PROFILE TECHNOLOGIES, INC.

Inspection of Cased Pipe by Guided Electromagnetic Waves: EMW-C

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PHMSA CASED PIPELINE INTEGRITY ASSESSMENT WORKSHOP
Tuesday, July 15, 2008
Chicago, IL

Overview

- Understanding the EMW-C Technology
  - Background
  - Current Uses
  - The Process
  - Testing and Equipment
  - Data
  - Additional Points
- Guidedwave Inspection Methods
  - Similarities and Differences

EMW-C Background

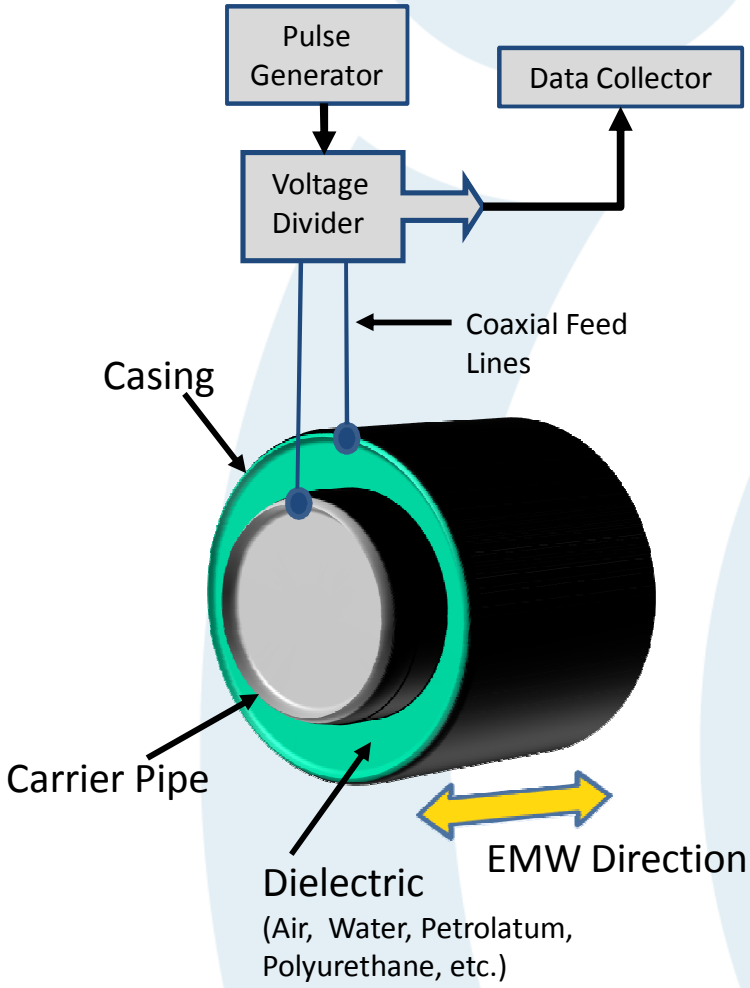
- The EMW-C is a patented inspection process for cased pipe.
- It is a long range electromagnetic scanning method that has been developed and refined for over 15 years.
- Similar to RADAR, electromagnetic waves (EMW) are transmitted and received allowing location and identification of materials and conditions.
- EMW fills the annulus between the carrier pipe and casing and travels lengthwise to the end of casing.

EMW-C
Current Uses

- Long range detection of anomalies and corrosion indicators:
  - Corrosion Product
  - Electrolytes (water, soil),
  - Metallic Shorts
- Location of mechanical structures or deformations:
  - Spacer location
  - Carrier pipe sag / change in offset
  - Crushing of the casing.

- Resolution of the location and length duration of a single or multiple anomalies within a cased section.
- Characterization of the magnitude of the anomaly based on data and equivalency models.
- Continuous or periodic monitoring to detect changes over time.
  - Permanent connectors may be installed.

EMW-C
The Process



- Connection is made to the carrier and casing using coaxial connectors and cables.
- A pulse generator creates electromagnetic waves (EMW) in the annulus (Dielectric).
- The casing and carrier pipe guide the waves, which travel through the annulus and through the dielectric material(s) in the space between.
- The waves are reflected back to the equipment from material changes in the annulus.
- Changes in dielectric material (rust, water, spacers, wax) are seen as variations of amplitude and polarity of reflections.
- Lengthwise distance to reflectors (anomalies) are determined by time of return.

