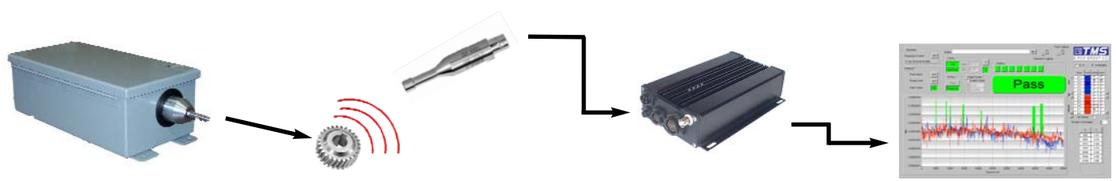
## What does NDT Resonant Inspection detect?

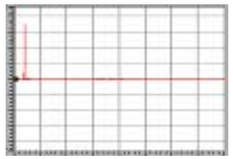
- Cracks, chips, holes, and voids
- Porosity & Nodularity
- Out-of-tolerance dimensions
- Variations in hardness
- Residual stress
- Bonding, welding, or brazing failures
- Machining or heat-treating processes

## RAM NDT provides confidence and peace of mind. It is simple, reliable and affordable.

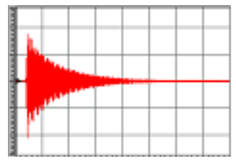
## Here's how it works...

IMPACT THE PART | MEASURE THE RESPONSE | PROCESS THE DATA | QUANTIFY THE RESULTS

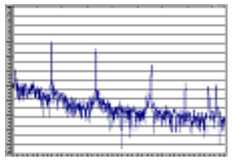


An industrial instrumented impact hammer taps each part with a measured and repeatable force.



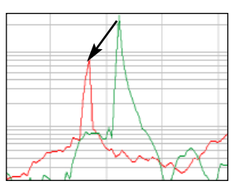
The impact causes the part to "ring" - audible and inaudible sound is measured by the microphone.



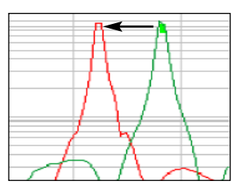
The Smart Digital Controller performs a Fast Fourier Transform (FFT) on the measured data.


NDT-RAM software compares the results to acceptable limits and accepts or rejects the part accordingly.

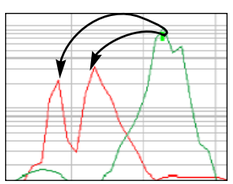
## Changes in mass, stiffness & damping due to certain defects can cause...



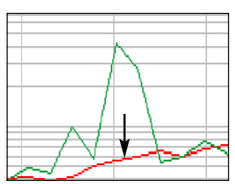
...resonant frequency peaks to shift in both frequency and amplitude.



...resonant frequency peaks to shift frequency but maintain amplitude.



...peak shifts with more pronounced splits in resonant frequency.



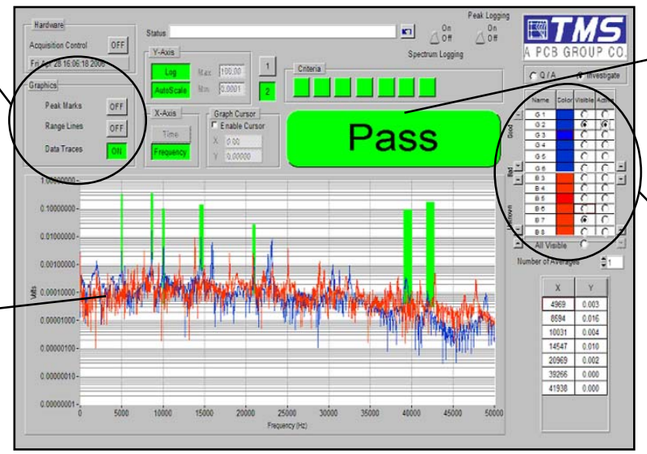
...resonant frequency peak energy to disappear completely.



