Characterization of Pipeline Defects

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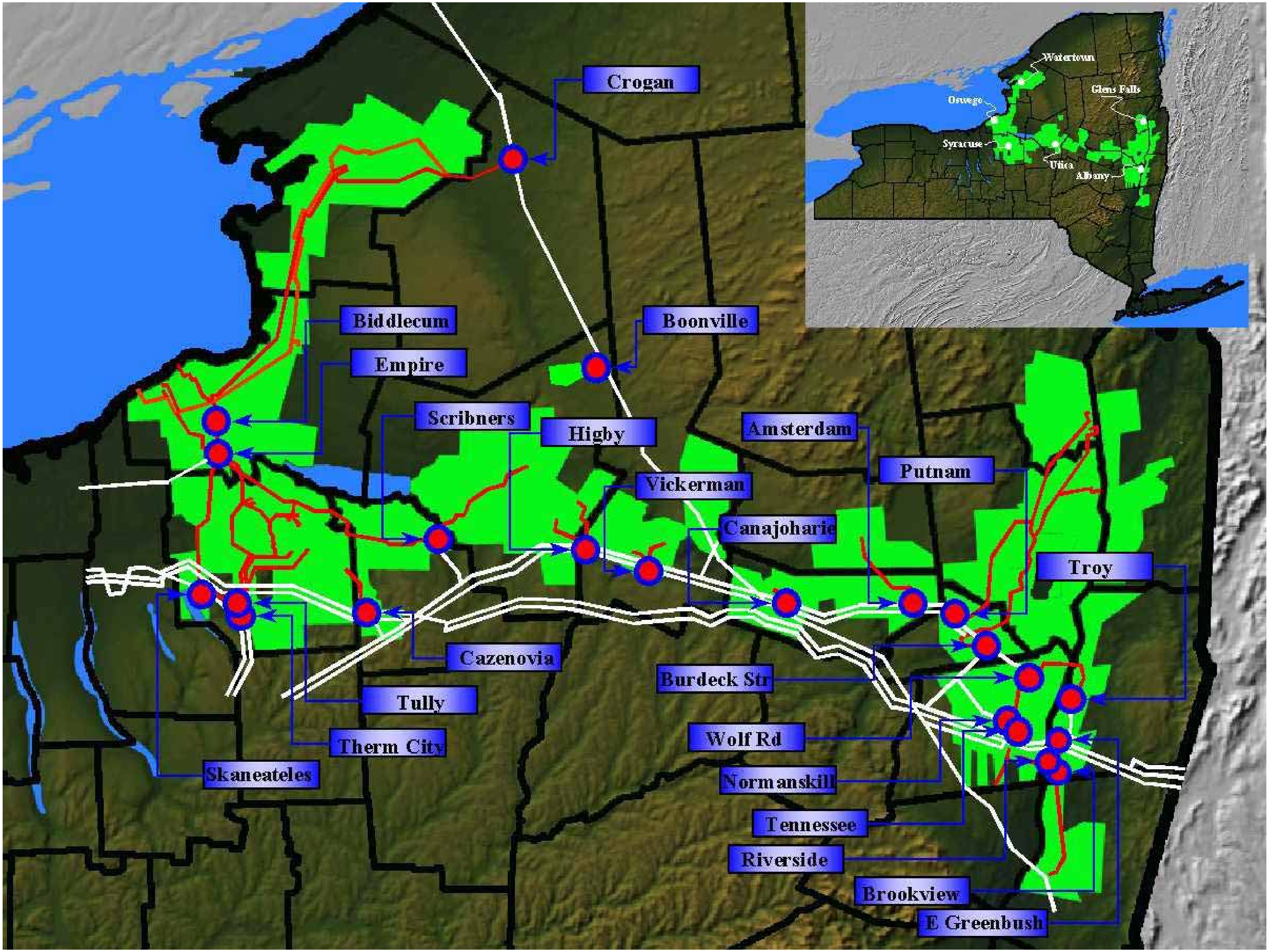
nationalgrid


Watertown
Oswego
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Putnam
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Canajoharie
Troy
Cazenovia
Burdeck Str
Tully
Wolf Rd
Therm City
Normanskill
Skaneateles
Tennessee
Riverside
Brookview
E Greenbush

NG's current service territory covers 4,500 square miles and serves 549,300 customers.

Infrastructure

- 22 Gate stations (delivery points)
- **278 Miles Transmission main (pipeline)**
- 387 Gas regulating stations (pressure reducing)
- 7,948 Miles distribution main
- 490,790 Services
- 562,711 Meters
- 314,271 Service regulators

National Grid Gas Transmission In Upstate N.Y.

