MsS Technology

For long-range guided-wave inspection and monitoring of large structures

Southwest Research Institute™

San Antonio, Texas

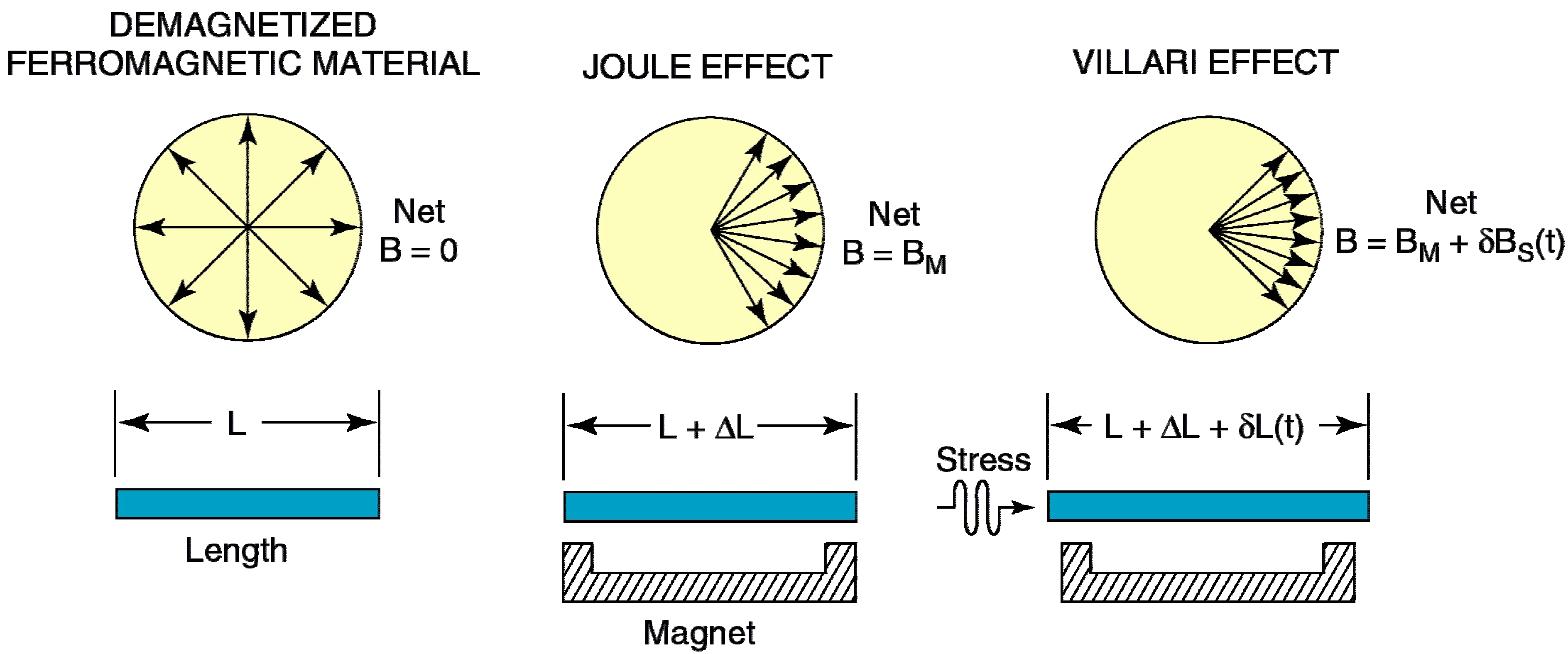
MAGNETOSTRICTIVE SENSOR (MsS) TECHNOLOGY

- A new emerging technology for rapidly assessing large structures for defects
  - Piping networks, boiler tubes, plates, storage tanks, pressure vessels, beams, cables, etc.
- Used to launch a pulse of structure-borne elastic waves, called guided waves, along the structure, and detect signals reflected from defects in the structure
  - Inspect and monitor a large area of the structure from a fixed test location

