

# HIGH-POWER, LONG-RANGE, GUIDED-WAVE INSPECTION OF PIPELINES

DOT Contract No. DTRS56-03-T-0013  
SwRI Project 14.10062

DOT Project Review Meeting  
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by

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# OUTLINE

- Overview of Project
  - ◆ Objective/target goal, technical approach, work plan/scope, schedule/budget and participants
- Work Accomplished and Findings
- Remaining Work
- Summary



# PROJECT OVERVIEW

- Objective – develop a high-power MsS to extend the range of guided-wave inspection
- Target Goal – a 20-fold (26-dB) increase in signal amplitude
  - ◆ This corresponds to an additional inspection range of
    - ◆ 6.5 ft on pipeline with  $\alpha = 2.0$  dB/ft
    - ◆ 13 ft on pipeline with  $\alpha = 1.0$  dB/ft
    - ◆ 26 ft on pipeline with  $\alpha = 0.5$  dB/ft
    - ◆ 52 ft on pipeline with  $\alpha = 0.25$  dB/ft
    - ◆ 130 ft on pipeline with  $\alpha = 0.10$  dB/ft



# TECHNICAL APPROACHES USED FOR ENHANCING MsS POWER

- Alternate Strip Material (to nickel)
- Sensor Optimization
- Multiple Sensor Pairs



# WORK PLAN/SCOPE

- (1) Evaluate Power-Enhancing Approaches in Laboratory and Determine Implementation Plan
- (2) Modify Existing MsS Instrument Hardware and Refine Software and Test Procedures for Field Implementation
- (3) Conduct Field Evaluations and Determine Inspection Capabilities and Limitations



# OVERALL DURATION/BUDGET AND PARTICIPANTS

## ■ Overall Duration

- ◆ Initial Plan—18 months (9/8/2003 to 2/28/2005)
- ◆ Now extended by additional 3 months to 5/31/2005

## ■ Total Budget—\$ 625,020

## ■ Participants and Cost Contribution

- |                                 |           |
|---------------------------------|-----------|
| ◆ DOT                           | \$272,420 |
| ◆ PRCI                          | \$150,000 |
| ◆ SOCAL (in-kind)               | \$ 50,000 |
| ◆ Gulf South Pipeline (in-kind) | \$ 50,000 |
| ◆ SwRI (in-kind)                | \$102,600 |

