Use of Digital X-ray & CT in Failure Analysis

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Quality Engineering Manager

Emerson Process Management
Rosemount Inc

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Agenda

- Company Background
- Failure Analysis
- Digital X-ray & CT in Failure Analysis
- Examples

Emerson At-a-Glance

- **$24.8 Billion** in sales (2008)

NYSE: EMR

Diversified global manufacturer and technology provider

Approximately 141,000 employees worldwide

Headquarters in St. Louis, Mo.

- Manufacturing and/or sales presence in more than 150 countries
- 255 manufacturing locations, 165 outside the U.S.
- No. 111 on 2008 FORTUNE 500
- Founded in 1890

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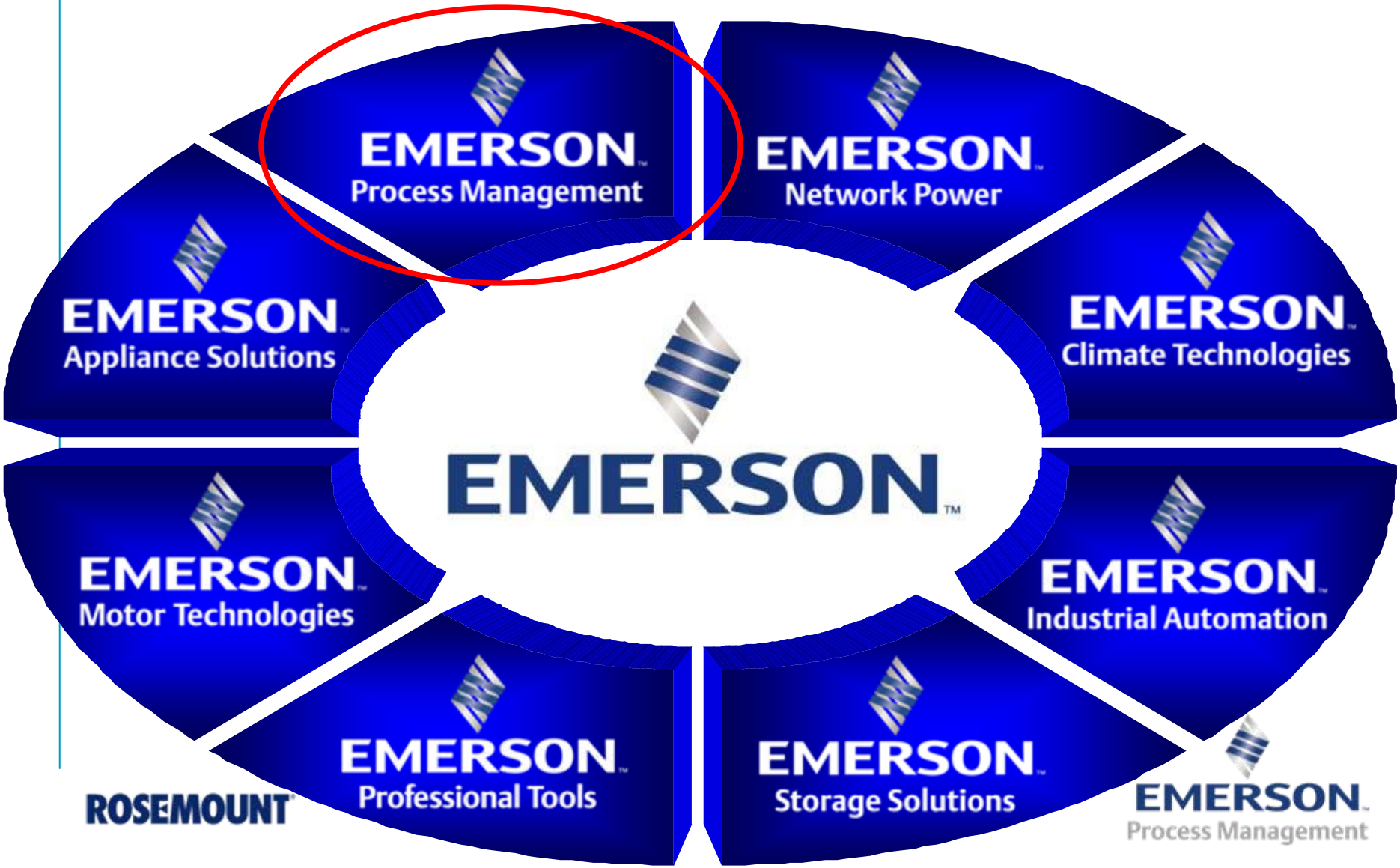
Emerson is Organized Around Eight Customer-Focused Businesses



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Systems & Solutions

- DeltaV
- Ovation
- Solutions
  - Chemical
  - Oil & Gas
  - Refining
  - Power & Water
  - Life Sciences
  - Metals & Mining
  - Pulp & Paper
  - Food & Beverage
  - Marine
  - Remote Automation

Asset Optimization

- AMS Suite
- Services and Technologies
  - Mechanical Equipment
  - Electrical Systems
  - Process Equipment
  - Instruments & Valves