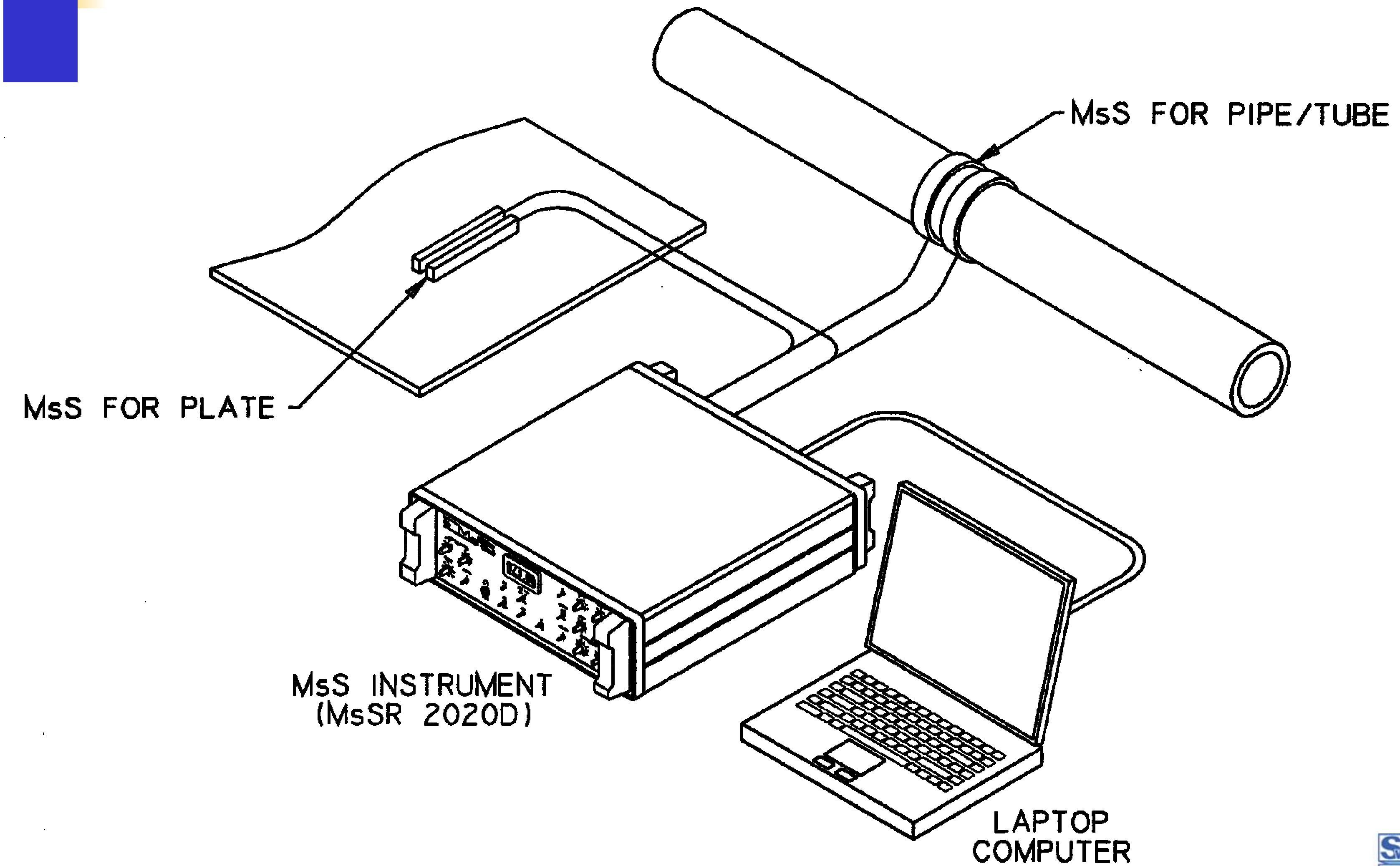
MsS FEATURES

- Generates and detects guided waves electromagnetically in ferrous materials
- Requires no coupling medium or direct contact
- Inexpensive
- Versatile (in configuration, frequency, and wave mode)