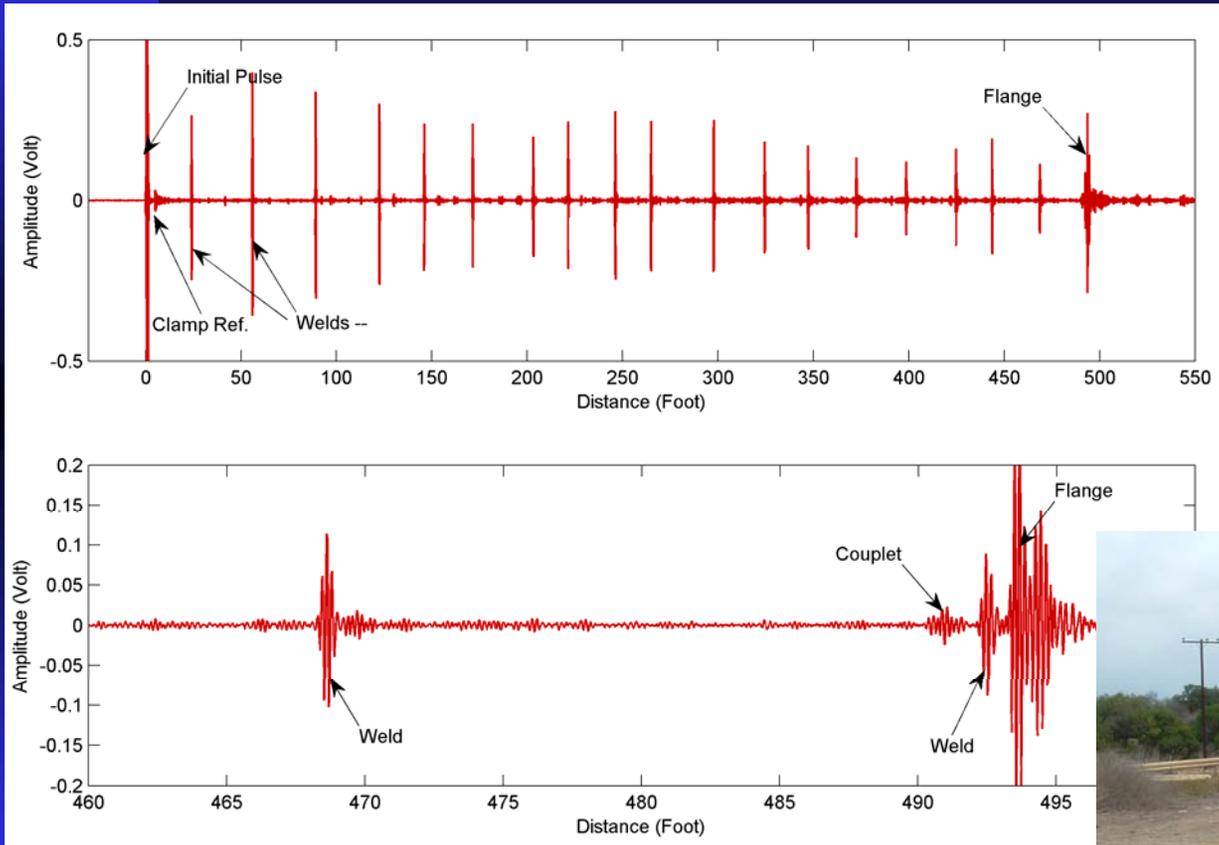


# WORK ACCOMPLISHED AND FINDINGS (as of March 18, 2005)

- Work Progress – All tasks completed except one additional field evaluation and reporting
- Target goal of 20-fold increase in signal amplitude has been met by combined use of
  - ◆ Better strip material – HIPERCO<sup>®</sup> 50HS
  - ◆ Sensor optimization
- In straight aboveground pipelines, more than 500 feet can be tested in one direction for detection of 2% defects



# EX. DATA – 16-INCH GAS TRANSMISSION LINE



# PHYSICAL PROPERTIES OF STRIP MATERIALS

	Hiperco <sup>®</sup> 50HS (iron-cobalt alloy)	Nickel (annealed)
Saturation Magnetostriction	$60 \times 10^{-6}$	$35 \times 10^{-6}$
Curie Temperature	1720°F	662°F
Yield Strength	73 ksi	15 ksi



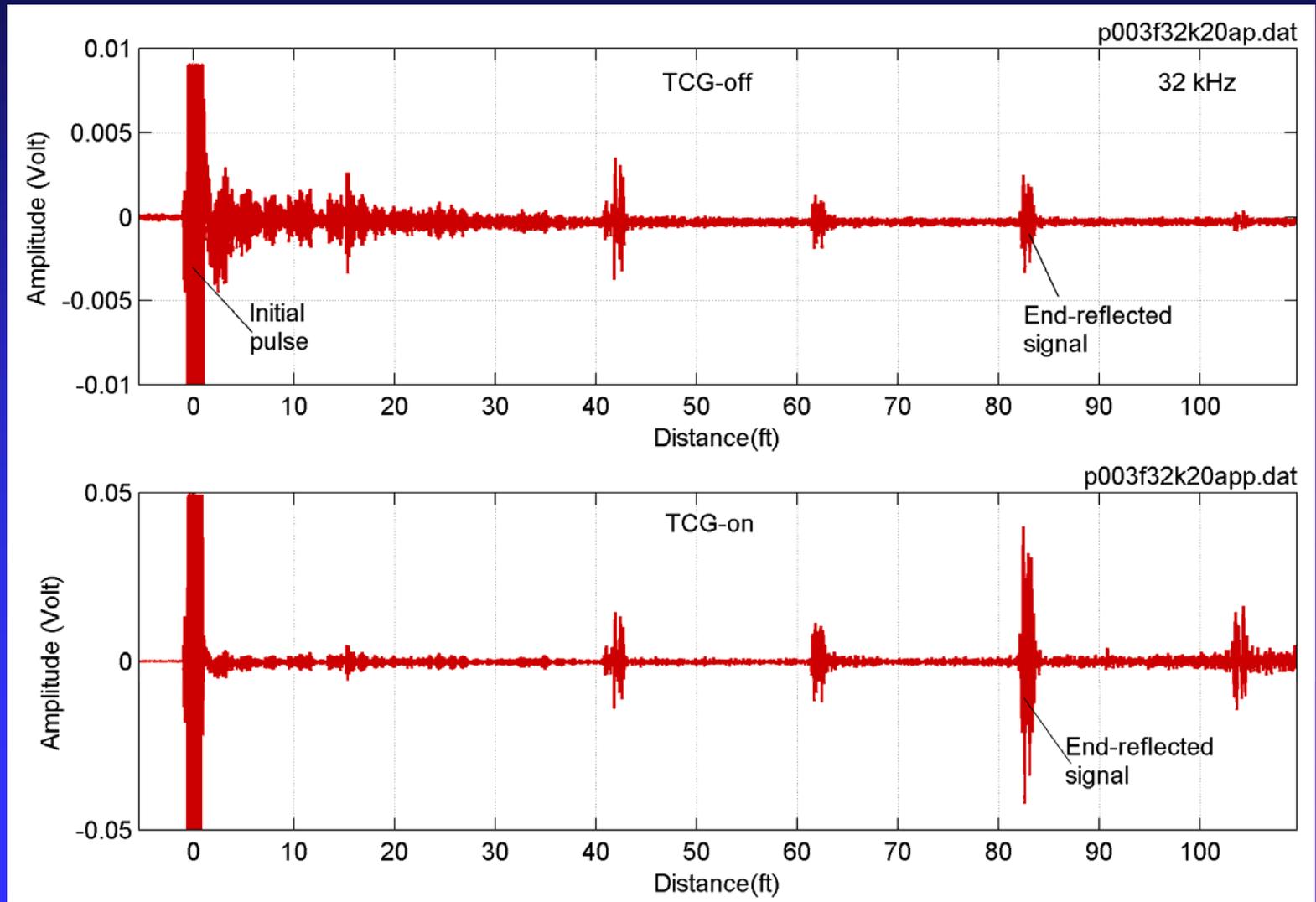
# WORK ACCOMPLISHED AND FINDINGS (cont'd)

