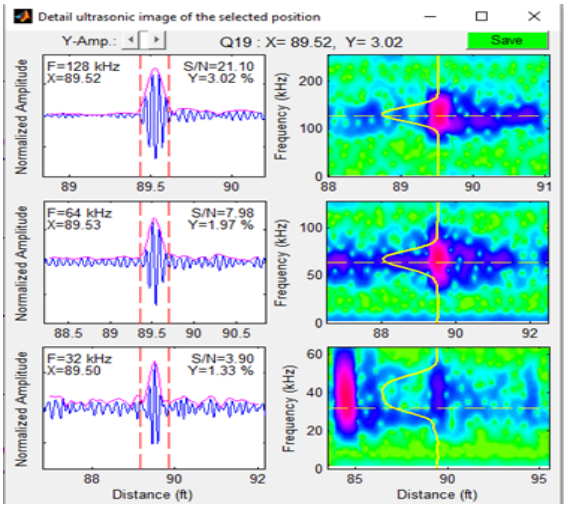
Guided Wave Analysis LLC

Solutions for Guided Wave Testing

Consulting

Training

Sales & Rental



Magnetostrictive Sensor (MsS) System

- Composed of MsS equipment, probe, and software
- Electromagnetically generates and receives ultrasonic waves for long-range guided wave testing

MsSR3030R and MsSRv5R Equipment

- Wide frequency range operation: 5 to 350 kHz
- System band pass filter at 16, 32, 45, 64, 90, 128, 180, and 250 kHz
- Two operation modes: pulse-echo and pitch-catch
- Time-corrected gain (TCG) function in hardware
- Battery operation for 2 days in normal conditions
- Lightweight

MsS Probe

- Operating center frequencies at 8 to 16 kHz, 20-, 32-, 45-, 64-, 90-, 128-, 180-, and 250-kHz
- Several coupling methods depending on surface conditions - Dry coupling, shear couplant, and epoxy bonding
- Installation on any pipe diameter
- Minimum install clearance of 1-inch
- Pipeline inspection up to 500°C surface temperature
- No near field length
- Dead zone length of only 4-11 inches

MsS GIM Software

- Step-by-step procedure for data analysis
- Several automatic processes with pipeline drawing information
  - Amplitude, velocity, and attenuation calibration
  - Setting threshold level
  - Indication finding
- Reduction of false calls by marking mirror and multiple reflection signals
- Multi-frequency analysis up to 8 different center frequency for finding different size of Defects
- Calculation of remaining wall loss from percent reflection by assumption of defect shape
- Generation of ultrasonic images of each indication

Guided Wave Analysis LLC
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Guided Wave Analysis (GWA) LLC sells and rents Magnetostrictive sensor (MsS) Systems for guided wave testing. Through our highly skilled personnel GWA provides training and supports many industrial facilities and service companies around the world.

Our Services

- MsS System Sales and Rental
- Guided Wave Testing Training
- Special Inspection Support and Consulting
- Software Development

Our System

- MsSRv5R – Battery operated guided wave testing system for long-range ultrasonic testing
- MsS Probe – Light ultrasonic guided wave transducer coupled to pipe through dry coupling, shear coupling, or epoxy bonding. Multiple center-frequency operation
- MsS Sector Probe – Ultrasonic transducer for sectional focusing inspection (SFI) of pipe, plate, vessel, and tank wall.

MsSR3030R

CAPABILITIES AND APPLICATIONS

CAPABILITIES

- Detecting corrosions and cracks in aboveground, buried, and insulated pipe
- Inspection of any material and diameter pipe including plate, vessel, and tank wall
- Volumetric inspection along pipe
- Probes can be attached for long term monitoring
- MsS dry coupling tool allows for high temperature inspection without removing heat tracer lines : up to 500°C surface temp

APPLICATIONS

- Piping systems in oil, gas, chemical and petrochemical facilities
- Offshore piping systems and risers
- Power generation piping systems
- Road crossings and levee penetrations
- CUI and PMI inspection

CODE COMPLIANT

- MsS Guided Wave Technology is covered by ASTM and other international standards.