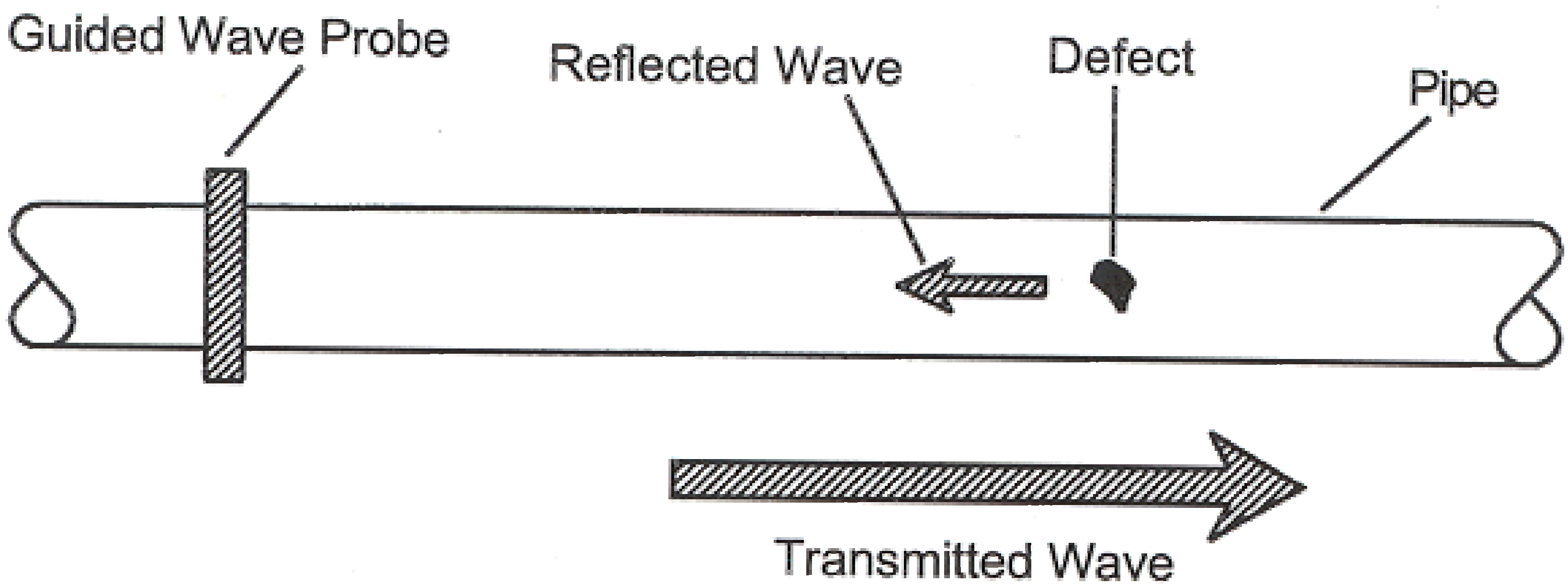
PHYSICAL PRINCIPLES OF MsS FOR GENERATION AND DETECTION OF WAVE



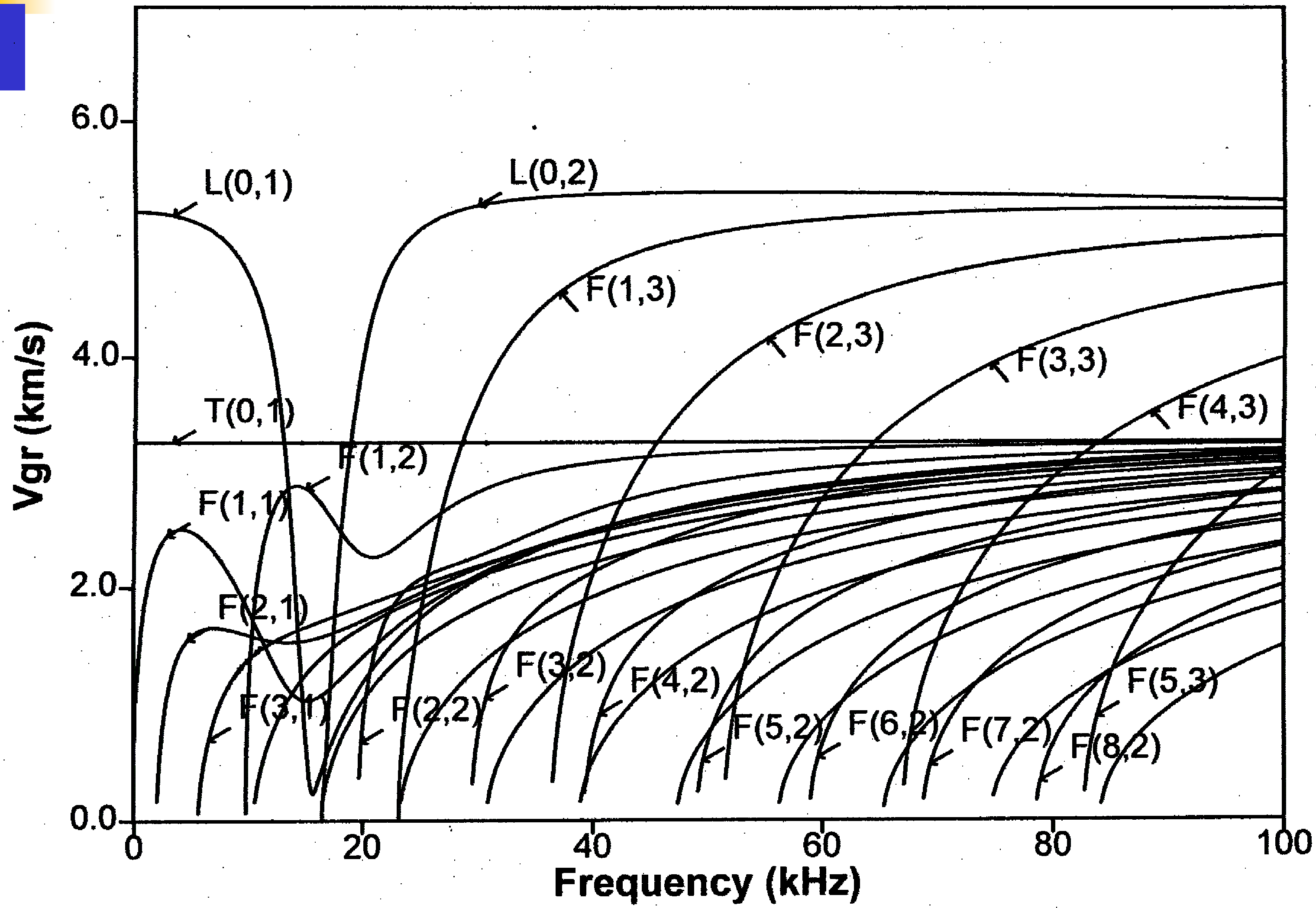
MsS INSTRUMENT SYSTEM



MsS APPLICATION FOR LONG-RANGE GUIDED-WAVE PIPING INSPECTION



GUIDED-WAVE DISPERSION CURVES IN PIPE— 4.5” OD, 0.337” WALL STEEL PIPE



TESTING OF 60" OD PIPELINE

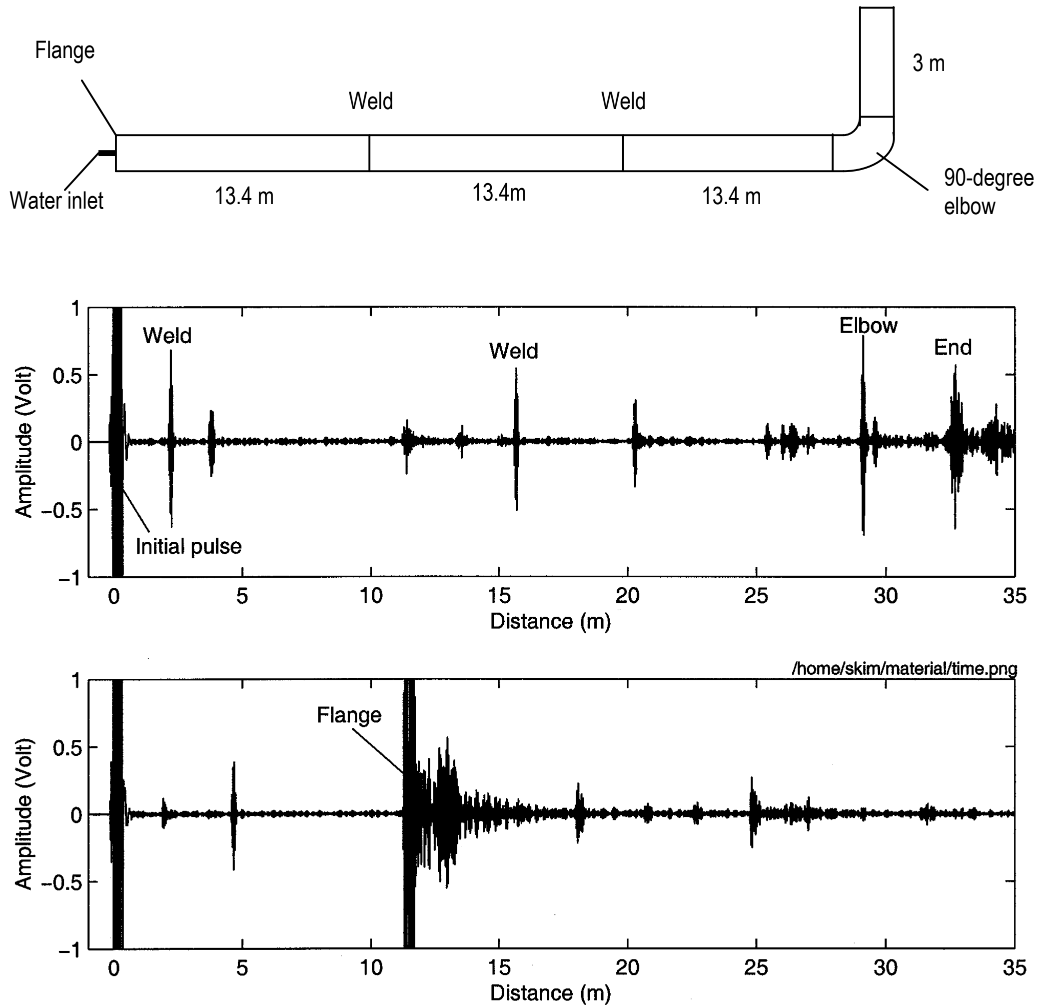
TESTING OF SLEEVED PIPES AT A ROAD CROSSING