- MsS system hardware modified and refined
  - ◆ Time control gain (TCG) feature added – improves signal quality
- Testing procedures refined
  - ◆ Procedures for adhesively bonding strips to pipe improved – better bonding quality and shorter setup time
    - ◆ Test time on 24-inch pipe less than 1 hour
  - ◆ Calibration procedures added (based on hose-clamp signal)



# EFFECT OF TCG ON SIGNAL QUALITY

(data taken from 6-5/8-inch-OD bitumen-coated pipeline sample)

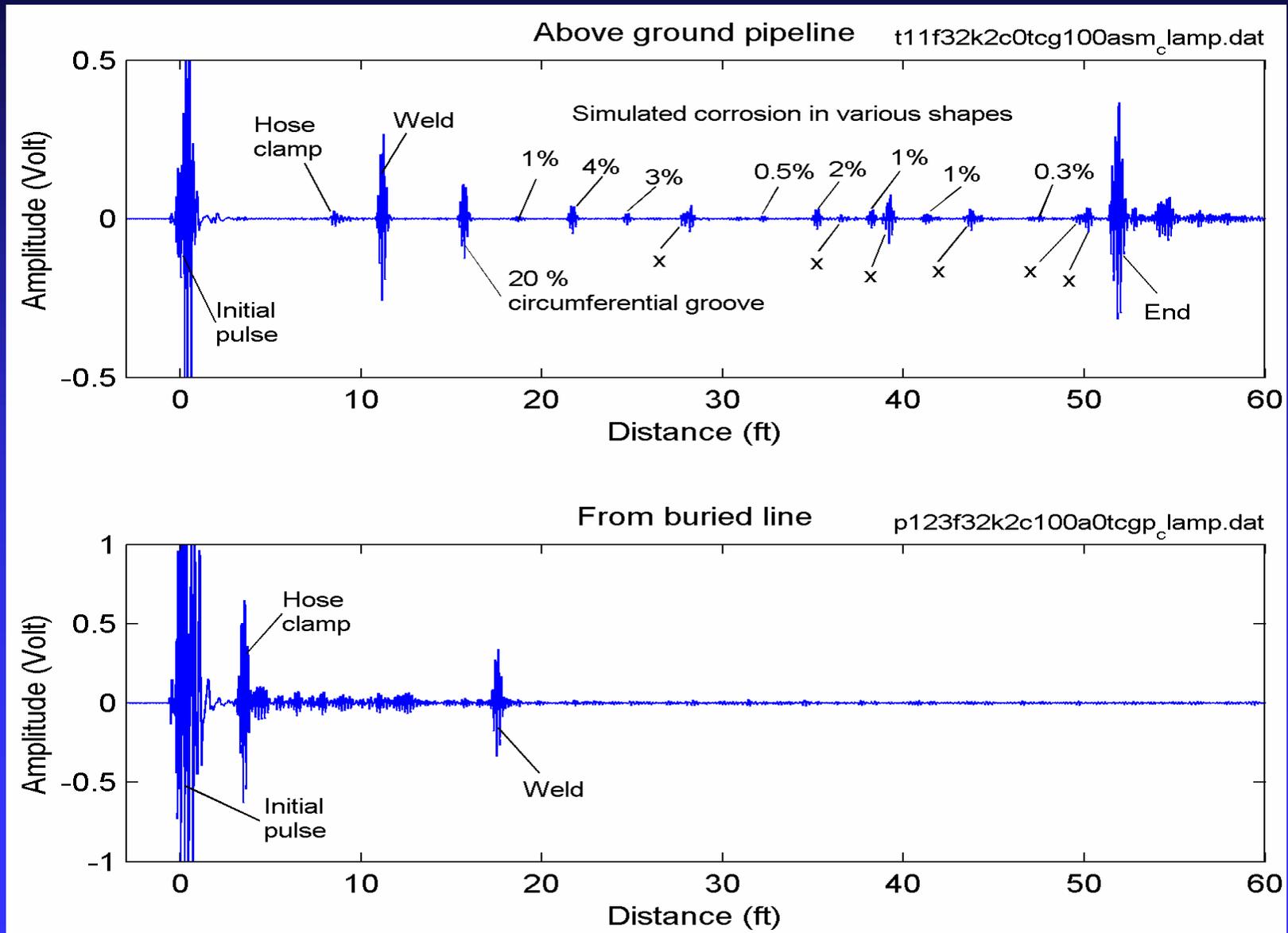