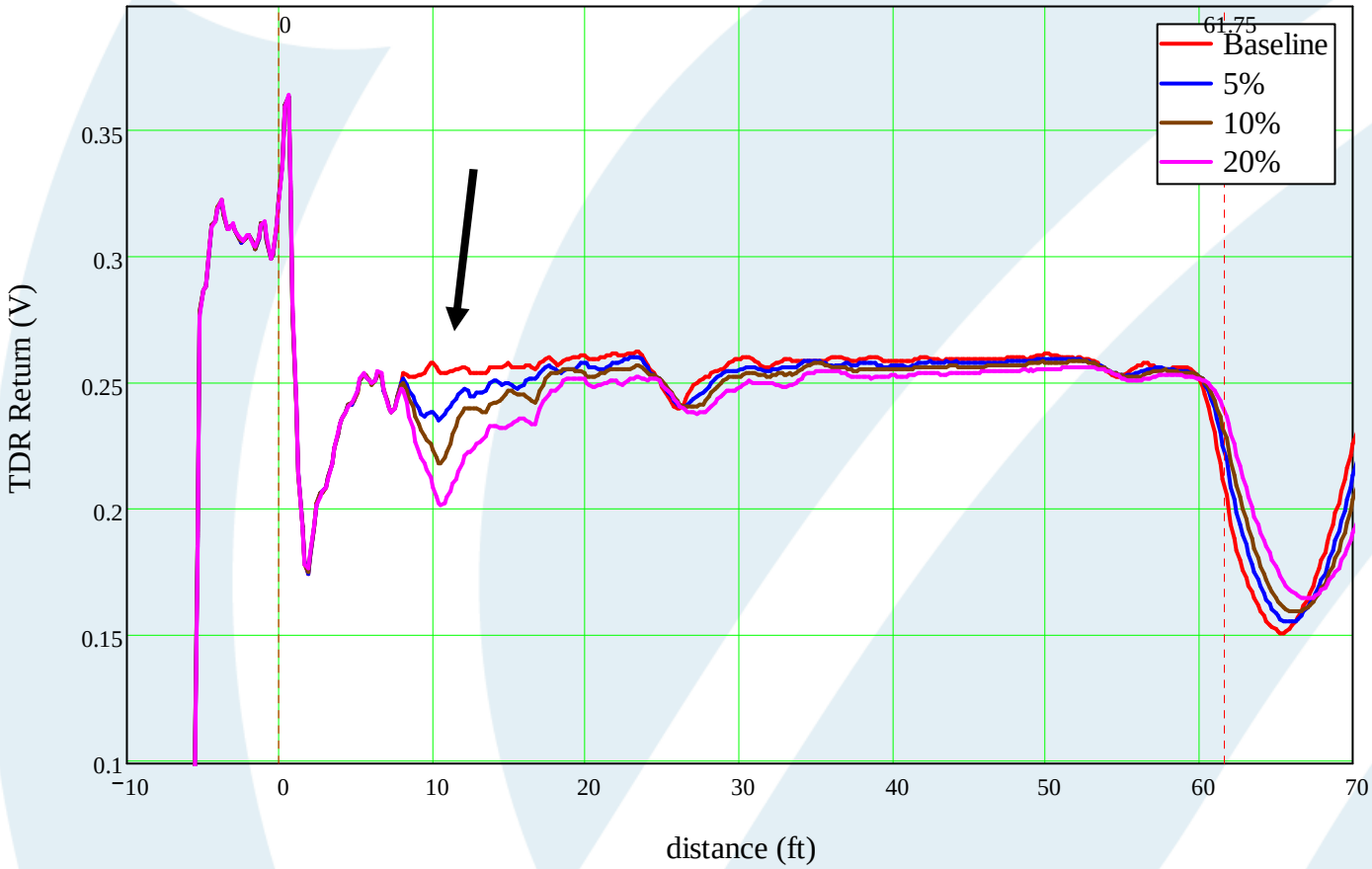
EMW-C
Testing and Equipment

- EMW-C Casing Setup and Testing
  - Require Bellhole access to casing end for 2 men.
  - Prefer testing from both ends for double coverage.
  - Small ½" Diameter coating removal at 4 locations.
  - Boot and Endseal removed.
  - 15/15/15 – 15 minute setup / 15 minute test / 15 minute breakdown
- EMW-C Equipment
  - Small Rugged Box and Remote Laptop
  - Can inspect 2 casings (4 shots) in 3 to 4 hours
  - Range dependent on casing fill – 100 feet is reasonable for air.
  - Unverified data analysis can be made available onsite.
  - Permanent connectors available for long term / aboveground monitoring.