TESTING OF VERTICAL LINES

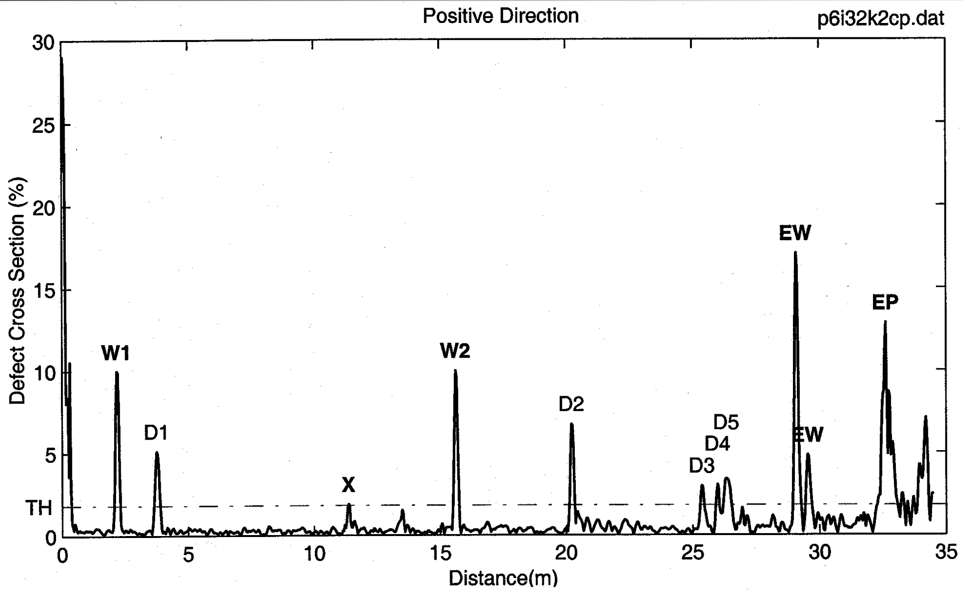
RECENT ADVANCES FOR PIPING INSPECTION

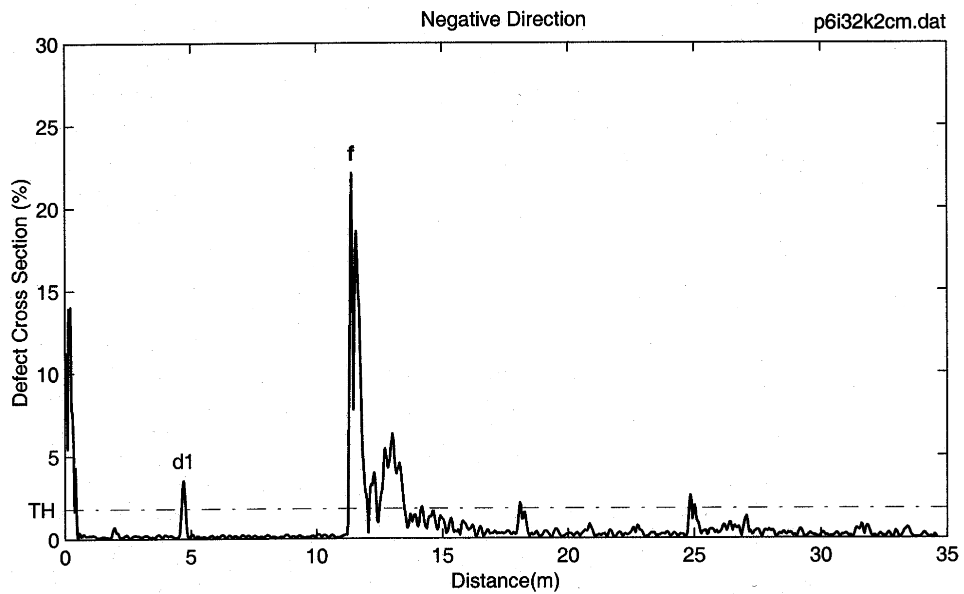
- Use of torsional mode instead of longitudinal mode
  - Thin nickel strip instead of heavy magnets
  - Lightweight and low sensor assembly cost
  - Greater spatial resolution and defect detection sensitivity
  - Sensor assembly can be permanently installed for inexpensive long-term (years) periodic monitoring and inspection
- Automated data analysis and reporting software
  - Greatly reduces time for analysis and reporting (down to several minutes)
  - Greatly reduces inspector skill level
- Upgraded instrument (MsSR-2020D)
  - Pulse-echo operation (reduces number of sensor coils by half)
  - Built-in digital output (operates with common laptop computers)

32-kHz T-WAVE DATA OBTAINED FROM WATER-FILLED PIPELINE SAMPLE (TOP)



VIDEO DATA AND COMPUTER ANALYSIS RESULTS





INSPECTION REPORT GENERATED BY SYSTEM COMPUTER AFTER ANALYSIS

02-May-2002

Inspector: Bob Spinks

Location: SwRI

Pipe: 168-mm-OD, 7.1-mm-wall Steel Pipe

Velocity: 3.221 m/msec

Attenuation: 0.054 dB/m

Threshold: 1.8 % Defect

Assumption ---> Weld Signal: 10.0 % Defect

Frequency: 32 kHz

Cycles: 2

Gain: 24 dB

Filter: 32 kHz

Sampling Freq.: 1.0 MHz

Positive Direction

p6i32k2cp.dat

No.	Symbol	Dist.	% Defect	Class	Comments
1	**W1**	**2.17**	**10.00**	**Weld**	
2	D1	3.75	5.11	Defect	
3	**X**	**11.37**	**1.87**	**Directionality**	
4	**W2**	**15.62**	**10.00**	**Weld**	
5	D2	20.22	6.72	Defect	
6	D3	25.36	2.96	Defect	
7	D4	25.98	3.05	Defect	
8	D5	26.33	3.39	Defect	
9	**EW**	**29.07**	**17.08**	**Elbow Weld**	**90-degree elbow**
10	**EW**	**29.53**	**4.84**	**Elbow Weld**	**90-degree elbow**
11	**EP**	**32.63**	**12.87**	**End of Pipe**	

Negative Direction

p6i32k2cm.dat

No.	Symbol	Dist.	% Defect	Class	Comments
1	d1	4.71	3.50	Defect	
2	**f**	**11.39**	**22.11**	**Flange**	