# HOSE-CLAMP REFERENCE

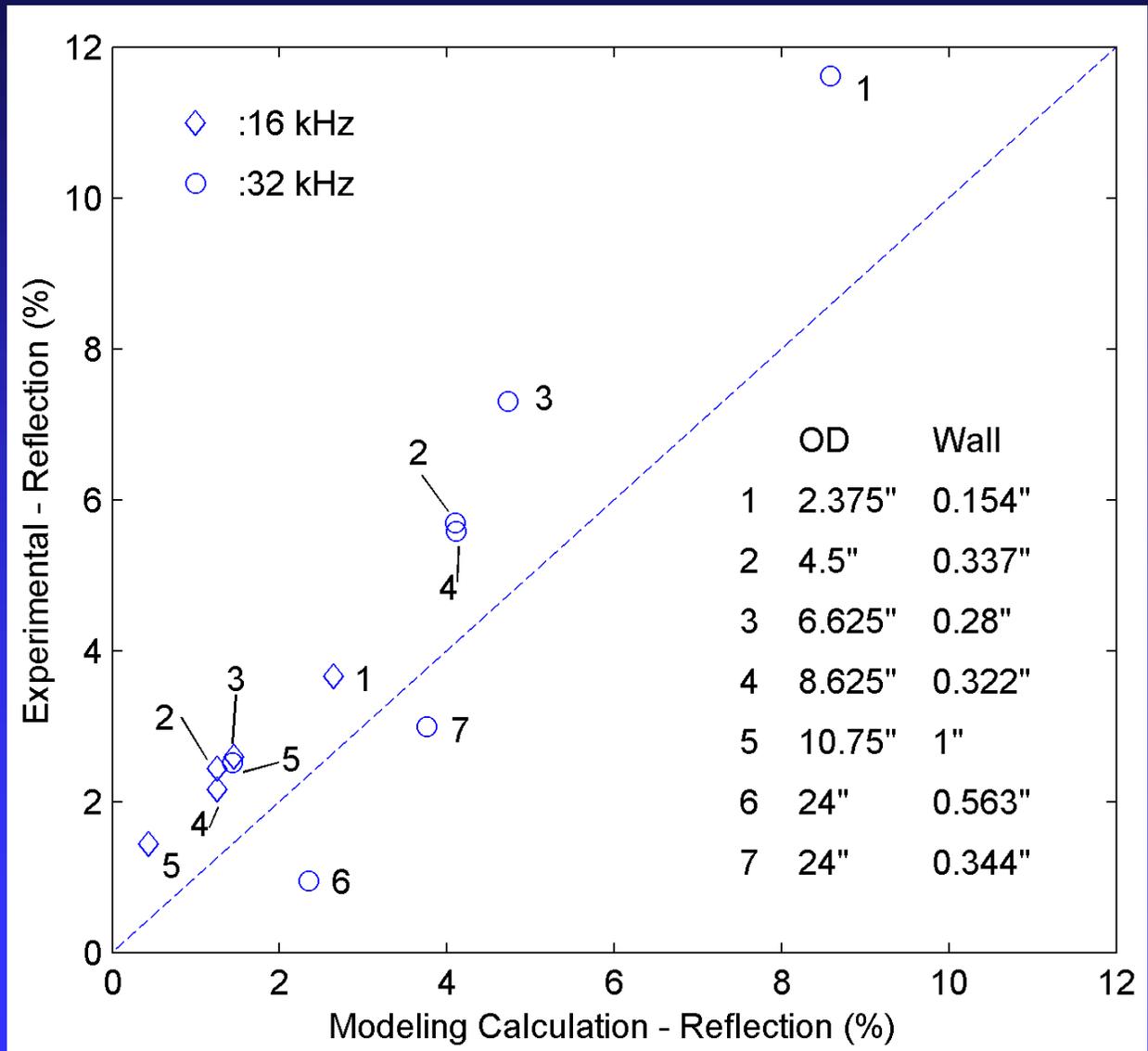


# Ex. of Clamp Reference Signals and Calibration

## 32 kHz, comparison between aboveground and buried lines



# REFLECTION COEFFICIENT OF HOSE-CLAMP REFERENCE



# WORK ACCOMPLISHED AND FINDINGS (cont'd)

- MsS system software for data acquisition, analysis, and reporting modified and refined (ongoing process)
  - ◆ Features for differentiating weld signals from defect signals added – based on phase information
    - ◆ Weld signals – in phase
    - ◆ Defect signals – out of phase