Measurement

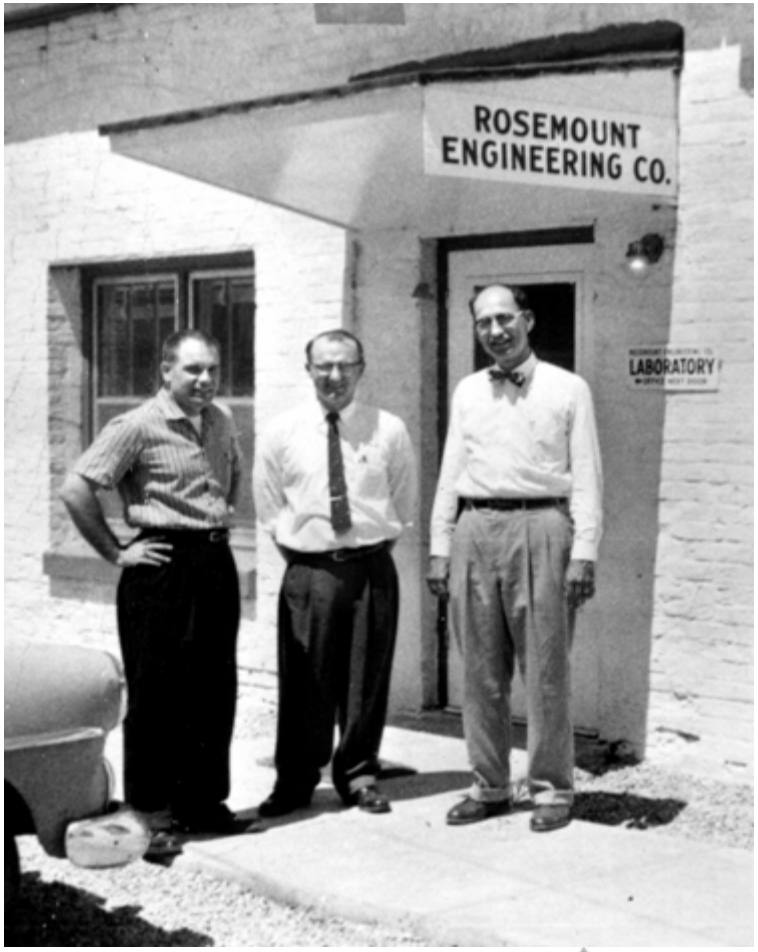
- Rosemount
- Rosemount Tank Radar
- Micro Motion
- Brooks
- Rosemount Analytical
- Daniel
- Mobrey

Valves & Regulators

- Fisher
- Baumann
- Bettis
- El-O-Matic
- Shafer
- Damcos

Rosemount History

- **1956** - Rosemount Engineering Co. founded
- **1950s and 1960s** - Manufactured temperature sensors for jet aircraft and Apollo space missions
- **1960s** - Aeronautical technology applied to industrial products
- **1976** - Acquired by Emerson
- **1990** - Chanhassen facility constructed
- **2006** - Facility expanded for growth
- **Today** - Global leader in industrial pressure, temperature, level and flow measurement devices



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Emerson Process Management Rosemount Inc

- Headquartered in Chanhassen, MN
  - $1.6B sales worldwide in FY08
- Approximately 5,300 employees worldwide and 1,800 in the Twin Cities
- World Leader in Pressure, Temperature, Level and Flow Instrumentation for the process control industry
  - Products built on Quality, Reliability and Innovative Technologies

Pressure **Temperature** **Level** **Flow**

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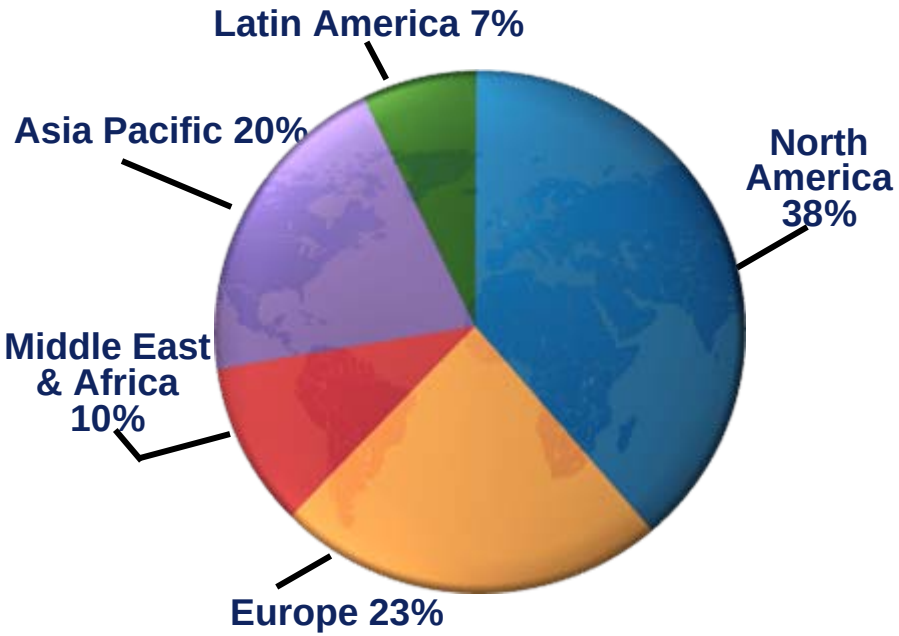
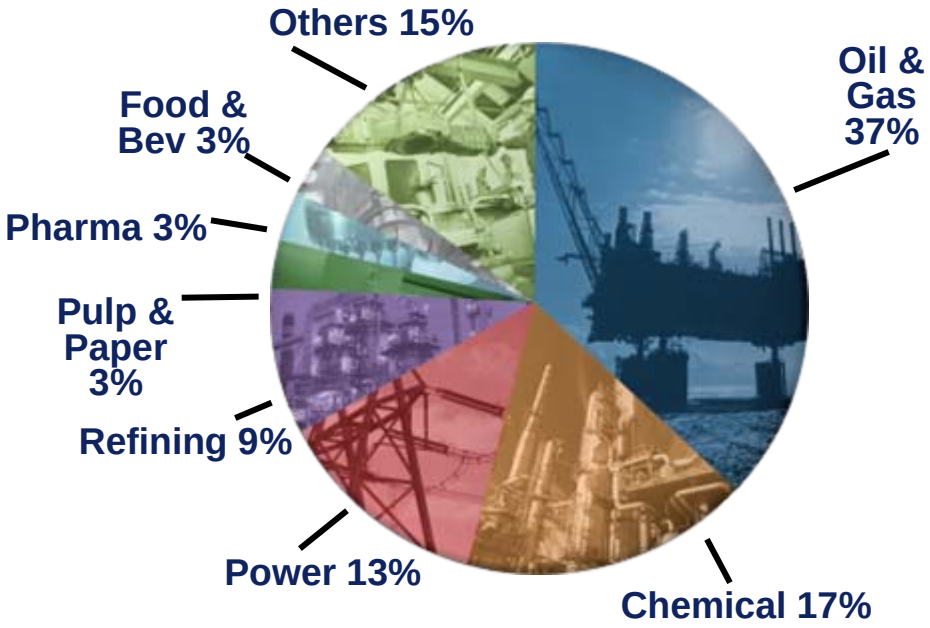
2008 Business Mix