EMW-C
Example of Corrosion Growth Detection

Data showing change as corrosion increases.

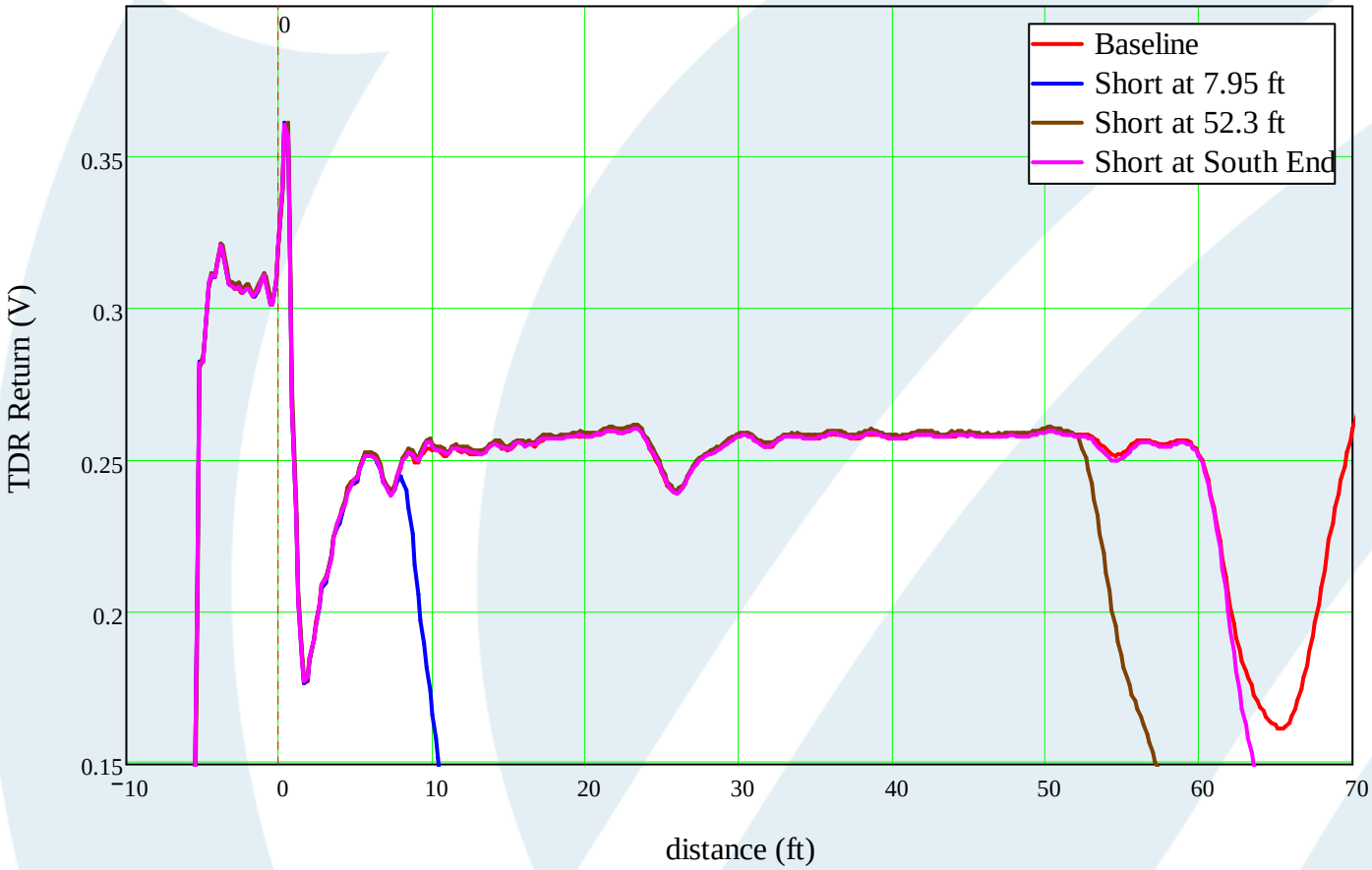
Consecutive data traces with increased corrosion at 10 foot mark.