For further information on guided wave testing technology and inspection applications, visit us at gwanalysis.com or contact us:

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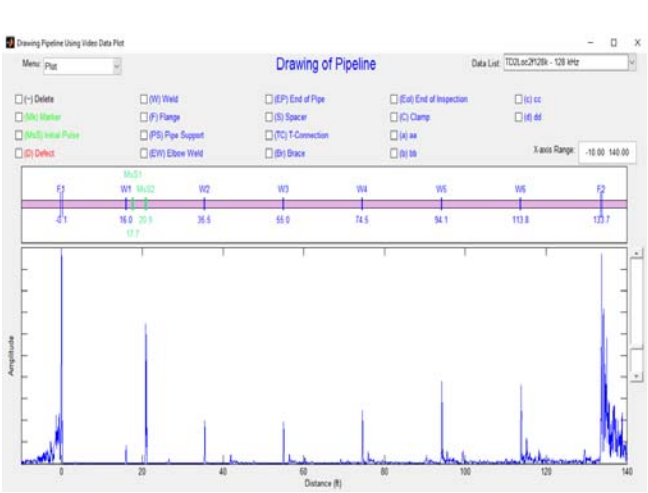
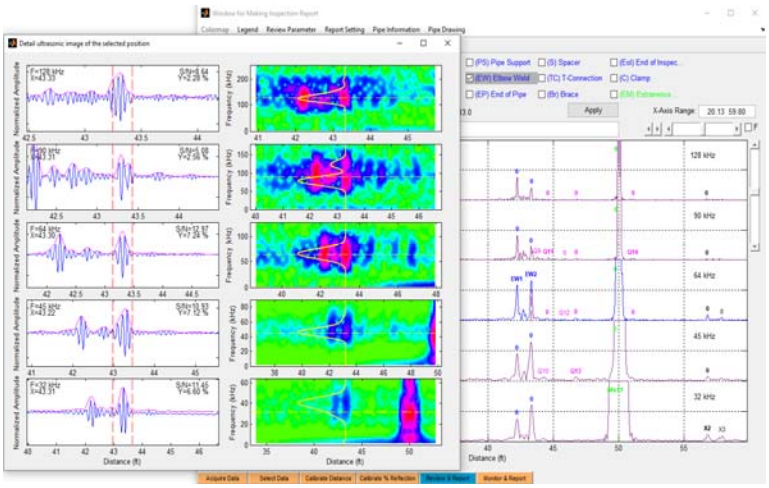
Guided Wave Inspection and Monitoring Software (GIM)

GIM software has the following merits in guided wave testing of pipeline:

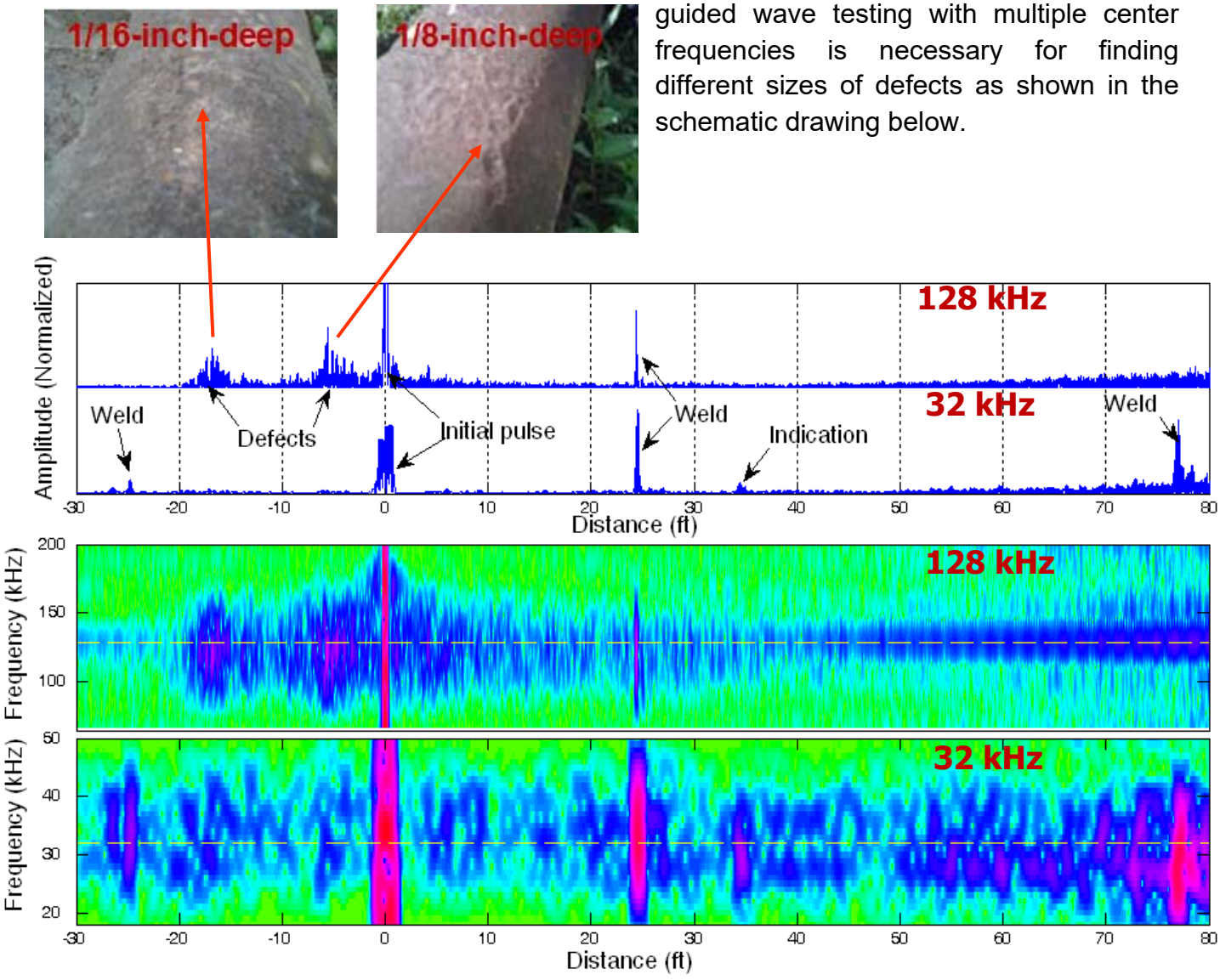
1) Generate inspection report with the information of geometric features in pipeline drawing.
    a. Better distance, amplitude, and attenuation calibration by considering many geometric feature locations.
    b. Automatic setting threshold level and finding indications
    c. Automatic marking of all geometric features
2) Analyze up to 8 data sets for finding more defects at multiple center frequencies
3) Better estimate defect size with multiple frequencies
4) Generate ultrasonic images of a selected signal and save its image in many different frequencies. The ultrasonic image includes rf data plot, video data plot, spectrogram plot, FFT plot of selected signal.
5) Has function of merging and separating signals for better marking of indications
6) Has automatic parameter setting function in data acquisition.
7) Includes several data display function
8) Shows the tested frequency in data acquisition.
9) Includes monitoring software that allows subtracting the monitoring data from the baseline data