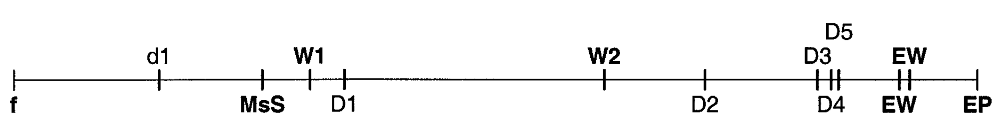


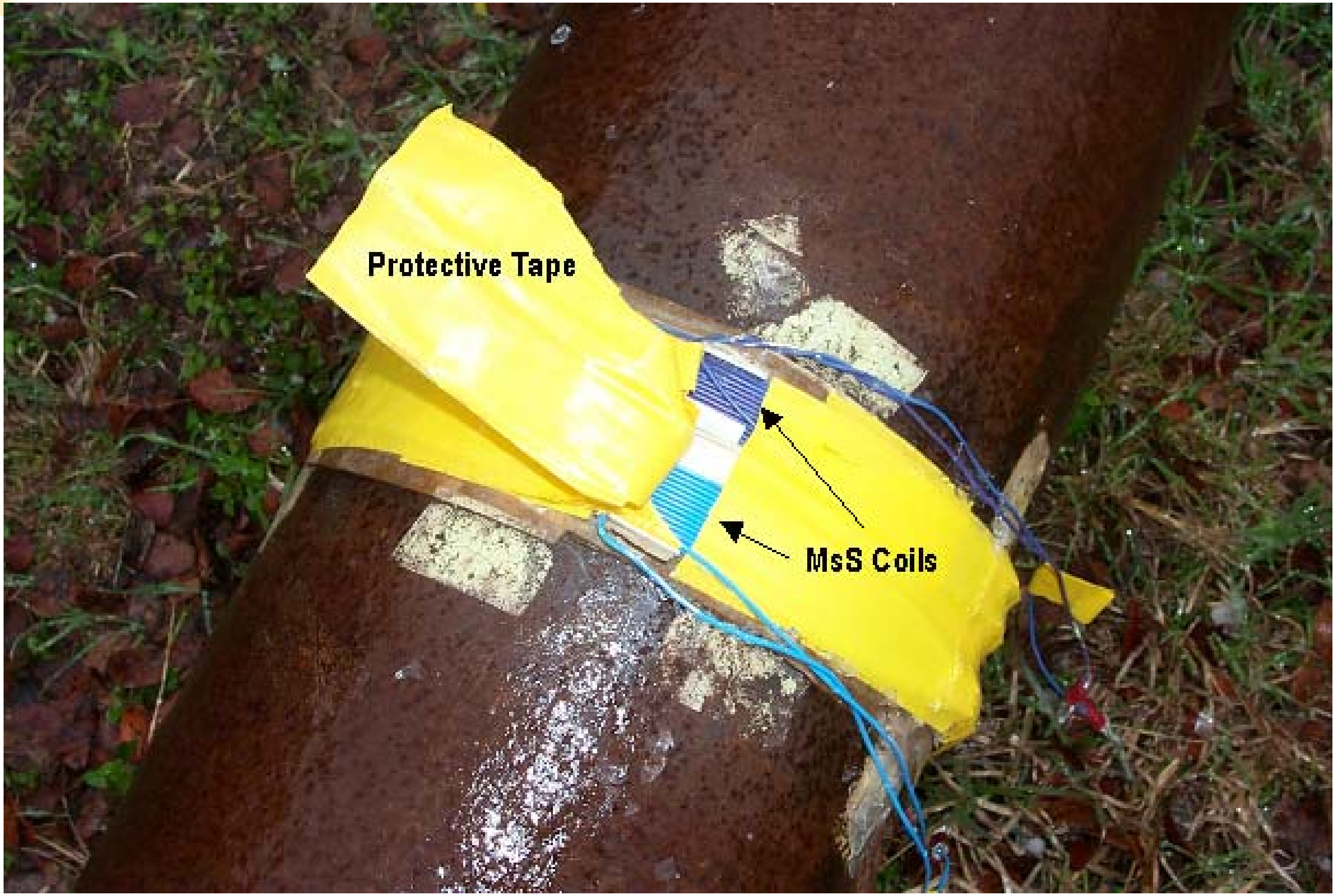
TABLE 1. CAPABILITIES/LIMITATIONS OF PRESENT MsS SYSTEM FOR PIPING INSPECTION

Item	Capabilities/Limitations	Remarks
Dead Zone	14 inches (35 cm) at 64-kHz L-wave or 32-kHz T-wave	Using a two-cycle pulse, will vary with frequency and number of cycles in pulse
Spatial Resolution	7 inches (18 cm) at 64-kHz L-wave or 32-kHz T-wave	Using a two-cycle pulse, will vary with frequency and number of cycles in pulse
Pipe Material	Any material	For nonferrous pipe, a thin nickel strip is bonded
Pipe Size	Up to more than 48-inch (122-cm) diameter and less than 0.5-inch wall thickness	Outside the range, performance will be reduced due to lower MsS sensitivity
Inspection Range	100 feet (30 m) or greater with 64-kHz L-wave or 32-kHz T-wave	In bare, straight pipe in good surface condition
Detectable Defect Type	Isolated corrosion pits and circumferential cracks; both internal and external defects	Longitudinal defects could also be detectable if their circumferential cross section exceeds minimum detectable defect size
Minimum Detect-able Defect Size	2 to 3% of pipewall cross section	Isolated defects in pipes with otherwise good surface condition; varies with frequency and defect shape
Defect Location	Axial location within ±2 inches (5 cm) at 64-kHz L-wave or 32-kHz T-wave	Cannot determine circumferential orientation
Defect Characterization	Limited to rough estimation of circumferential cross section	Cannot determine depth, width, and length, whether it is on OD or ID

TABLE 2. EFFECTS OF PIPELINE GEOMETRIC FEATURES AND OTHER CONDITIONS ON CURRENT INSPECTION CAPABILITIES

Features/Conditions	Effects
Flange/Valve	Prevents wave propagation; forms end point of inspection range
Tee	Causes large disruption in wave propagation; limits inspection range up to that point
Elbow	Causes large disruption in wave propagation; limits inspection range no farther than elbow region
Bend	Has negligible effect if bend radius is greater than 3 times pipe OD; if bend radius is less than above, behaves like elbow
Side Branch	Causes a wave reflection and thus produces a signal; no significant effects on inspection capabilities
Clamp	Causes a wave reflection and thus produces a signal; no significant effects on inspection capabilities
Weld Attachment	Causes a wave reflection and thus produces a signal; if attachment is large (such as pipe shoes), can reduce inspection range
Paint	Has negligible effects
Insulation	Has no effects unless insulation is bonded to pipe surface, in which case inspection range will be shortened due to higher wave attenuation
Coating	Has negligible effects if coating is thin (e.g., fusion-bonded epoxy coating); thicker coating (e.g., bituminous or polyethylene coating) increases wave attenuation and shortens inspection range
Liquid in Pipe	No effect on T-wave; significant degradation on L-wave
General Surface Corrosion	Increases wave attenuation and shortens inspection range
Soil	If pipe is buried, surrounding soil increases wave attenuation, inspection range is shortened