Business by World Area



Business by Industry



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Emerson Process Management Key Industries & Customers

Chemical
- Dow Chemical
- Eastman Chemical
- Kodak

Oil & Gas / Refining
- ExxonMobil
- BP

Power
- Duke Energy
- American Electric

Pulp & Paper
- International Paper
- Williamette Industries

Food & Beverage
- Cargill
- Anheuser Busch
- General Mills

Pharmaceutical
- Eli Lilly
- Merck

We have over 85,000 end-user customers worldwide in a wide variety of industries.

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Failure Analysis at Rosemount

- Centralized as a service within the company's Quality organization in the mid 1990s
- Failure Analysis Objectives:
  - Provide customers with failure mode and/or root cause analysis documented in a formal report
  - Provide up-to-date product quality field return data to be used to measure Rosemount quality and reliability
  - Work with Rosemount engineering resources to produce product quality and process improvements based upon field return data

Failure Analysis Philosophy

Believe that a failed item is most valuable as it can reveal vital product secrets about what caused the failure

Failure Analysis at Rosemount

- Failure modes can be categorized by the following issues or problems:
  - Product Quality (Design, Manufacturing, or Materials)
  - Installation (Device Configuration, Orientation, Grounding, etc.)
  - Misapplication of Product
  - Incorrect Product for Application
- Failure Analysis results lead directly to improvements in the quality of services and products provided
  - Internal Customers
  - End-User Customers

Failure Analysis Capabilities

- Environmental Test Chambers (Pressure, Temperature & Humidity)
- Circuit and Electronic Component Analysis
- Optics & Imaging Systems w/ Digital Image Capture Software
  - Microscopes & Stereoscopes
  - Digital Borescope
  - Thermal Imaging Camera
- Real-Time X-Ray
- Computed Tomography (CT)
- SEM w/ EDX
- Metallurgical Analysis (CWI Technicians)
- Hardness Testing
- Tensile/Compression Testing
- XRF Coating Thickness Measurement & Material Analysis
- PMI

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Most cost effective resource in the toolbox

Radiography History at Rosemount

1960s - Hard-Film Radiography
RT Certified Personnel

2001 - Acquired Original Real-Time X-ray System
(150kV Tube with Image Intensifier)

2005 - Upgraded Real-Time System
(Workstation, 320kV Tube, & Digital Detector)

2008 - Added Computed Tomography
Directly integrated into existing system

2008 - Upgraded/Replaced Major Components
(225kV Tube, Digital Detector, & Image Intensifier)