GWT using Multiple Center Frequencies

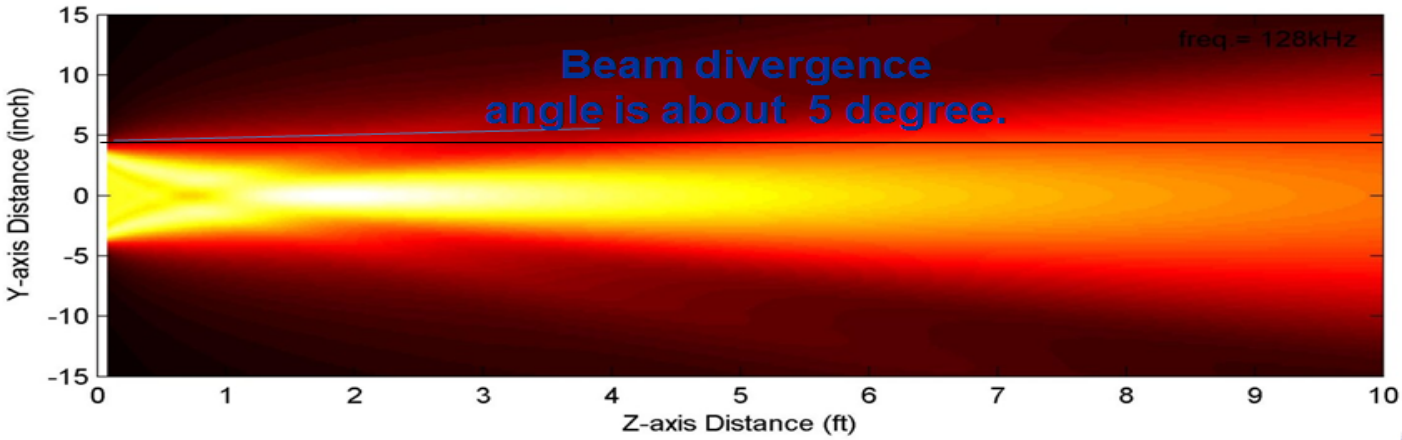
Do you know that the most important thing in guided wave testing (GWT) is using multiple center frequencies? GWT method is used to inspect pipelines that have different sizes of defects. MsS guided wave system allows using multiple center-frequency probes at every test location. The mostly used center-frequencies are 32, 45, 64, 90, 128, 180, and 250 kHz for guided wave testing because their wavelengths match with different sizes of defects. This is the same as using a flaw detector with 1, 2.25, 5, and 10 MHz probe for the ordinary ultrasonic testing. The graph below shows guided wave testing data acquired at 128- and 32-kHz center-frequency. The 128-kHz data shows the 1/8-inch-deep generalized corrosion defects at -6.5 ft to -4 ft, but 32-kHz data does not show any indication at those locations. This proves that the guided wave testing with multiple center frequencies is necessary for finding different sizes of defects as shown in the schematic drawing below.



Sectional Focusing Inspection (SFI) Using MsS Guided Wave System

Sectional Focusing Inspection (SFI) allows inspectors to focus ultrasonic guided waves on a section of pipe circumference to locate the defects along the pipe's circumference. SPI is highly sensitive to defects due to the sector probe only focusing ultrasonic guided waves on a targeted section of pipe circumference. The sector probe can inspect any pipe size including plate structure of vessel and tank wall. Compared with an encircling probe and piezoelectric ring or belt, SFI increases the defect detection sensitivity up to 40 times depending on pipe diameter and has merits of inspecting the following applications with high sensitivity:

- Cased road crossing
- Corrosion under insulation (CUI)
- Dike and concrete wall penetration
- Soil-air interface, clamp area
- Pipe support
- Offshore piping having complex geometry
- Elbow section inspection
- Pressure vessel
- Tank wall, spherical tank, and other plate-like structures,
- Thick-wall plate



Short-Range Guided Wave Inspection of an Elbow in Concrete

The short-range guided wave inspection technique can be applied to examine an elbow embedded in concrete. Figure 1 displays two welded elbows with the MsS sector probe installed onto the section that is aboveground. The elbow is scanned by rotating the MsS sector probe along the pipe circumference. Figure 2 below is a three-dimensional plot of the ultrasonic image. The image is nearly symmetric at 180˚ and illustrates signals reflected from the welds and flange. The section of the elbow that is aboveground is to the right of the initial pulse and the section belowground is to the left. The curvature of two weld signals is explained by the distance change that occurs, between the MsS probe and the welds, along the angle as a result of probe installation at the elbow. The two elbow sections are in very good condition and have no corrosion, illustrated by the green and light blue regions, except at the weld locations.