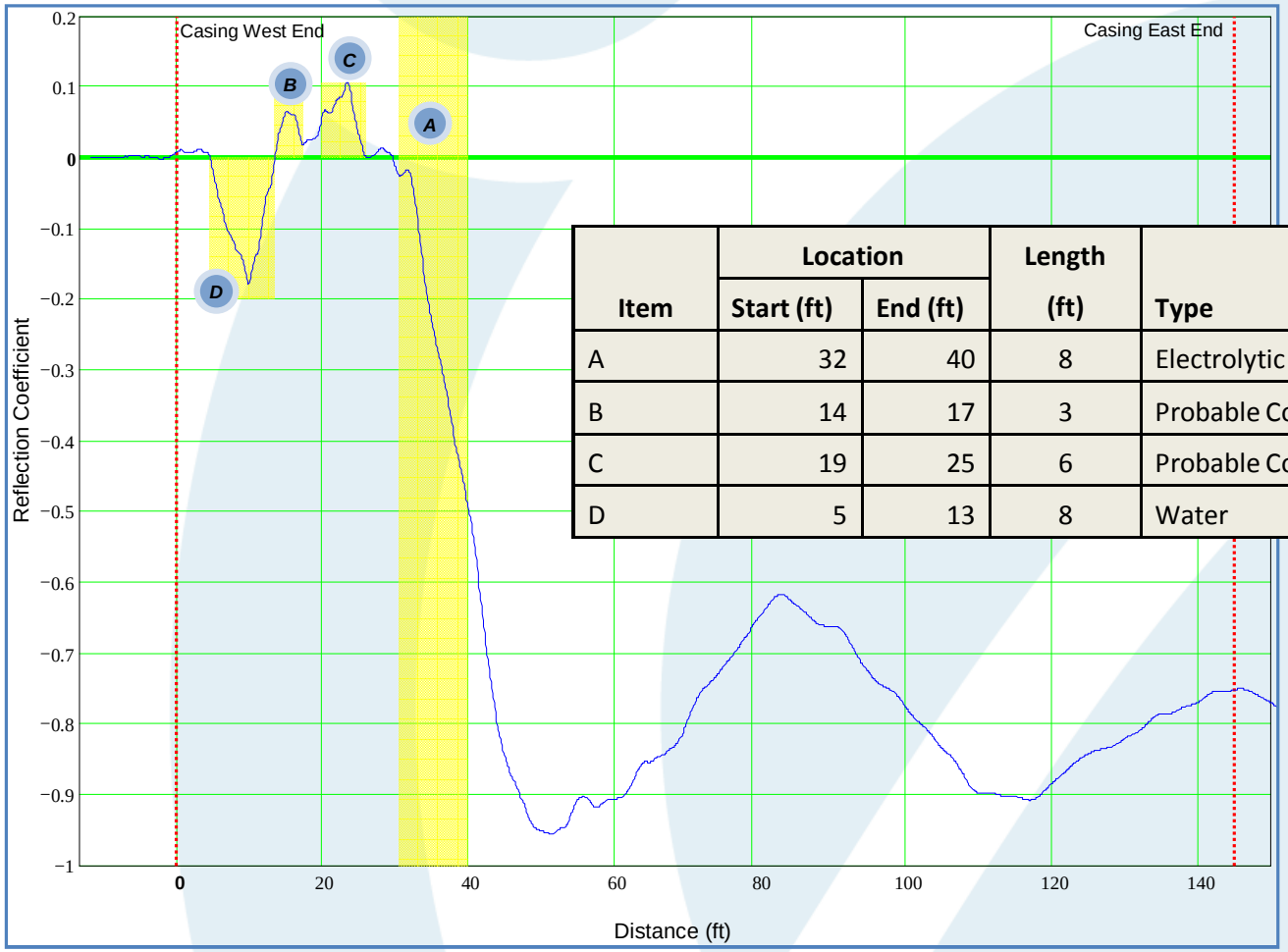
EMW-C
Detection of Shorts

Data showing various pipe to casing short locations.

(Individual data traces overlaid).



EMW-C Data
22" Carrier / 36" Casing – 145 feet



Item	Location		Length	Type	Reflection Coefficient	
	Start (ft)	End (ft)	(ft)		Direction	Magnitude
A	32	40	8	Electrolytic Contact	-	0.96
B	14	17	3	Probable Coating Loss	+	0.06
C	19	25	6	Probable Coating Loss	+	0.11
D	5	13	8	Water	-	0.18

EMW-C
Additional Points

- This technology has been used for locating corrosion under insulation (CUI) in Alaska by BP and ConocoPhillips
- The EMW-C is now being used by PG&E in California and evaluated by NYSEARCH.
- Capabilities also include volumetric monitoring of the annulus for conditions such as wax fill levels, voids, and water in wax. Periodic monitoring can be used to watch for changes in wax and/or corrosion growth versus baseline.