PERMANENTLY INSTALLED MsS COILS ON A PIPELINE



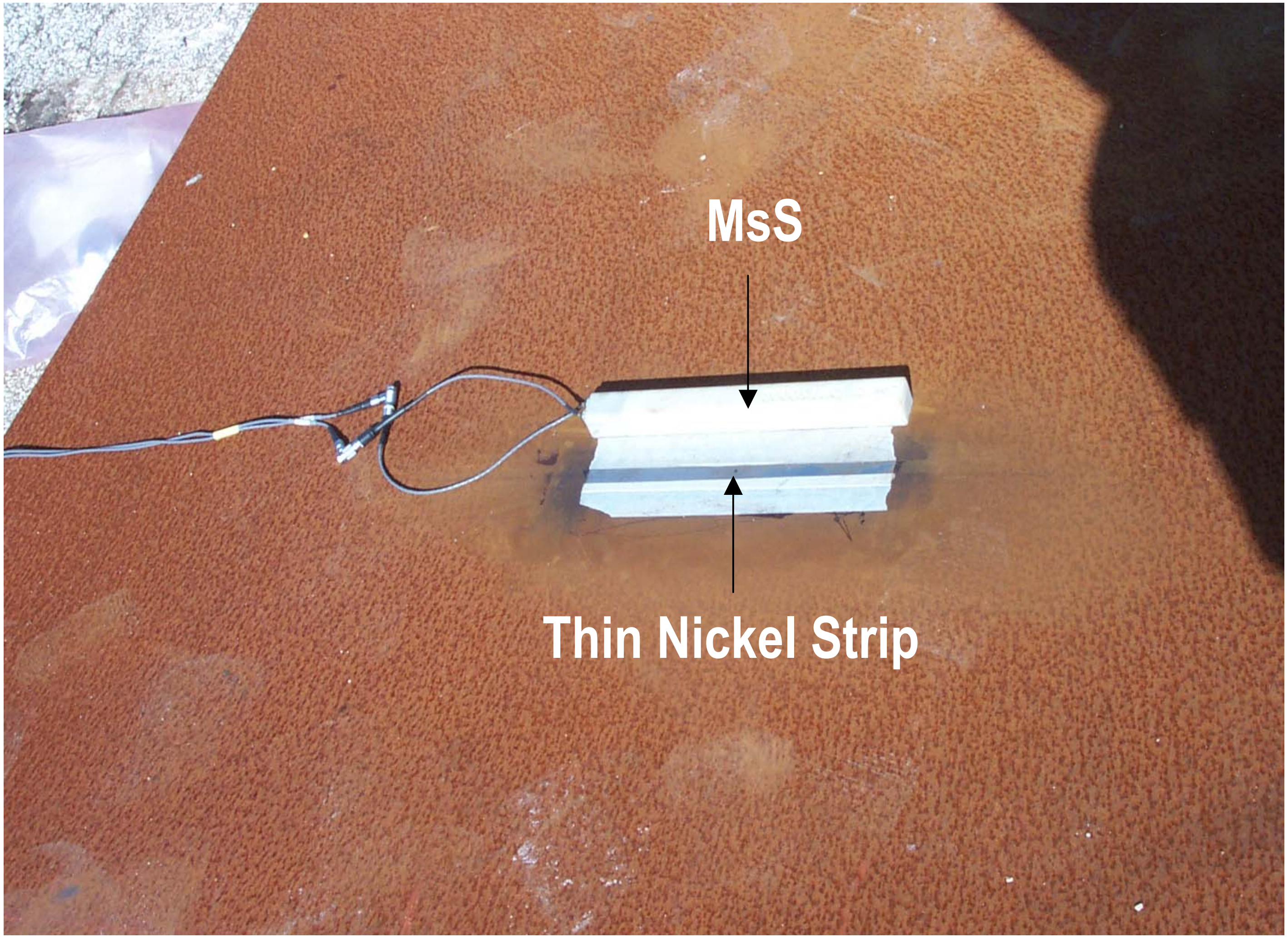
ONGOING AND NEAR FUTURE RELATED R&D ACTIVITIES

- Long-term monitoring of buried transmission pipelines for corrosion defects
- High-power MsS system for extended inspection range (about 20-fold increase in signal amplitude)
- Heat-exchanger tubing inspection system (from inside tube)