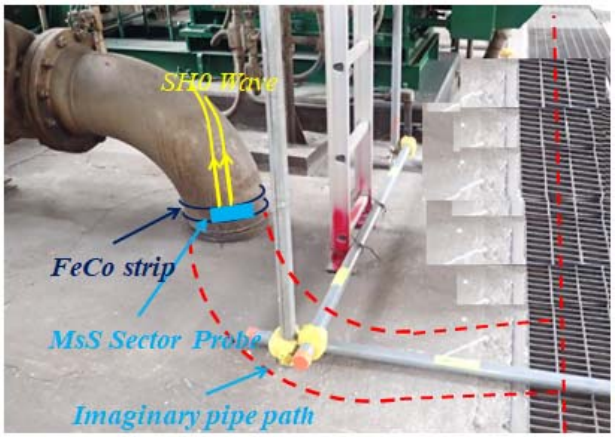


Figure 1: Short-range guided wave inspection technique applied to an embedded elbow.

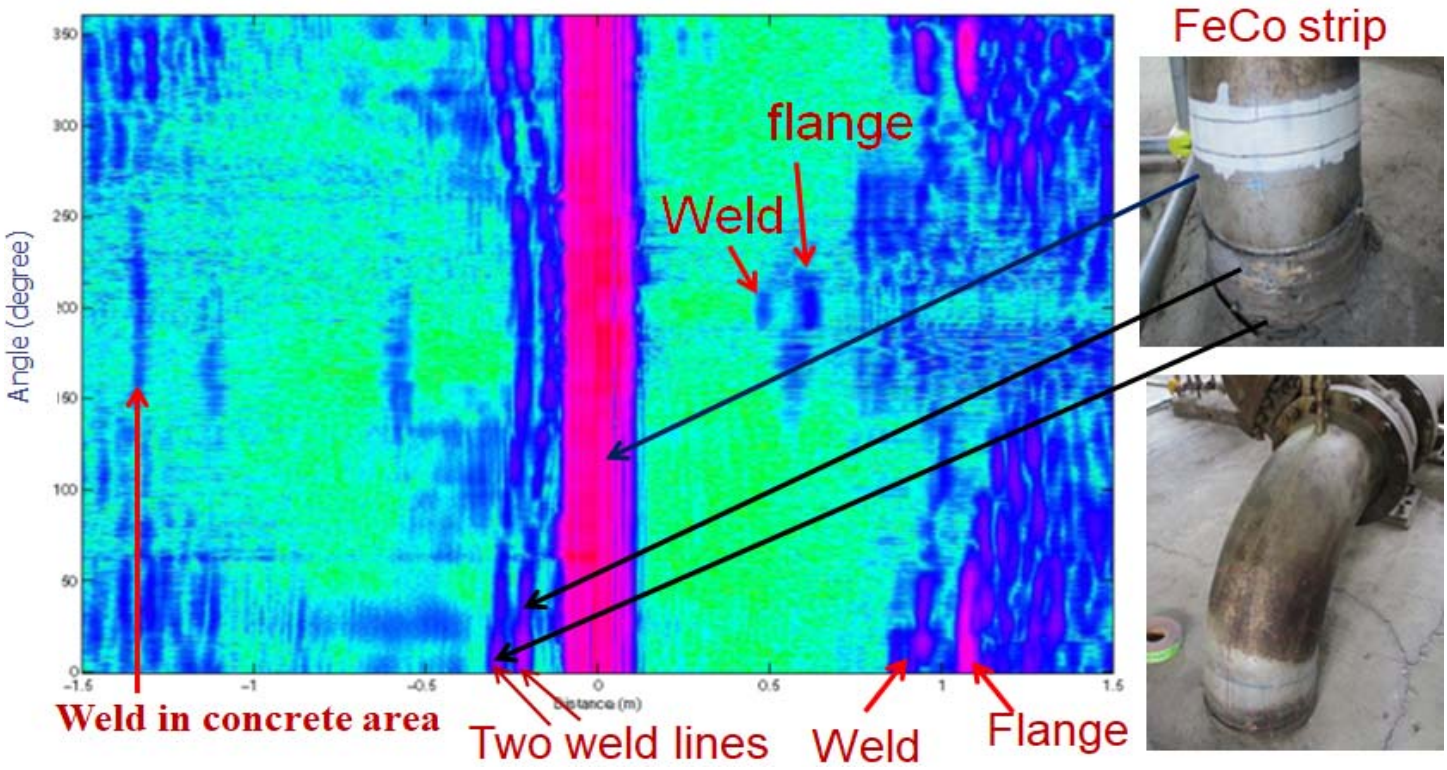
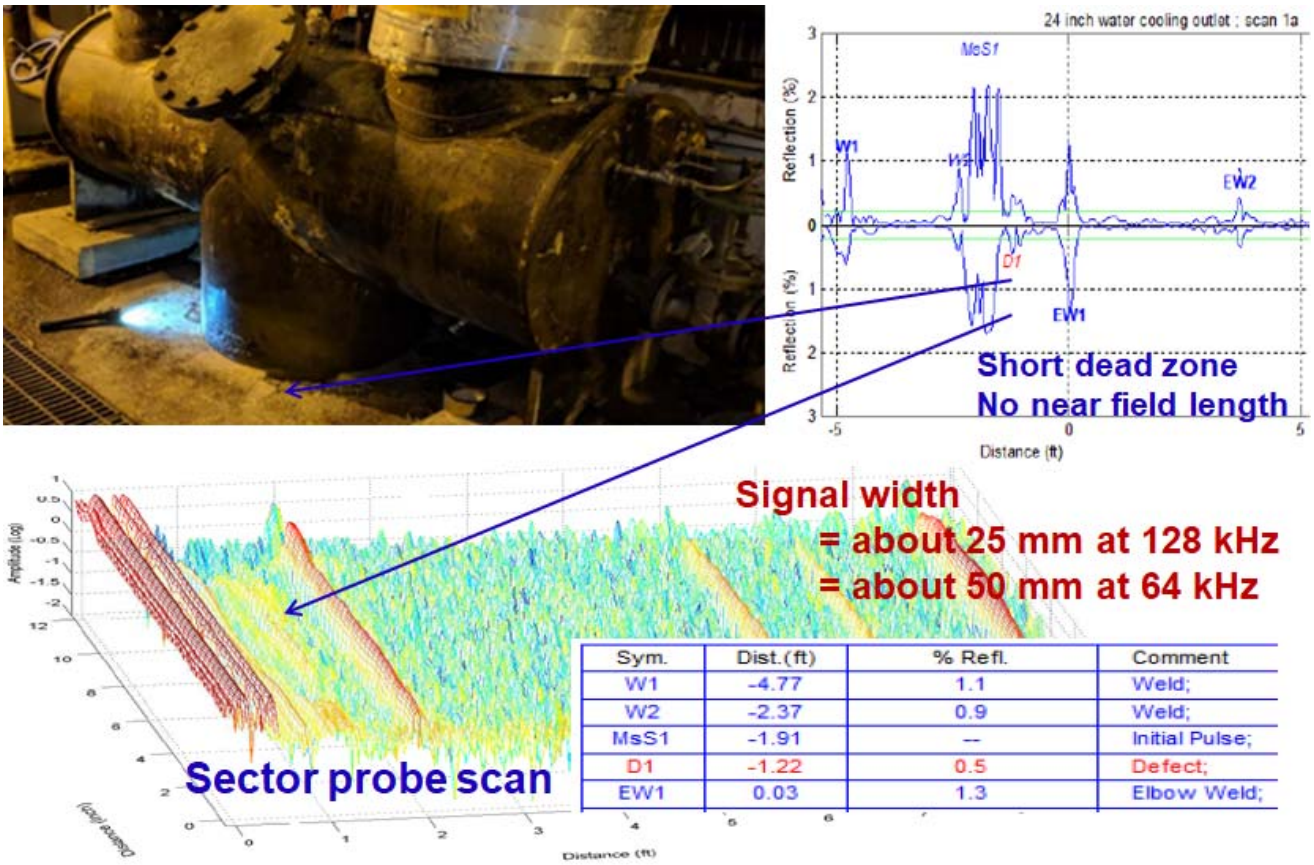