- 278 miles transmission pipe
  - 170 miles > 30% SMYS
  - 108 miles 20% - 30% SMYS
  - 190 miles constructed prior to 1970
  - 58 miles in HCAs
  - Most one way feed

Stress and Flaw Depth Relationship

$$\% \text{ SMYS} = \frac{100 \cdot \left\{ \frac{P \cdot D}{2t} \right\}}{\left\{ \begin{matrix} \text{Material} \\ \text{Strength} \end{matrix} \right\}}$$

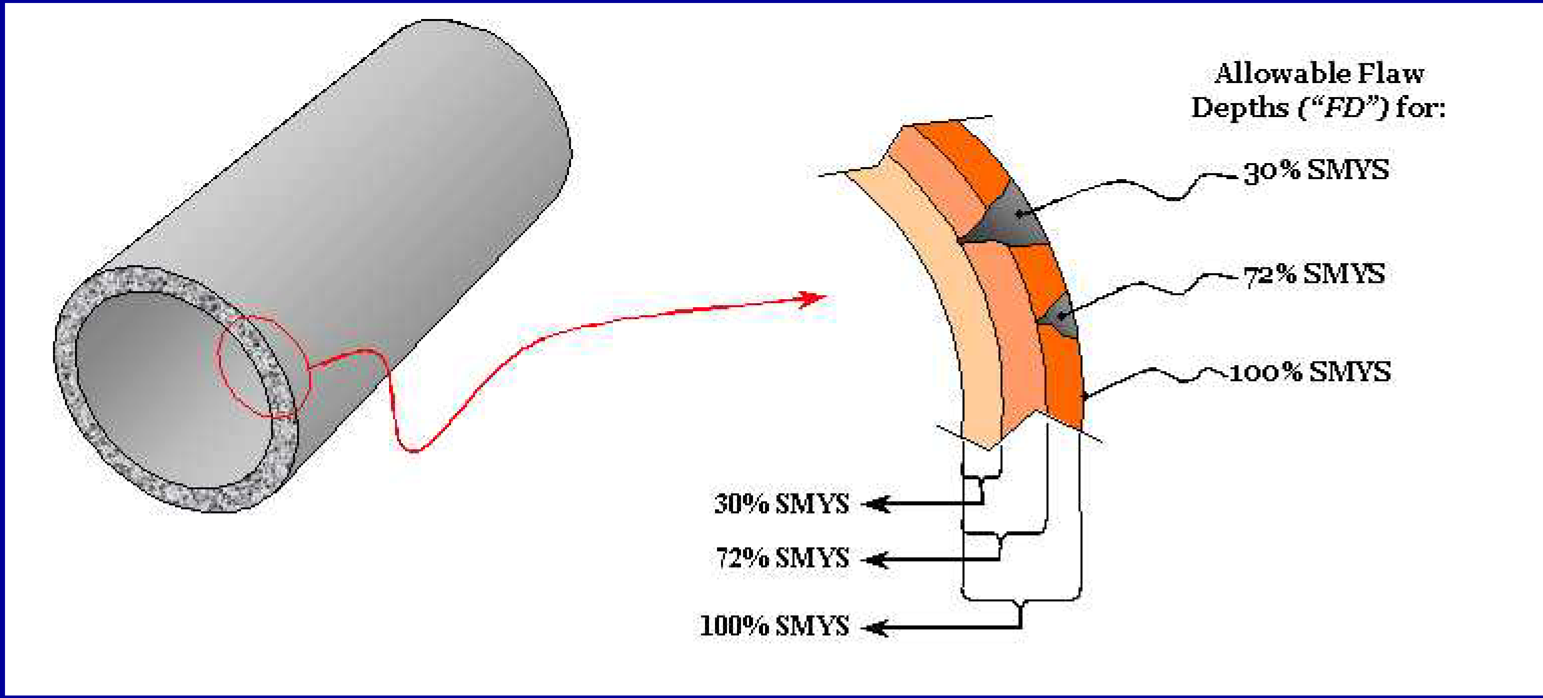
Where:

P = **Pressure (psig)**

D = **Outside Diameter (inches)**

t = **Pipe Wall Thickness (inches)**

Material Strength =
Specified Strength of the Material



Low Stress vs High Stress

Low-stress lines are inherently less risky than high- stress lines, specifically:

- Consequences of failure are reduced ("potential impact area" is reduced).
- Likelihood of failure is reduced for third party damage, internal and external corrosion (larger and deeper defects are required to cause failure).
- Failure modes pose less risk (leak vs. rupture).