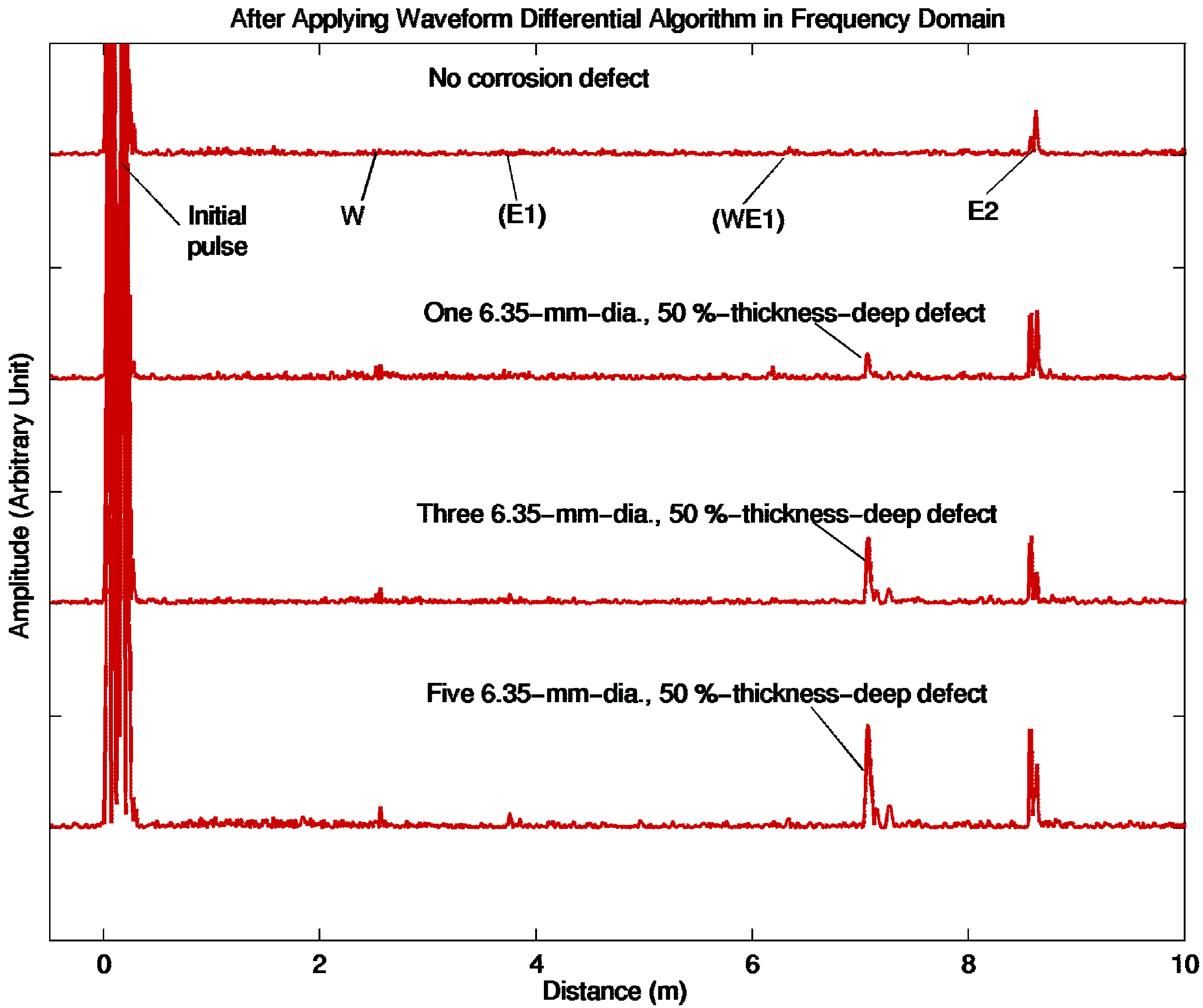
EXAMPLES OF OTHER MsS APPLICATIONS

- Inspection and monitoring of plate-type structure (e.g., aboveground storage tanks, pressure vessels, nuclear containment liners)
- Inspection of suspension bridge cables
- Inspection of buried anchor rods