Future - Computed Radiography

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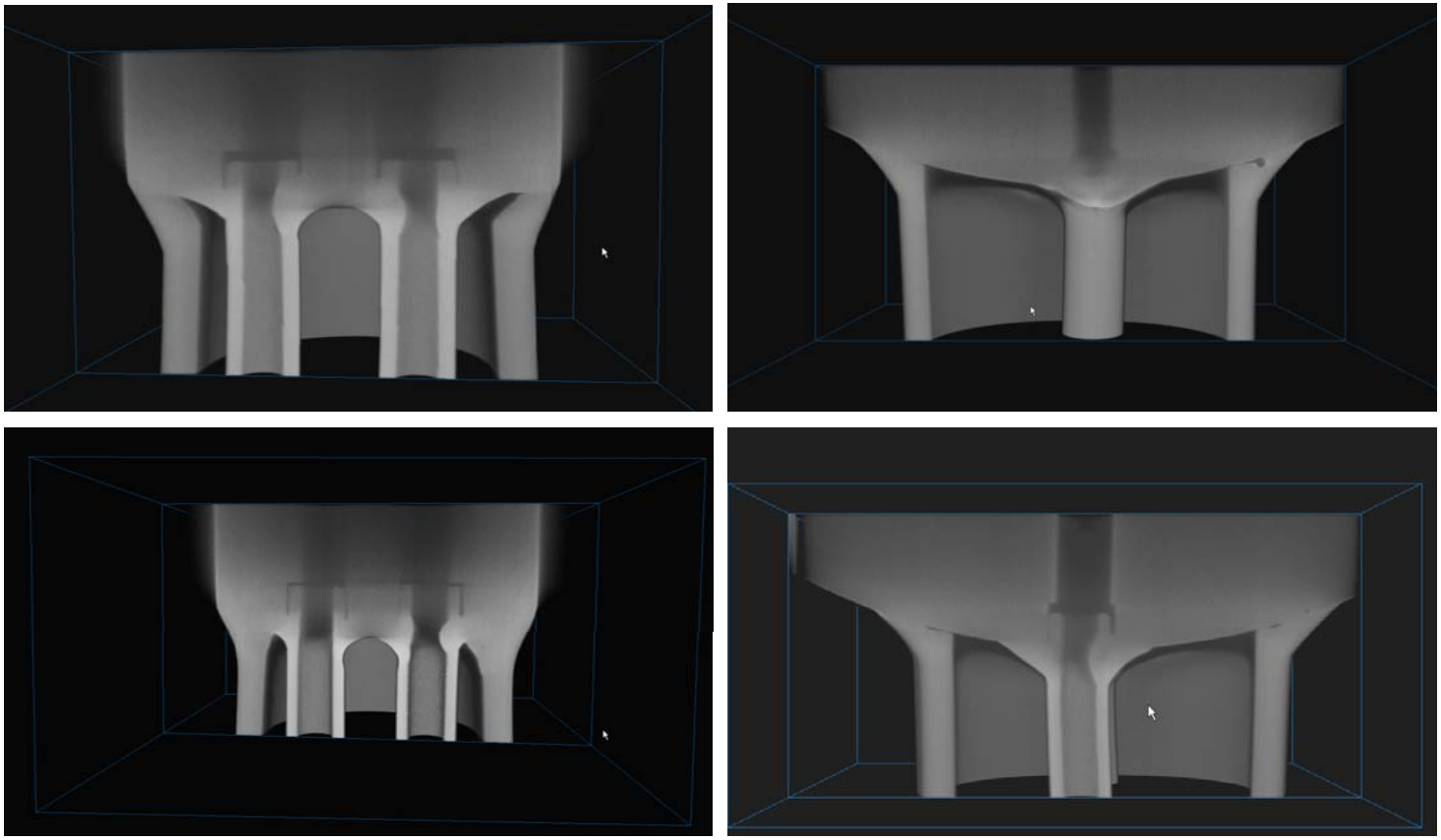
Digital X-ray & CT in Failure Analysis

- How is Digital X-ray & CT cost effective?
  - Reduces time to evaluate product
  - Establishes a target area for further evaluation
  - Characterizes condition of internal components prior to disassembly or destructive testing
  - Ability to capture images not feasible by other testing methods, reducing the time to determine root cause for a problem
  - Can provide critical information without destroying product

Internal Weld Assembly



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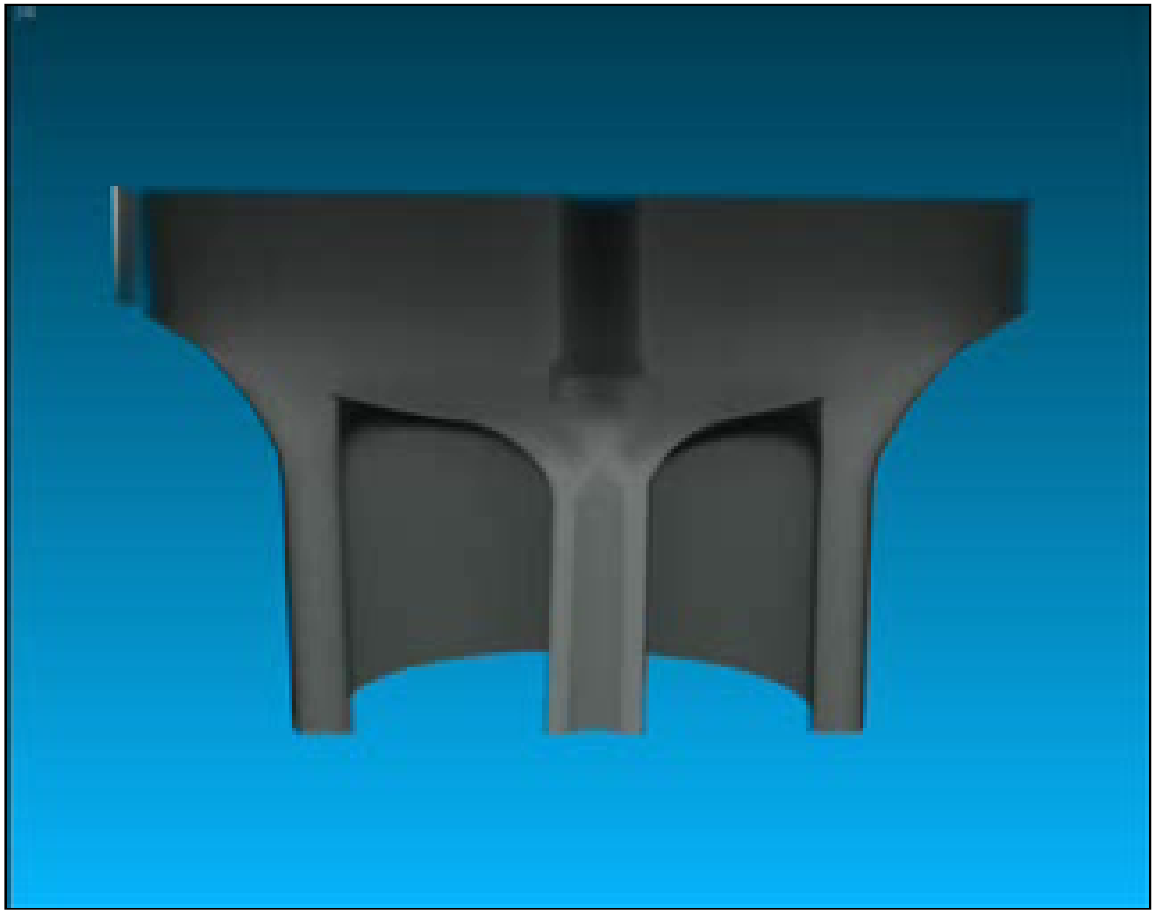
Internal Weld Assembly (Video)