Classification of Defects

is dependent upon the following ratio:

$$P_f \text{ ratio} = \frac{P_f}{MAOP}$$

where P_f ratio = Predicted failure pressure ratio of a defect

P_f = Predicted failure pressure of a defect (determined by B31.G or equivalent)

MAOP = Maximum Allowable Operating Pressure of the Pipeline

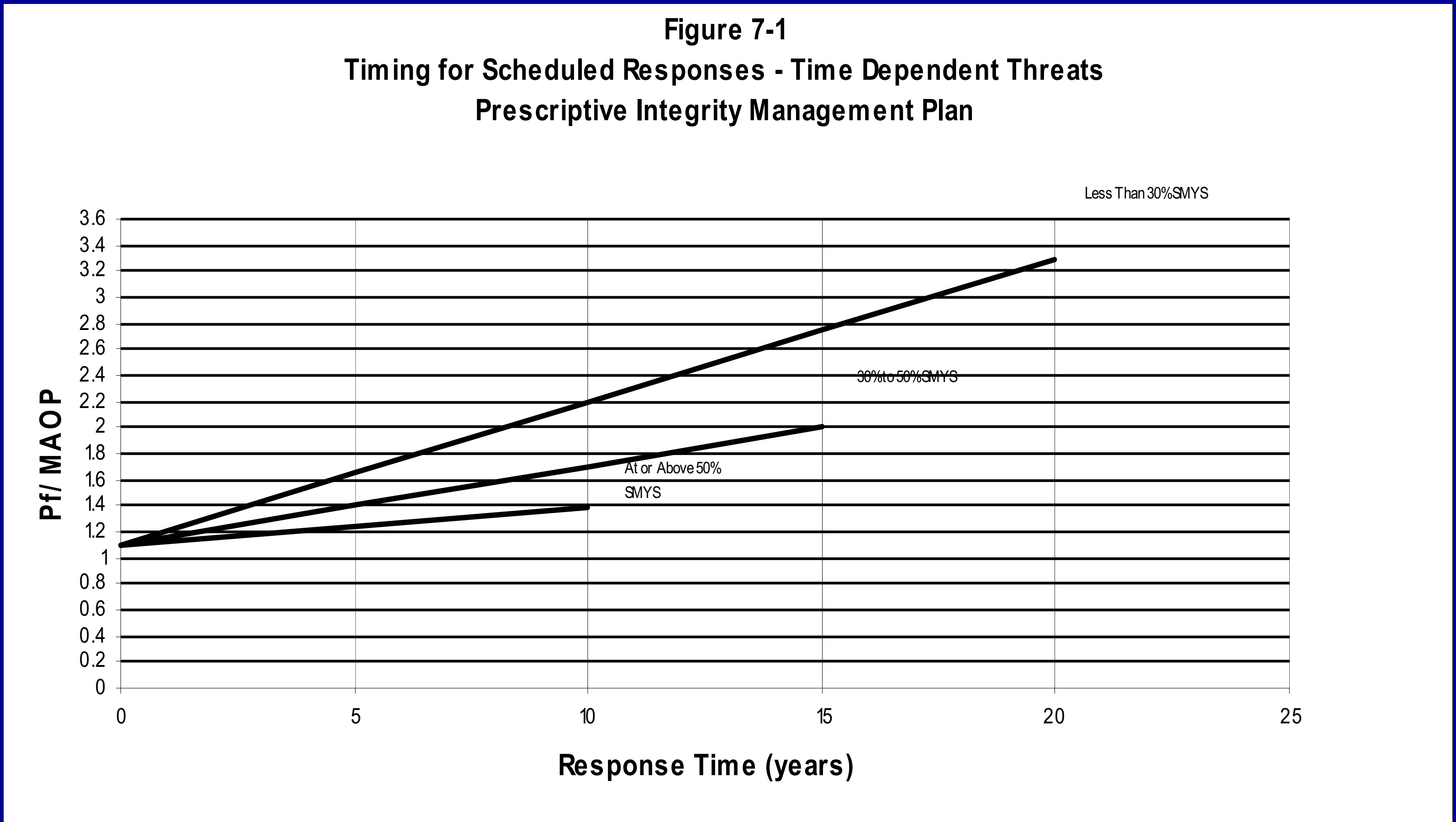


Figure 7-1 contains three plots of the allowed time to respond to an indication. The figure is applicable to the prescriptive-based program. The intervals may be extended for the performance-based program, as provided in Section 7.2.5.