EMW-C
Additional Points

- Though this technology is technically a guided wave method, the typical characteristics of GWUT do not necessarily apply.
- EMW-C uses electromagnetic waves which are not affected by bends and turns and attenuation is caused by (certain) materials in casing rather than coating on carrier.
- The PHMSA 18 point checklist is GWUT vendor specific and does not ‘fit’ the EMW-C.
- Current options for use under HCA Rule include Other Technology or as a tool in ECDA.

Guided Wave Inspection Methods – Guiding Waves to our Advantage

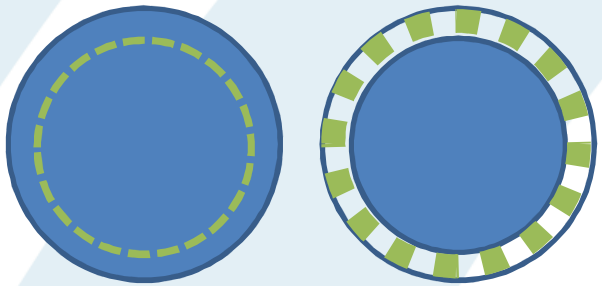
- A ‘guided wave’ is a common tool in physics and industries including communications and inspection.
- In recent years, the term guided wave has become synonymous with the Long Range Ultrasonic Test (LRUT) or Guided Ultrasonics (GUL) pipe inspection methods.
- A similar inspection method using Magnetostrictive Sensors also utilizes guided waves.
- Profile Technologies uses Electromagnetic guided waves to inspect cased pipe using a process called the (EMW-C).

Guided Wave Inspection Methods- Similarities and Differences

Comparison of Guided Wave Inspection Methods

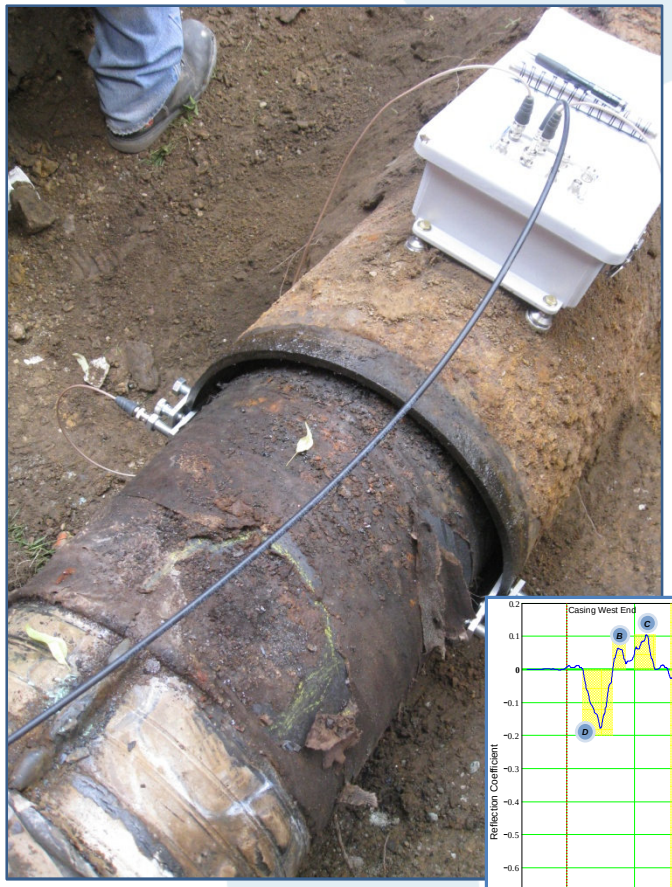
Method	Wave Type	Wave Source	Waveguide
LRUT, GUL	Mechanical - Acoustic	Piezoelectric Transducers	Pipe cross-section
MsS	Mechanical - Acoustic	Magnetostrictive Sensors	Pipe cross-section
EMW-C	Electromagnetic	Pulse Transmitter / Coaxial Connectors	Annular space between pipe and casing

Cross – Sectional view of pipe and casing. The dashed sections show the waveguide and "inspection area" for each method.



LRUT, GUL, MsS EMW-C

Thank You!



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