# WORK ACCOMPLISHED AND FINDINGS (cont'd)

- Several Field Evaluations Conducted
  - ◆ Pipeline Simulation Facility
  - ◆ Gulf South Pipeline – Vicksburg area
  - ◆ SOCAL – Santa Barbara and LA areas
  - ◆ Con. Edison – NY
- Capabilities
  - ◆ Capable of inspecting 500 to 1000 feet in one direction for 2 to 3% defects in straight aboveground pipelines



# WORK ACCOMPLISHED AND FINDINGS (cont'd)

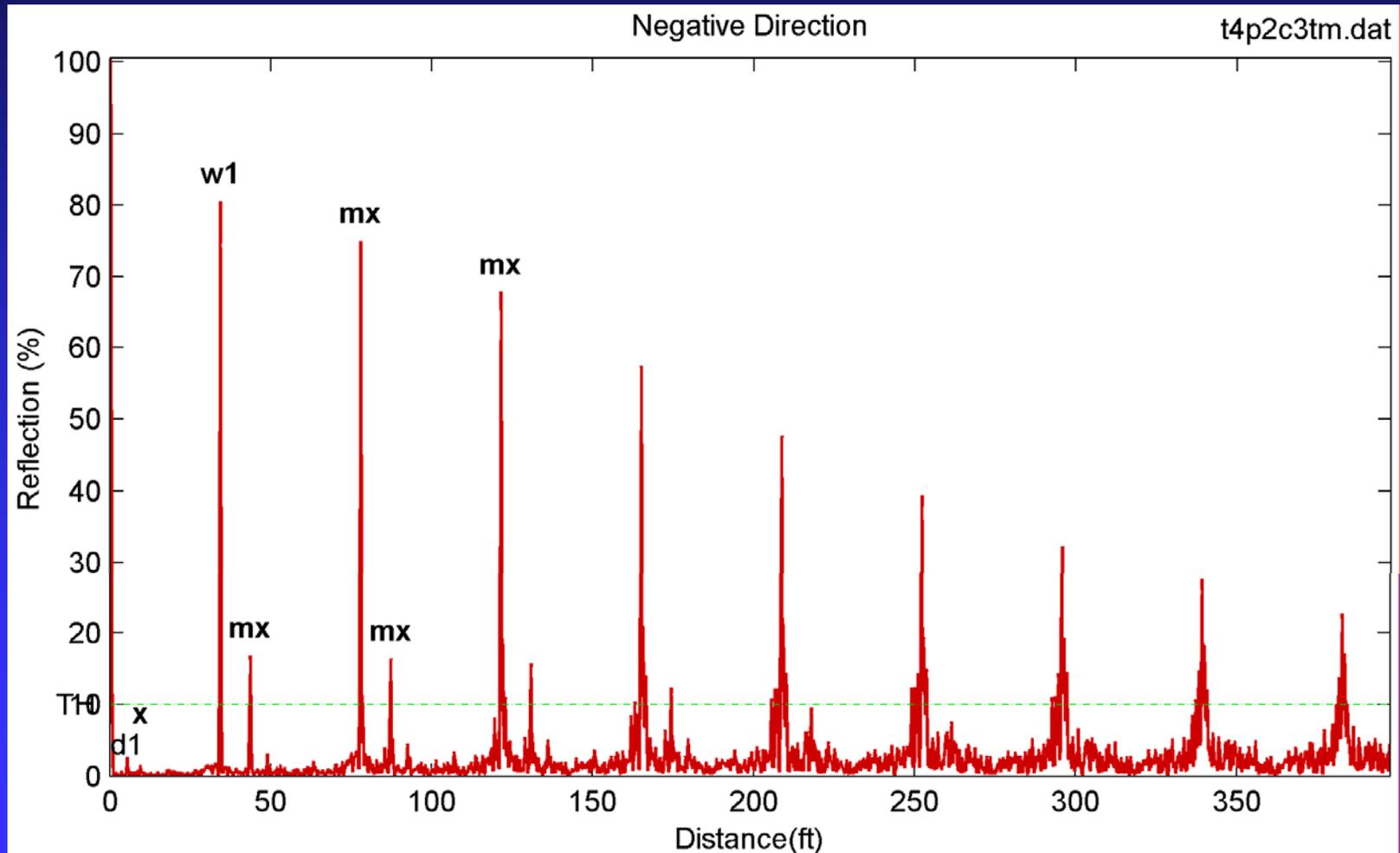
## ■ Capability Limiting Factors

- ◆ Wave propagation stoppers and alterants in the line
  - ◆ Flanges, tees, short radius elbows, reducers
  - ◆ Weld joints (if joint is poor)
- ◆ Wave dampers and attenuators on the line
  - ◆ Coating – bitumen, coal tar, PE, etc.
  - ◆ Composite wraps/clamps at supports
  - ◆ Surrounding soil
- ◆ Other line features
  - ◆ Pipe supports, miter joints, clamps, etc.