Corrosion Defect

1931, 18” diameter, .312” wall, seamless, Grade B pipe, operating pressure - 300 psi, stress - approximately 25%.

Mechanical damage

1951, 12” diameter, .312” wall, seamless, Grade B pipe, operating pressure - 237 psi, stress - approximately 13%.

Characterization by Threat

Time Dependent	**1. • External corrosion** **2. • Internal corrosion** **3. • Stress corrosion cracking**
Stable	4. Manufacturing Related Defects: • **Defective pipe seam** • **Defective pipe** 5. Welding/Fabrication Related: • **Defective pipe girth weld** • **Defective fabrication weld** • **Wrinkle, bend or buckle** • Stripped threads/broken pipe/coupling failure 6. Equipment: • Gasket o-ring failure • Control/relief equipment malfunction • Seal/pump packing failure • Miscellaneous

Characterization by Threat (cont.)

Time Independent	7. Third Party/Mechanical Damage: • **Damage inflicted by first, second or third parties (instantaneous/immediate failure)** • **Previously damaged pipe (delayed failure mode)** • Vandalism 8. Incorrect Operations: • Incorrect operational procedure 9. Weather Related and Outside Force: • Cold weather • Lightening • Heavy rain or floods • **Earth movements**

Three Sections of the Federal Code that address Pipeline Defects

- 192.307 & 309 Construction
- 192.711 & 713 & 717 Operation
- 192.933 Integrity Management

Construction (192.307 & 309)

(>20% SMYS)

- Each imperfection that could impair serviceability must be removed or repaired
  - Grinding repairs are permitted provided min. wall is maintained
- Dents must be removed as follows
  - with stress risers, effect longitudinal or seam welds
  - >40% SMYS ¼” deep or larger for <12” diameter
  - >40% SMYS 2% or larger for 12” diameter or greater

Operation (192.711- 717)

(>40% SMYS)

- Each imperfection that could impair serviceability must be removed or repaired
  - "Repair by a method that reliable engineering tests and analysis show can permanently restore the serviceability of the pipe"
- Each leak must be repaired by
  - Removing and replacing a cylinder containing the defect
  - Clamp or welded patch over corrosion
  - Other method that can permanently restore serviceability

Integrity Management (192.933)

(>20% SMYS)

"An operator must take prompt action to address all anomalous conditions…" as follows

- Immediate repair condition
  - Defects with a failure pressure ratio of 1.1 or less
  - Dents that contain stress risers
  - Any defect the operator deems necessary
- One year condition
  - Plain dent >6% (.5" for <12" dia.) in upper 2/3
  - Plain dent >2% (.25 for <12"dia.) effecting a girth or seam weld
- Monitored conditions
  - Plain dent >6% (.5" for <12" dia.) in lower 1/3
  - Plain dent >6% (.5" for <12" dia.) in upper 2/3 w/critical strain levels not exceeded
  - Plain dent >2% (.25" for <12" dia.) effecting a girth or seam weld w/critical strain not exceeded

Characterization of Defects

1. **Immediate - Defect is at or near failure point.**

   operators to make prompt repairs.

2. **Scheduled - Defect is significant but not at failure point.**

   operator to schedule repairs based on the severity of the defect.

3. **Monitored - Defect will not fail before next inspection.**

   operator to monitor the indication's growth at scheduled intervals.

Boils Down to Four Types of Defects

- Cracks
- Plain Dents
- Corrosion- Metal Loss
- Mechanical damage- Dents w/gouges

Cracks

Occur due to:

- Poor material properties- Manufacturing
- Poor welding- Construction
- SCC- Condition specific

Controlling the process and environment can limit the existence of these type of defects

Plain Dents

Occur due to:

- Installation/Construction
- Ground movement/settling
  - –Buckling
- Some rock impingement

Plain Dents are normally not harmful provided they are not extremely large

Corrosion

- We know the most about
- Understand and can model:
  - Behavior – leak vs. rupture
  - Growth Rates
  - Failure mechanisms
  - Mitigation/prevention

Our challenge is finding and sizing defects prior to failure

Mechanical Damage

- To effectively manage requires prevention
- Difficult to mitigate due to random/time independent nature of the defect
- Almost all fail immediately
- Those that do not can remain latent for years
- Most complex failure mechanism
- Tendency to rupture rather than leak