Select image to activate video



CT used to characterize internal welds prior to reliability or destructive testing

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BGA Component (Video)

Select image to activate video

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CT used to analyze BGA solder joints
for non-conformance characteristics

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Weld Voids & Porosity (Video)

Select image to activate video

Surfacing used in CT to indicate weld voids and porosity

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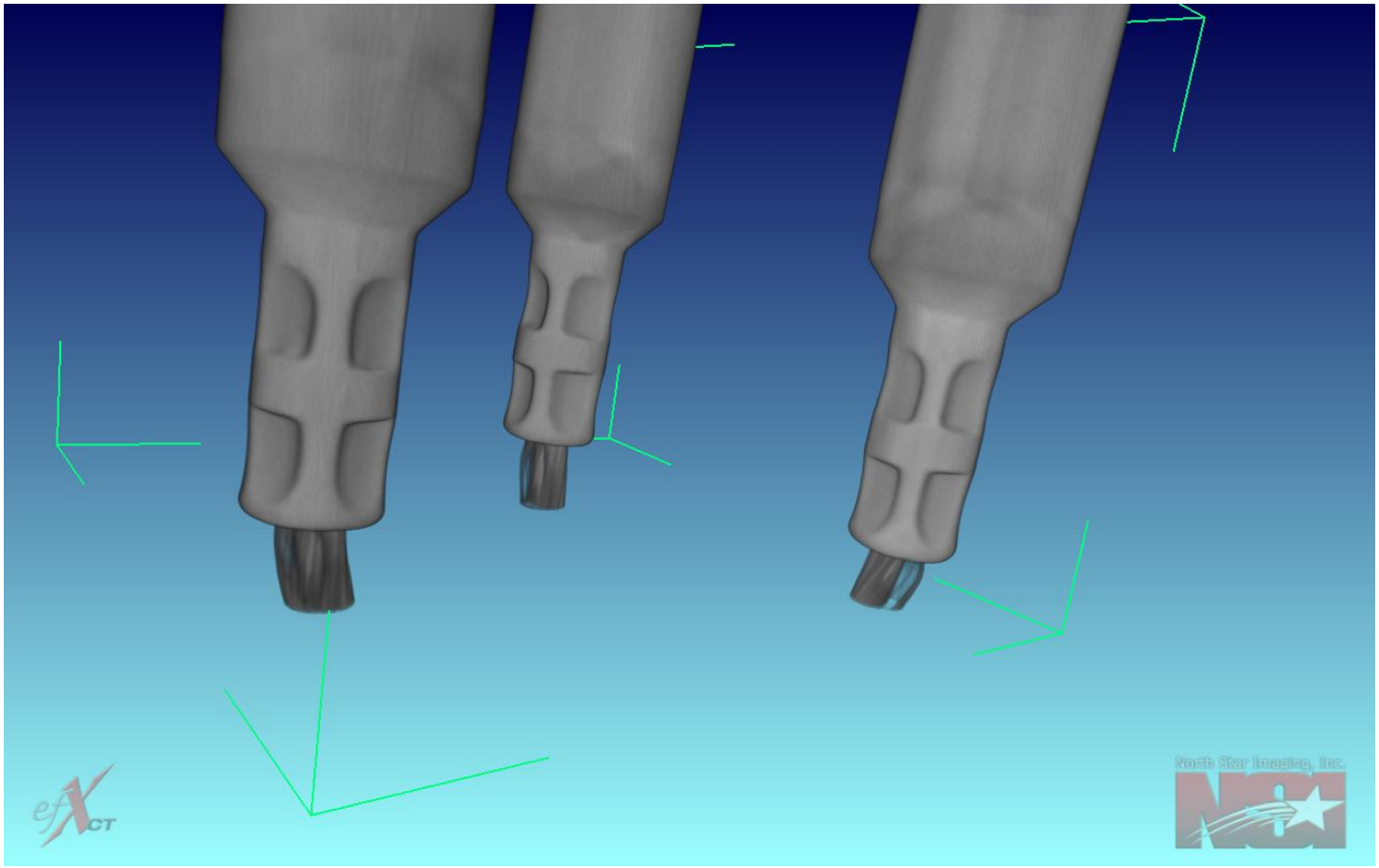
Electrical Connector



Connectors are not visible without CT due to encapsulation in potting and plastic enclosure