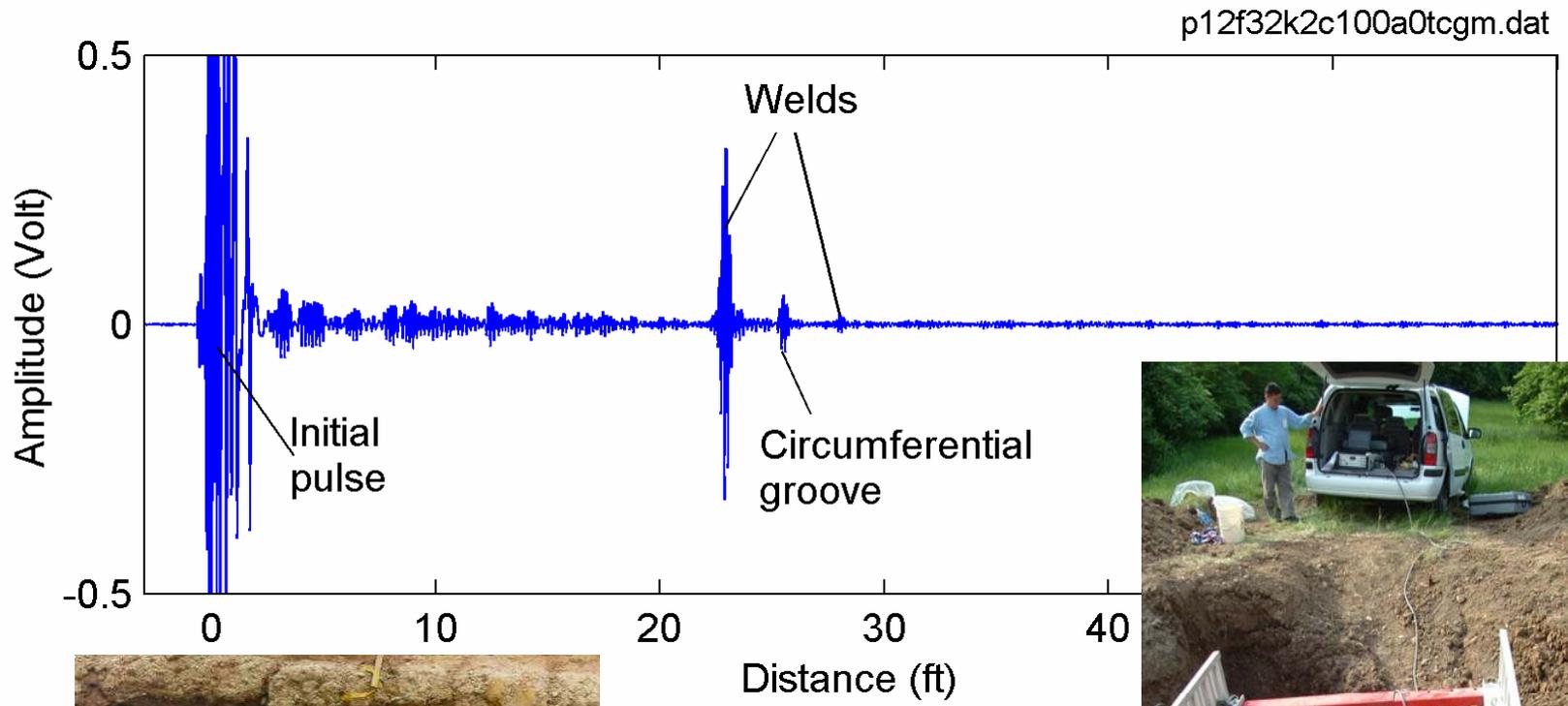
# Example of Limiting Case – Poor Weld Joint

32 kHz, taken from a straight horizontal 14-inch line



# Example of Limiting Case – Buried Lines

32 kHz, signals from a 5-foot-long reference defect sample welded into the flow loop at PSF – 20% circumferential groove



# CONCLUSIONS SO FAR ON GUIDED-WAVE TESTING

- Best used for aboveground pipelines
- Suitable for cased pipelines where lines are not directly surrounded by soil
- Usefulness limited on buried pipelines
  - ◆ Wave attenuation very high
    - ◆ 1 to over 3 dB/ft (compared to 0.01 to 0.03 dB/ft in aboveground piping) at 32 kHz
    - ◆ Lowering frequency may not help
  - ◆ Test range limited to no more than 30 feet for detection of 20 to 30% defects