Detection and sizing are key to analysis of latent defects

Failure from Mechanical Damage

1964, 16” diameter, .250” wall, ERW, X-42 pipe, operating pressure - 490 psi, stress - approximately 40% SMYS

Failure Mode - Latent Third Party Damage

What have we done

- B31.8S and IMP Regulations
- Develop Direct Assessment ICDA&ECDA
- ILI advancements

What have we done

- Robotics & Sensors for Autonomous inspections

- Advance Development of Guided Wave

What have we done

- Third Party Monitoring / Listening devices
- Advancements in leak detection





What have we done

- Ground probing radar and other locating devices
- Implement GIS and GPS mapping techniques

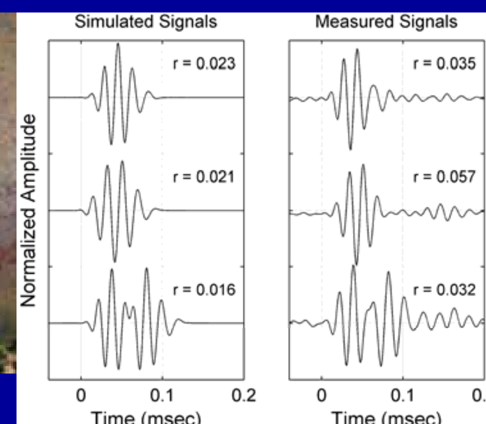
What have we done

- Constructed pipe beds to test new technology

What are we doing

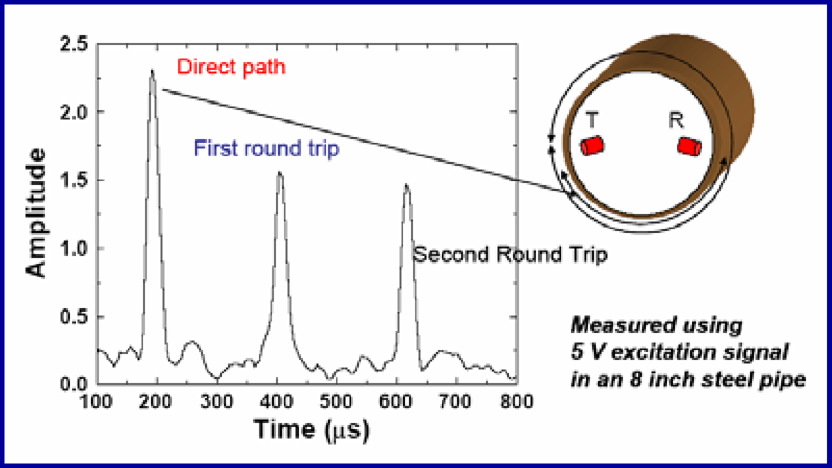
- Long Term Monitoring using Guided Wave (MsS)

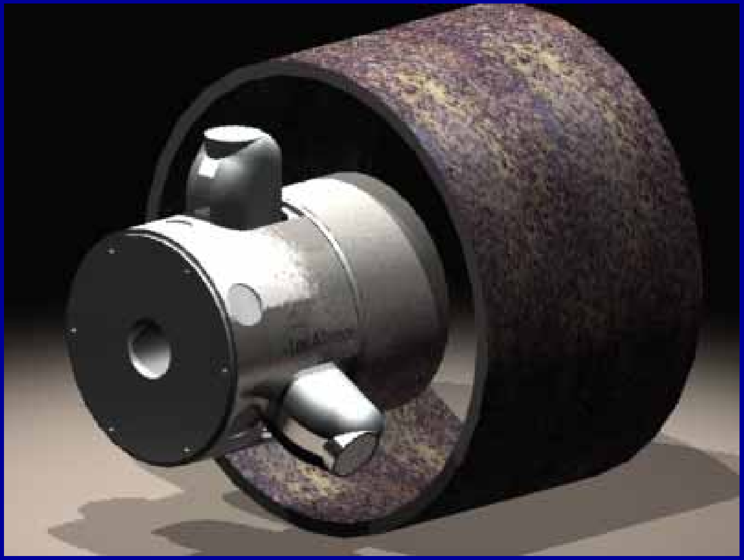
- Mini-Camera for Inspection of Cased Crossings



What are we doing

- Acoustic Stand-off Technique for Internal/External Inspection





What Remains to be done?

- New sensors for detecting defects
- Non intrusive inspections
- Further engineering evaluation of defects and failure mechanisms
- Reconcile %CSA to % thru wall
- Improve locating methods/ devices
- Education
- Damage Prevention technology