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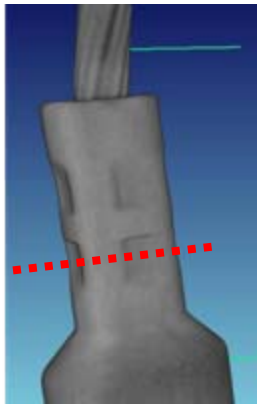
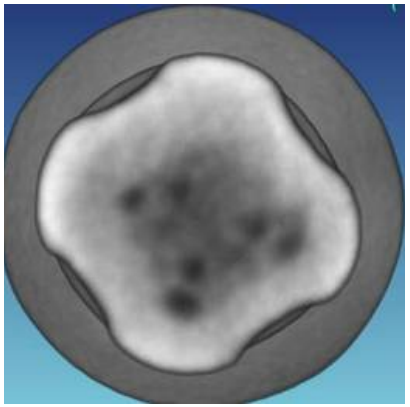
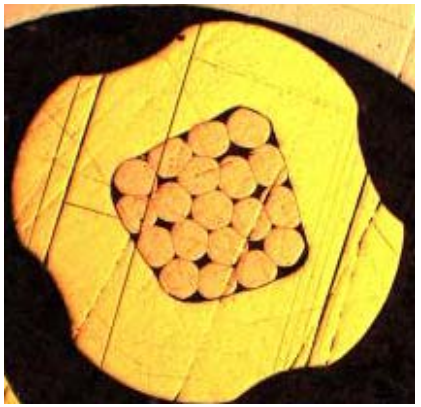
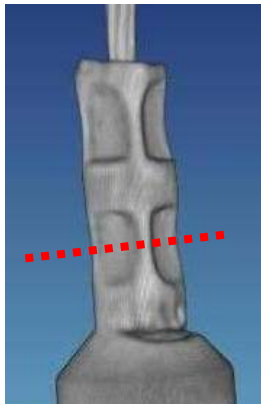
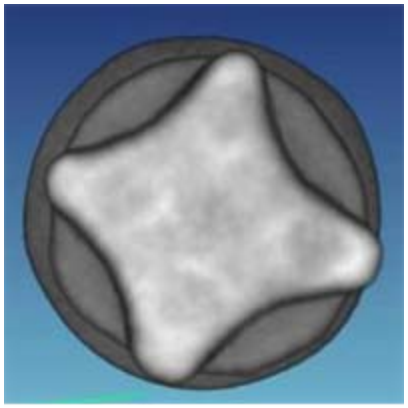
Electrical Connector

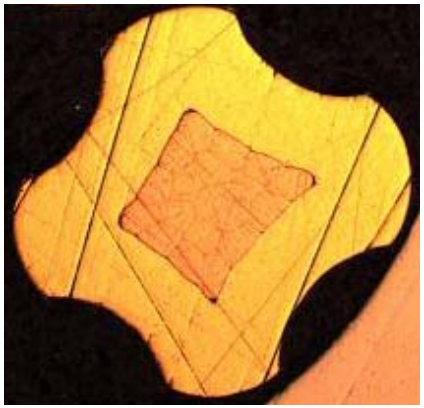












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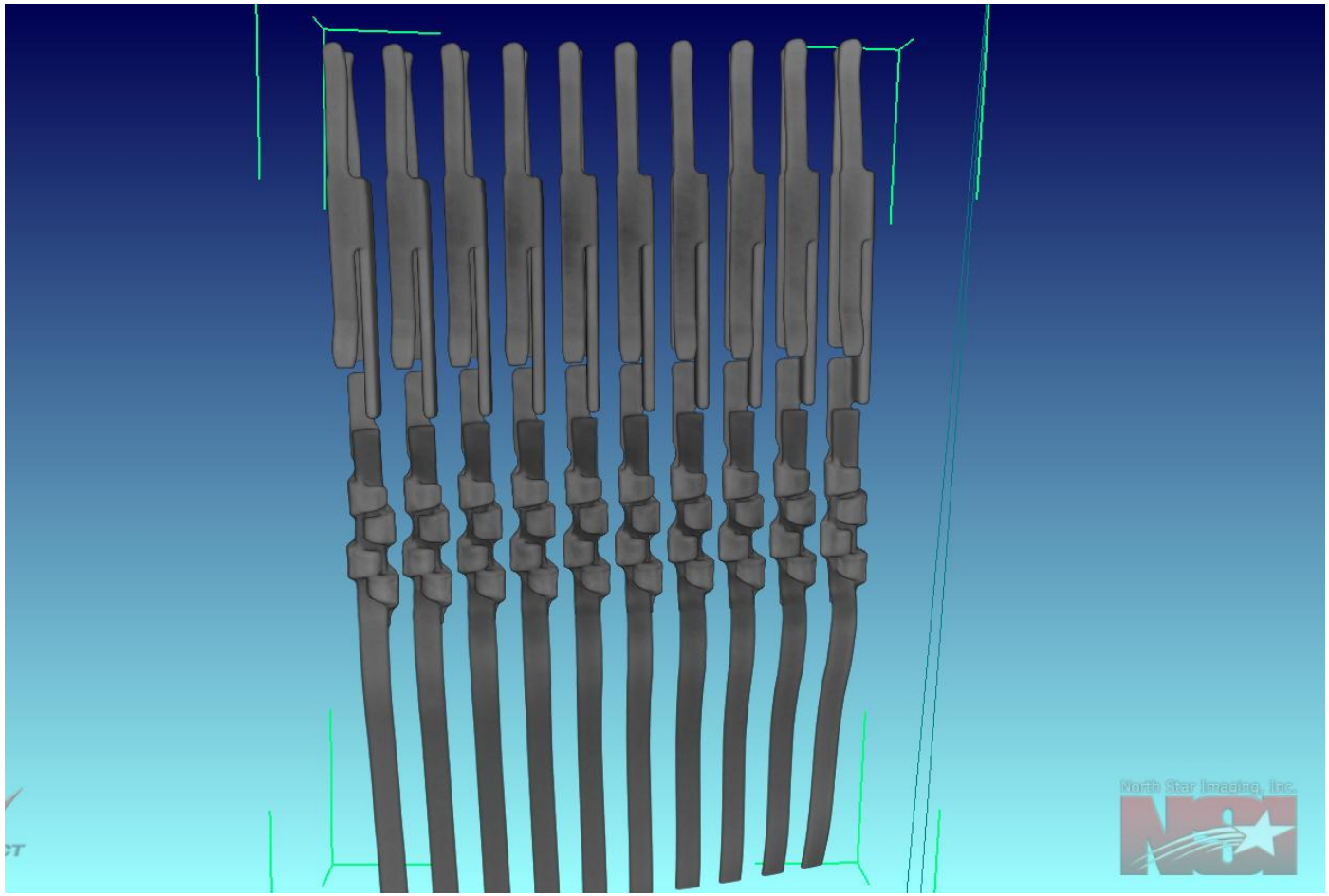
Ribbon Cable Assembly