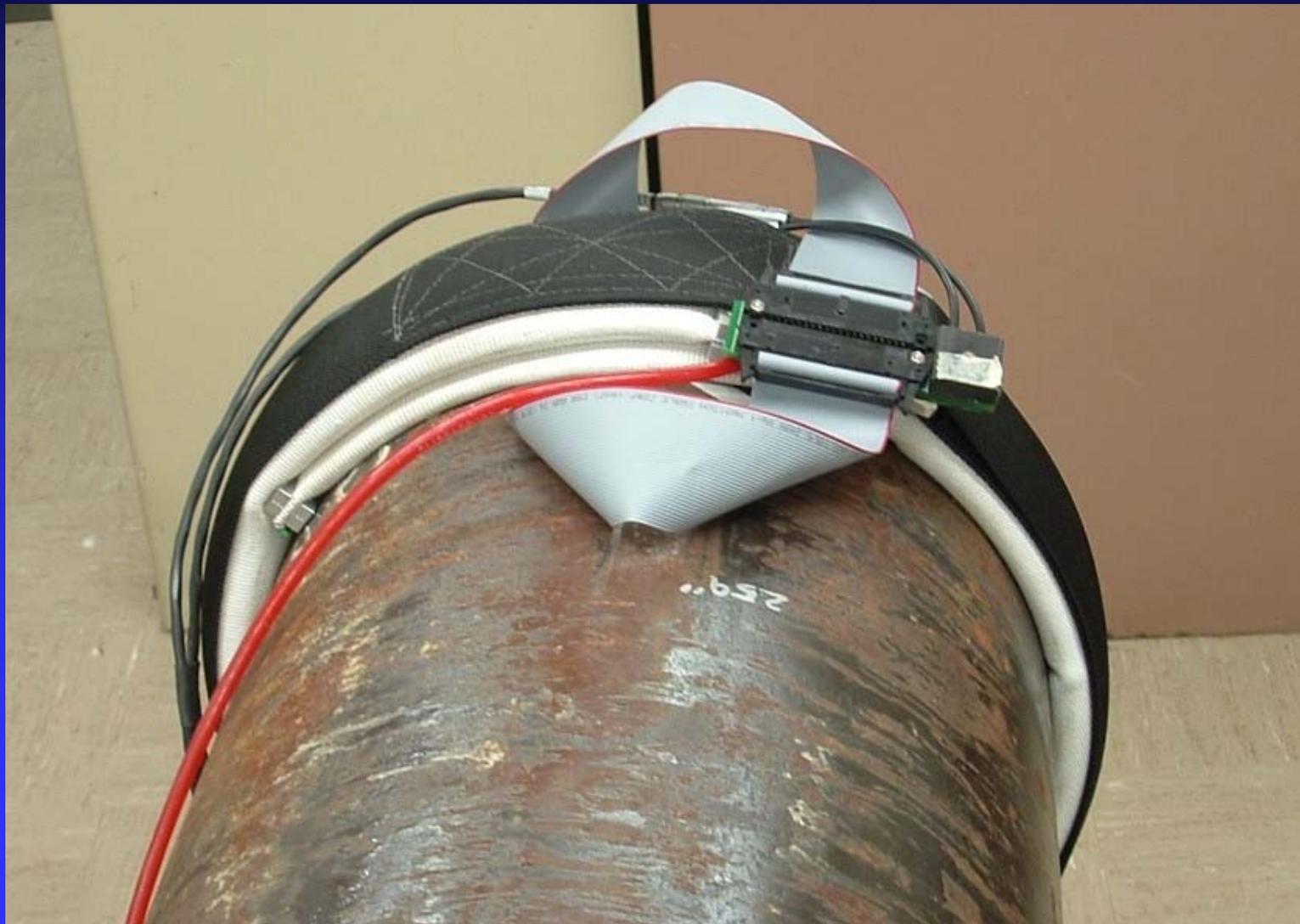


# ONGOING WORK

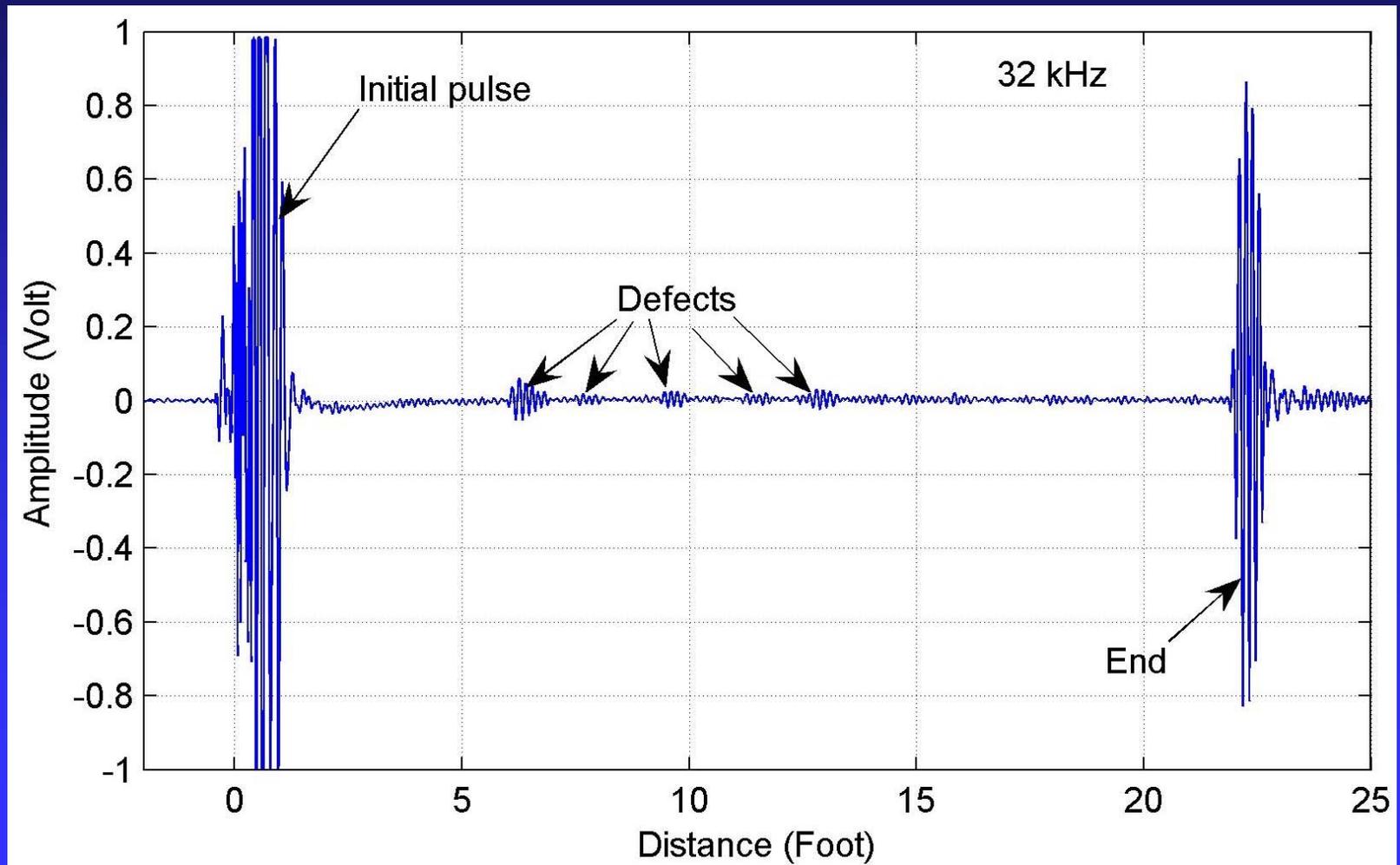
- Incorporation of dry-coupling approach
  - ◆ Eliminates adhesive bonding process
  - ◆ Shortens testing time and reduces cost
- The dry-coupling approach involves
  - ◆ Placing strips around pipe
  - ◆ Placing MsS coils over strips
  - ◆ Placing a bladder over MsS coils
  - ◆ Pressurizing bladder to mechanically couple guided waves from strip to pipe and vice versa



# DRY-COUPLING SETUP



# 32-kHz T-MODE DATA TAKEN USING DRY-COUPPLING APPROACH



# DRY-COUPLING METHOD INCORPORATION PLAN

- Refine bladder/belt arrangement
- Prepare tools for different pipe sizes for use during the field evaluation to be conducted in Spring 2005
- Test performance in the field



# REMAINING WORK

- System Software Refinement
  - ◆ Integration of the weld/defect differentiation feature into the software
- Additional Field Evaluation
  - ◆ Gulf South Pipeline
- Reporting
  - ◆ Review meetings (DOT)
  - ◆ Final report



# TIME SCHEDULE STATUS

- Project performance is behind schedule due to delay in conducting field evaluations
  - ◆ Field evaluation delayed due to weather and scheduling problems with Gulf South Pipeline Company
  - ◆ Field evaluation is expected to be conducted in Spring 2005
  - ◆ A 3-month no-cost time extension (from 5/31/2005 to 8/31/2005) is necessary to complete project work



# FINANCIAL STATUS

- Total project budget has changed due to lower-than-anticipated in-kind contribution for field evaluation on SOCAL pipelines
  - ◆ SOCAL spent \$30,335 to support field evaluations compared to \$50,000 initially anticipated (\$19,665 difference)
  - ◆ Consequently, total project budget was reduced from \$625,020 to \$605,355, raising DOT share from 43.6% to 45%
  - ◆ DOT Agreement Officer (Mr. Osterberg) was informed of changes, and request for agreement modification will be submitted
- Remaining spendable budget is sufficient to complete the project work