PLATE INSPECTION

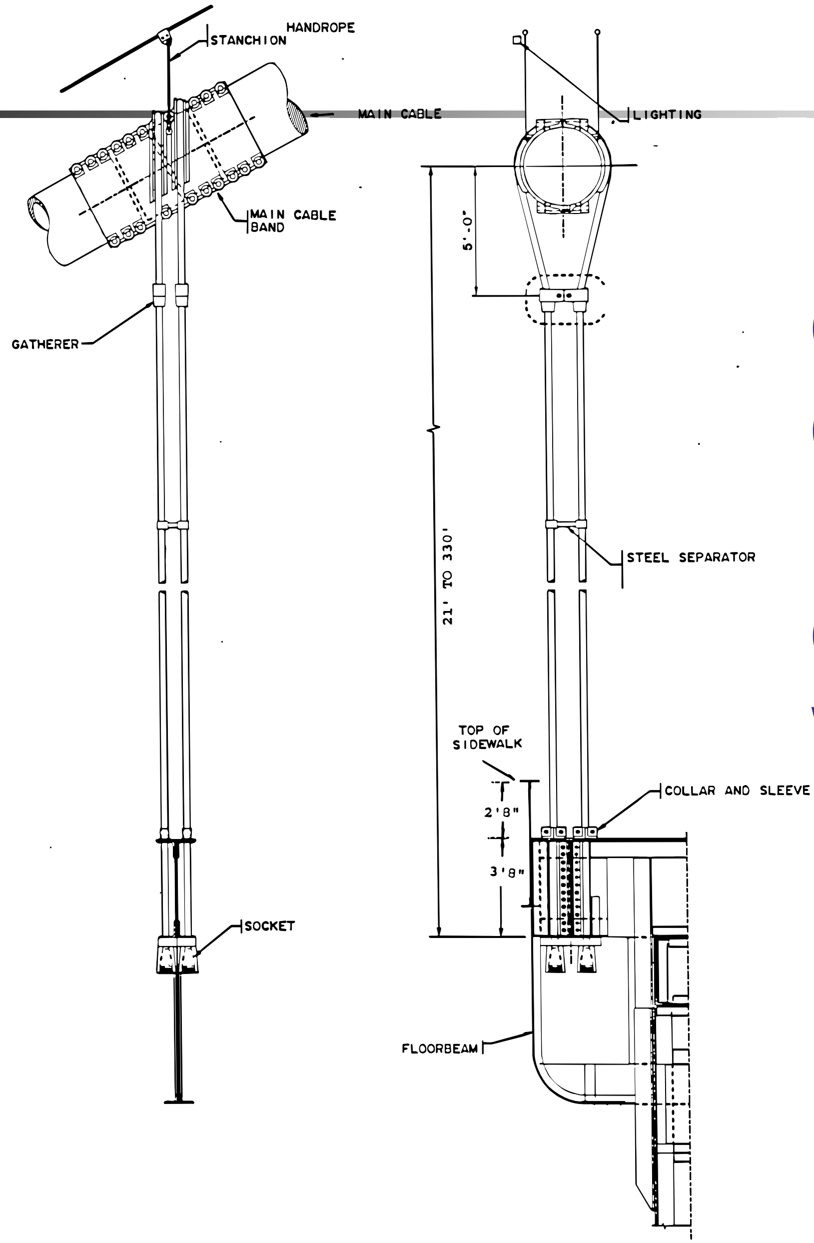


DIFFERENTIAL DATA FOR CORROSION MONITORING IN PLATE

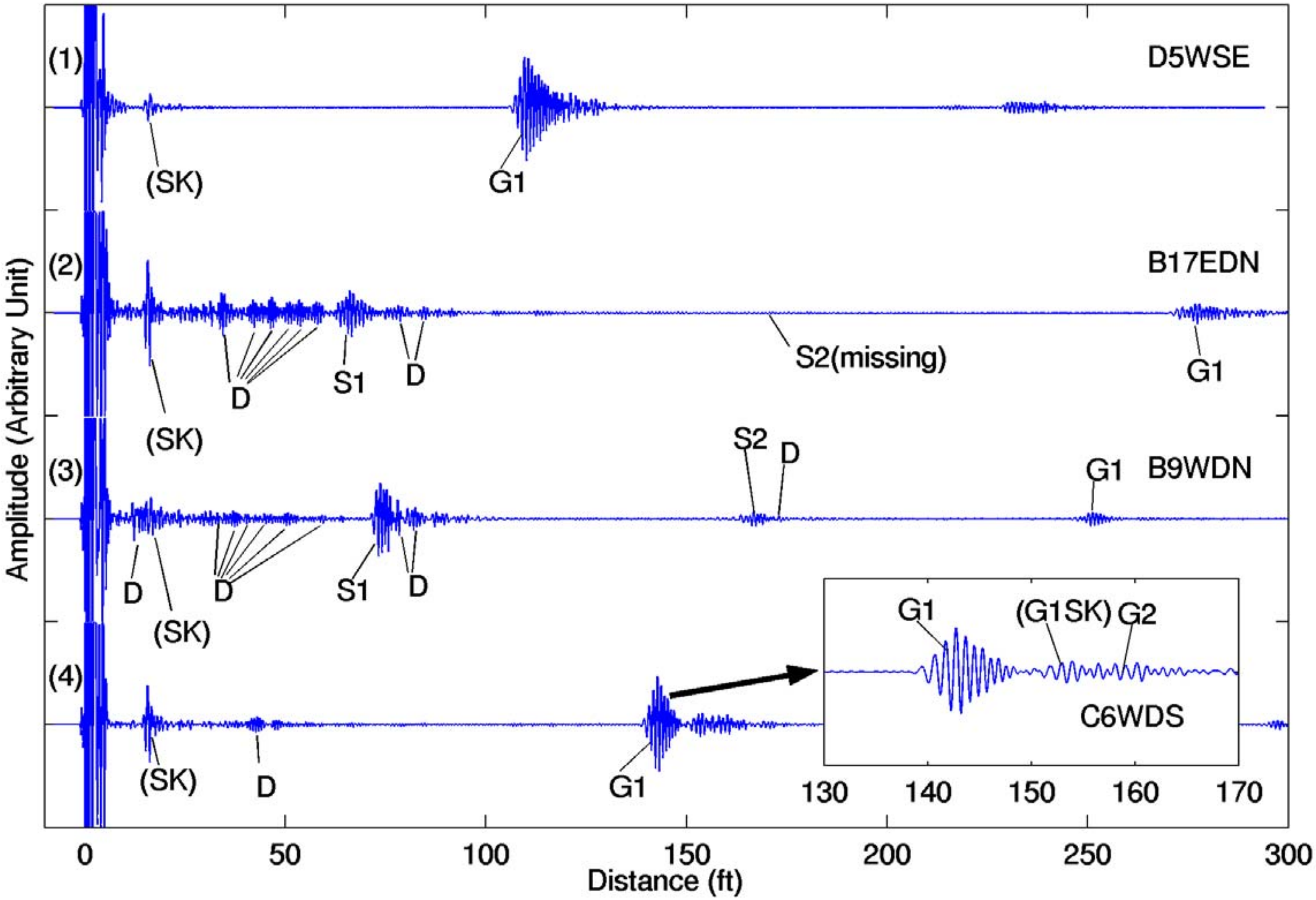


3” DIA. SUSPENDER ROPE INSPECTION—GEORGE WASHINGTON BRIDGE, NEW YORK

CONFIGURATION OF SUSPENDER ROPE ON GEORGE WASHINGTON BRIDGE



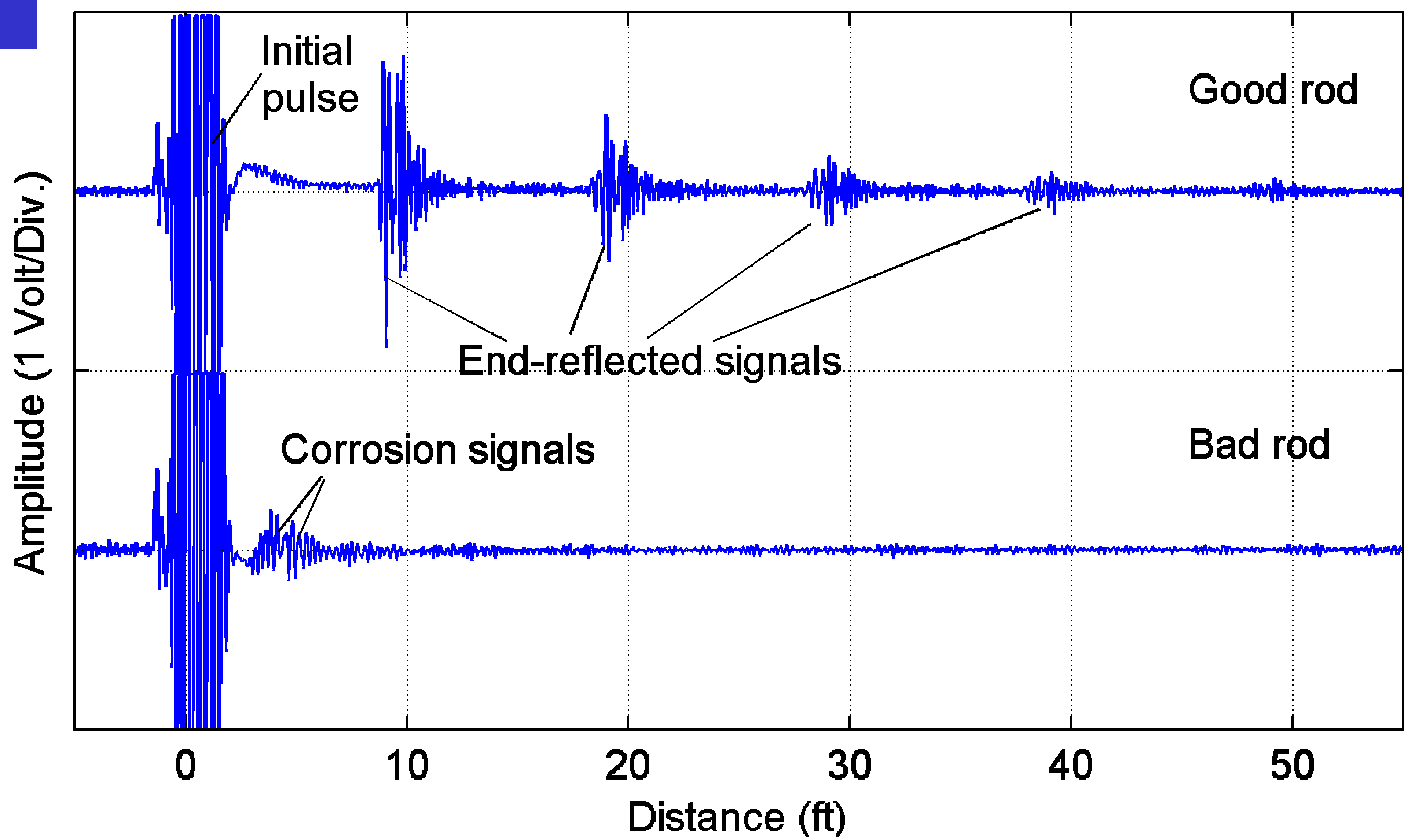
DATA FROM SUSPENDERS ON GEORGE WASHINGTON BRIDGE



Top trace was from a newly installed suspender; the rest were from existing suspenders.

ANCHOR ROD INSPECTION

ANCHOR ROD DATA



A BAD ROD REMOVED FROM THE GROUND

CONCLUSIONS

- MsS technology
  - Versatile and economical tool for inspection and condition monitoring of large structures
  - Can help reduce operating and maintenance costs while improving the structure reliability
- SwRI welcomes your inquiry for
  - MsS technology licensing
  - MsS system purchase
  - New applications

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