Assembly is not visible without CT due to encapsulation in potting and welded assembly

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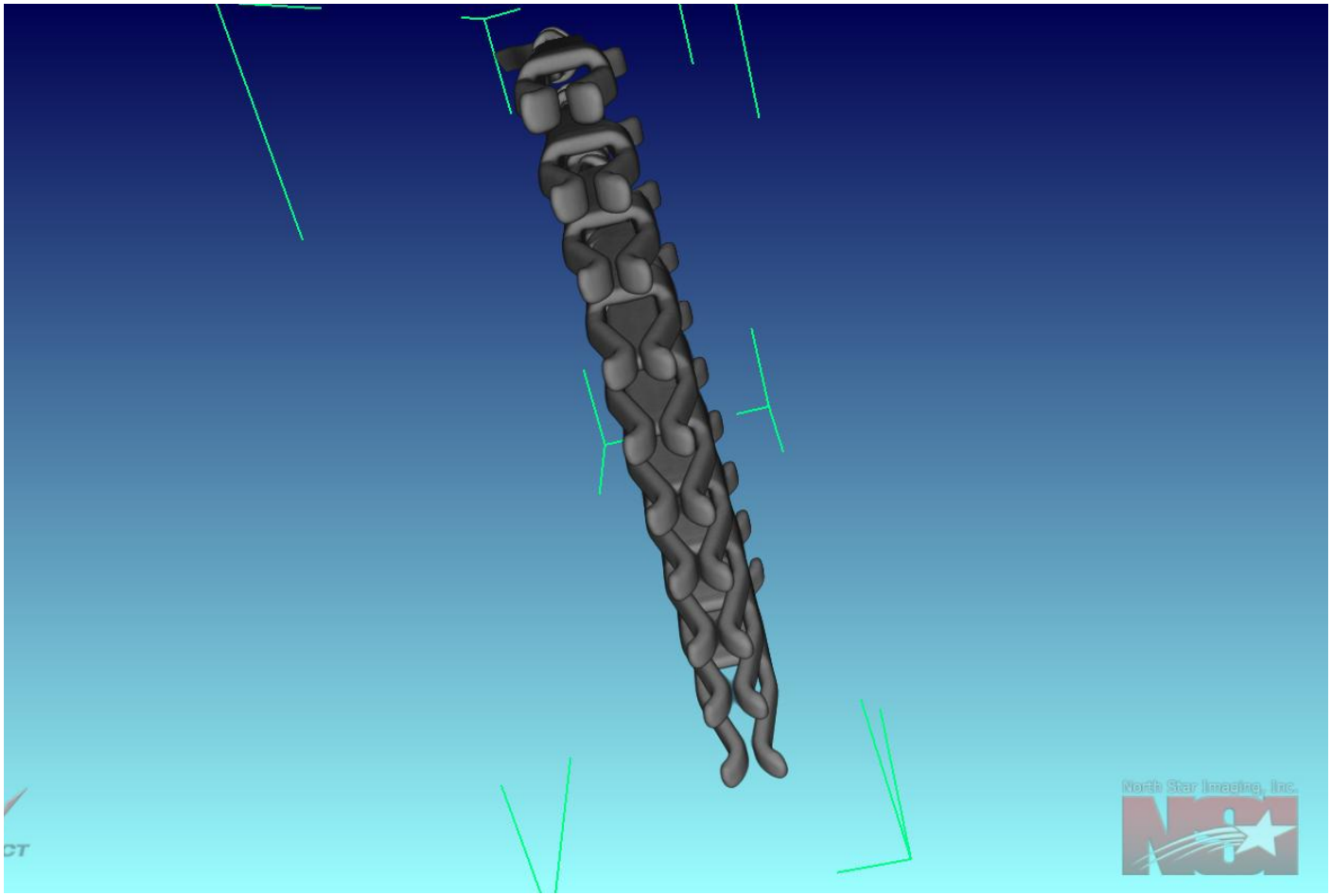
Ribbon Cable Assembly