## NDT-RAM's Graphical User Interface

Screen shot from NDT-RAM software showing resonant frequencies and sort result

Improved graphical features ease visual data evaluation




Clear indication of pass/fail by criteria range

Overlay of data shows color coded spectra for "good" and "bad" parts against acceptable criteria ranges

Improved investigate mode supports up to 1500 part spectra, labeled good, bad or unknown

## NDT-RAM's Report Generation

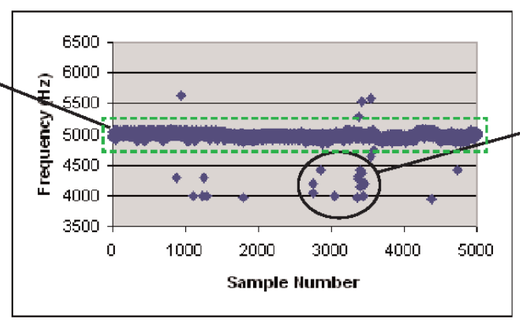
Allows you to fine tune criteria by using standard spreadsheets to evaluate statistical data taken for each part tested. Data from NDT-RAM can be exported to EXCEL® for statistical analysis. A typical scatter plot of resonant frequencies in a given criteria range for a lot of 5000 parts is shown below.

Report Dates: 26-Sep-04 12:09:15 - 26-Sep-04 12:10:13
Setup Name: "C:\NDT\Test.stp"

Company Name: Test
Part Name: Parts 123
Production Run: 2004

| Date | Time | STATUS | CRITERIA #1 | | CRITERIA #2 | | CRITERIA #3 | | CRITERIA #4 | |
|---|---|---|---|---|---|---|---|---|---|---|
| 26-Sep-04 | 12:09:32 | PASSED | P 10102 | 1.8071 | P 20883 | 0.3775 | P 29133 | 0.0332 | P 36750 | 0.0328 |
| 26-Sep-04 | 12:09:34 | PASSED | P 10102 | 3.0346 | P 20883 | 0.8493 | P 29133 | 0.0871 | P 36750 | 0.0386 |
| 26-Sep-04 | 12:09:37 | PASSED | P 10102 | 1.0789 | P 20883 | 0.4106 | P 29133 | 0.0443 | P 36750 | 0.0140 |
| 26-Sep-04 | 12:09:38 | PASSED | P 10102 | 2.8046 | P 20883 | 0.1199 | P 29133 | 0.0286 | P 36750 | 0.0487 |
| 26-Sep-04 | 12:09:40 | PASSED | P 10102 | 0.4268 | P 20883 | 0.2694 | P 29133 | 0.0276 | P 36750 | 0.0081 |
| 26-Sep-04 | 12:09:56 | FAILED | P 10125 | 0.3425 | F 20977 | 0.9665 | F 29273 | 0.0750 | F 36914 | 0.0139 |
| 26-Sep-04 | 12:10:03 | FAILED | F 9891 | 1.0599 | F 20484 | 0.2765 | F 28969 | 0.0847 | F 36445 | 0.0095 |
| 26-Sep-04 | 12:10:07 | FAILED | F 9891 | 1.2375 | F 20742 | 0.9112 | F 29016 | 0.0313 | P 36703 | 0.0104 |
| 26-Sep-04 | 12:10:11 | FAILED | F 9891 | 2.7080 | F 20484 | 0.1852 | F 28992 | 0.0562 | F 36445 | 0.0182 |
| 26-Sep-04 | 12:10:13 | FAILED | F 9867 | 1.2691 | F 20484 | 1.2729 | F 28969 | 0.0332 | F 36445 | 0.0544 |
| Total Passed: | 5 | | 6 | | 5 | | 5 | | 6 | |
| Average Passed: | 50.00% | | 10105.5 | 1.6418 | 20882.0 | 0.46 | 29136.2 | 0.0379 | 36740 | 0.0249 |
| Std Dev Passed: | | | 12.2 | 1.0262 | 0 | 0.335 | 0 | 0.0299 | 17.1 | 0.0143 |
| Total Failed: | 5 | | 4 | | 5 | | 5 | | 4 | |
| Average Failed: | 50.00% | | 9884.9 | 1.6857 | 20634.4 | 0.7225 | 29043.8 | 0.0561 | 36595.3 | 0.0363 |
| Std Dev Failed: | | | 11 | 0.7289 | 198.1 | 0.4209 | 116.2 | 0.0215 | 193 | 0.0336 |
| Total: | 10 | | 10 | | 10 | | 10 | | 10 | |

Structurally similar parts exhibit consistent resonant frequenccies




Statistical outliers indicate presence of a structural defect