Microwave Definition

Frequencies: 1.6-30 GHz
Wavelengths: 187 - 10 mm
Microwave inspection Principles of Operation

• Material under inspection is bathed in MW energy of an essentially constant frequency creating a series of standing waves in the object
Principles of Operation

Energy is reflected from each interface of differing relative permittivity within specimen.

The boundary in this case is any change in relative permittivity (Commonly known as Dielectric Constant) of the material.
Measurement Technique

The reflected energy is measured and creates a resulting output voltage signal.
Data Collection

The resulting voltage is sampled at discreet locations across sample to create an image.
Image Creation
MW Inspection Overview

• Multiple generations of equipment in the field
• Mechanical inspection devices for:
  – HDPE butt fusion and electrofusion joints
  – HDPE, FRP pipes and vessels (up to 12 feet in diameter)
  – Rubber expansion joints
  – Fully battery operated and bluetooth data transfer inspection equipment
• Microwave Inspection accepted as a new technique in ASNT
• ASTM Standards under development
• Microwave represented in ASME BPVC working groups on HDPE
Detectable Defect Types

- Disbonds & Lack of Fusion in HDPE Butt Fusion and Electrofusion Thermal Welds
- Foreign Material Inclusions
- Voids
- Moisture or other liquid contamination
- Mechanical damage
- Physical changes due to chemical attack
Current Uses

- Fiberglass Tanks and Pipes
  - Dow
  - Bayer
  - Borouge
  - Shell
- Fiberglass Armor
  - US Army (SBIR)
  - Kazak
- Reinforced Rubber Expansion Joints
  - Exelon
  - PSEG
  - FENOC
  - Wolf Creek
- Ceramic Materials
  - US Air Force (SBIR)
- HDPE Butt Fusion Joints
  - Axiall
Work In Progress

- Enhanced imaging techniques using Narrow Band Synthetic Aperture Focusing Techniques (SAFT)
  - Allow specific depth location
- Transition to Wide Band SAFT
  - Provide for 3D imaging (holographic) techniques
FIRST GENERATION LAB EQUIPMENT
Basic Equipment Setup

Laboratory Scan Table

Laboratory Scan Lathe

Evisive
NEW GENERATION FIELD EQUIPMENT
Blue Tooth Hand Held
Pipe Scanner
Pipe with manufactured defects

Pipe with erosion defects and insufficient glue

Inspection image of pipe
Pipe with manufactured defects

Gray scale image showing interference pattern at erosion hole

3D rendering of pipe
3D Rotated view of part
Fiberglass Panel
Thickness determination
MICROWAVE INSPECTION OF GFR

EVISIVESCAN™
MICROWAVE SCANNING NDT
Overloaded section of fiberglass boom

Boom section

Inspection image

Delamination
Internal erosion of pipe

Displaced structure caused by washout of resin matrix
Voiding at manufacture

Boom with voiding

Inspection image of boom

Voiding identified in inspection image
Internal pipe hydrolysis

Picture of pipe ID

Inspection image of pipe ID

Internal blistering identified in image
Environmental degradation of furan pipe

Photo showing chemical attack

Inspection image of chemical attack

Degraded resin to right of line
Resin poor areas of pultruded panel

Tensile test results (Pounds load to failure)

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Panel with various types of fod

Image focus changes based on relative position of the end of the antenna with respect to the material surface.

Metal, paper, cloth FOD
INSPECTION OF STEEL PIPE CORROSION BENEATH FIBERGLASS OVERWRAP
Corrosion Beneath Fiberglass Overwrap

- In service inspection of steel pipe corrosion under insulation or overwraps.
- Condition monitoring of pipe over time
Pipe Wrap with Artificial Defects

The wrap is hard fiber reinforced layer with mastic matrix and interlayer fill.

Scan image shows features in pipe surface, at pipe to wrap interface and in pipe wrap. Indications included artificial and unintended features.
Pipe wrap with artificial defects. The wrap is flexible fiber material with a resin matrix.

Microwave interference scan of pipe wrap showing features in pipe surface, at pipe to interface and in pipe wrap volume. Indications include artificial and unintended features.
Clockspring Inspection

Good bond / whole area

Crack

Strong indication, likely disbond at metal surface
Clockspring inspection

Section at x = 8 in.

Good Bond
Clockspring inspection

Corrosion/ Delamination at pipe surface

x = 18 in.
Clockspring inspection

Section at
x = 29 in.
THICKNESS MEASUREMENT
Thickness Measurement
Phase Plot
Calibration Panel
Phase & Magnitude Application

Wedge used to correlate thickness to color

Thicker area

Area with wall loss
Fiberglass Panel

Wall loss = .150”
Wall Loss = .155”
Wall Loss = .060”
Wall Loss=.050”
Inspection Image
3D Representation
QUESTIONS?

EvisiveScan™
Microwave Scanning NDT