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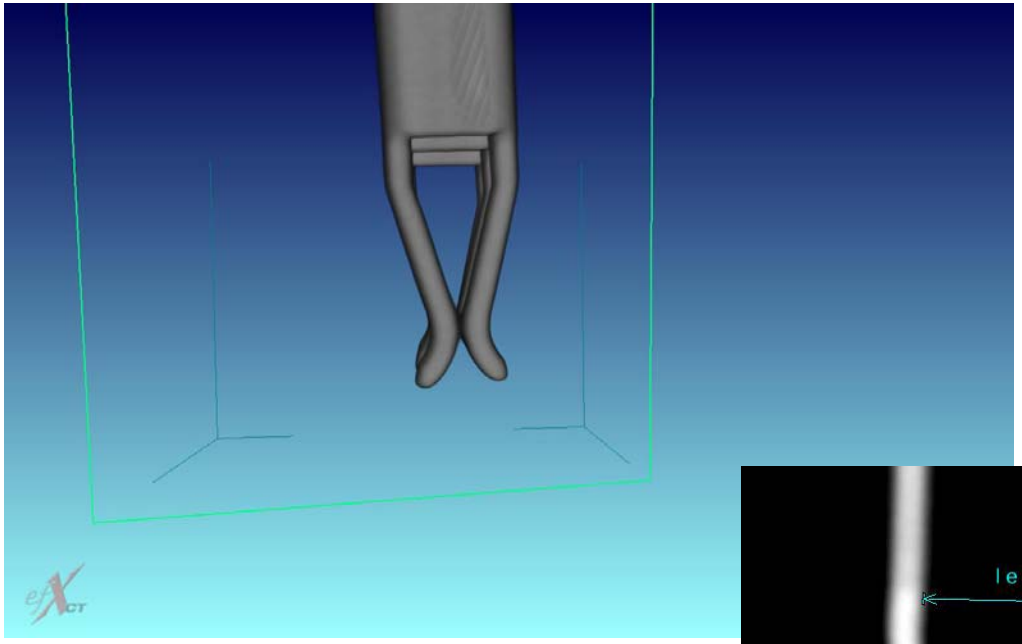
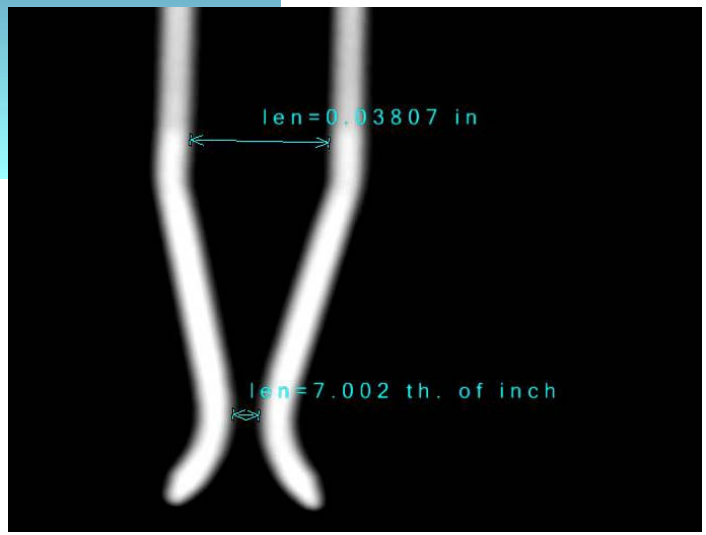
Ribbon Cable Assembly





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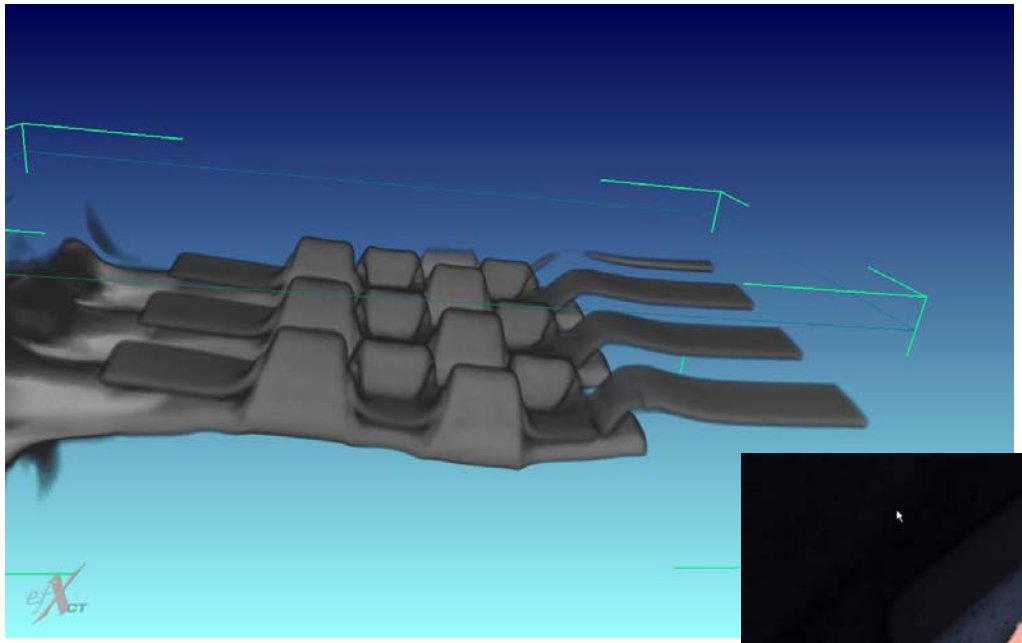
Ribbon Cable Assembly



Using Digital X-ray techniques to identify defects prior to destructive analysis

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Questions?

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