Figure 2: A three-dimensional plot of the ultrasonic image in green-blue-red sequence, where the red demonstrates the area with the highest amplitude.

Short-Range Guided Wave Testing Using MsS System

Magnetostrictive sensor (MsS) guided wave testing has a short dead zone length and no near-field length that allows high-accuracy short range guided wave inspection. The MsS system uses continuous ferromagnetic strip to generate and detect ultrasonic wave in material. It generates shear-horizontal wave in a plate-like structure and torsional mode in the pipe. The dead zone length is about 4 inches with 128-kHz center-frequency operation, about 7 inches with 64-kHz center-frequency operation, and about 11 inches with 32-kHz center-frequency operation. The MsS system and probe directly control particle displacement so that pure torsional and shear-horizontal modes are generated with 1 cycle for high spatial resolution.

The figure below shows the pipeline, test result, and MsS Sector scan showing defects near concrete area.



Sym.	Dist.(ft)	% Refl.	Comment
W1	-4.77	1.1	Weld;
W2	-2.37	0.9	Weld;
MsS1	-1.91	--	Initial Pulse;
D1	-1.22	0.5	Defect;
EW1	0.03	1.3	Elbow Weld;

Spatial Resolution of Guided Wave Testing Using MsS System

Guided wave testing uses two primary elements in defect detection. The first is a 2-to-1 signal-to-noise ratio for defect detection. The Magnetostrictive sensor (MsS) guided wave testing method has low background noise to achieve a high signal-to-noise ratio of ≥50 dB for end-reflected signals of pipes. The second aspect is spatial resolution that allows for detection of any defects near the geometric feature. For example, Figure 1 demonstrates an 8.625-inch-OD and 0.322-inch-wall stainless steel pipe that was tested. Figure 2 shows data acquired with both MsS encircling and sector probes. The defect is detected at approximately 4.1 m. with two encircling probes installed at either end of the pipe. The 4-inchlong MsS sector probe is used to verify the detected defect by rotating 360˚ along the circumference. The discrete defects are detected at approximately 10 cm behind the weld. This example demonstrates the importance of spatial resolution in guided wave testing.

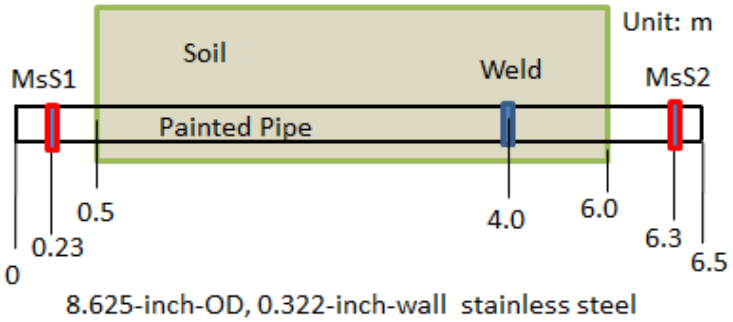


Figure 1: Schematic of an 8 NPS and schedule 40 stainless steel pipe that was tested by the MsS System.

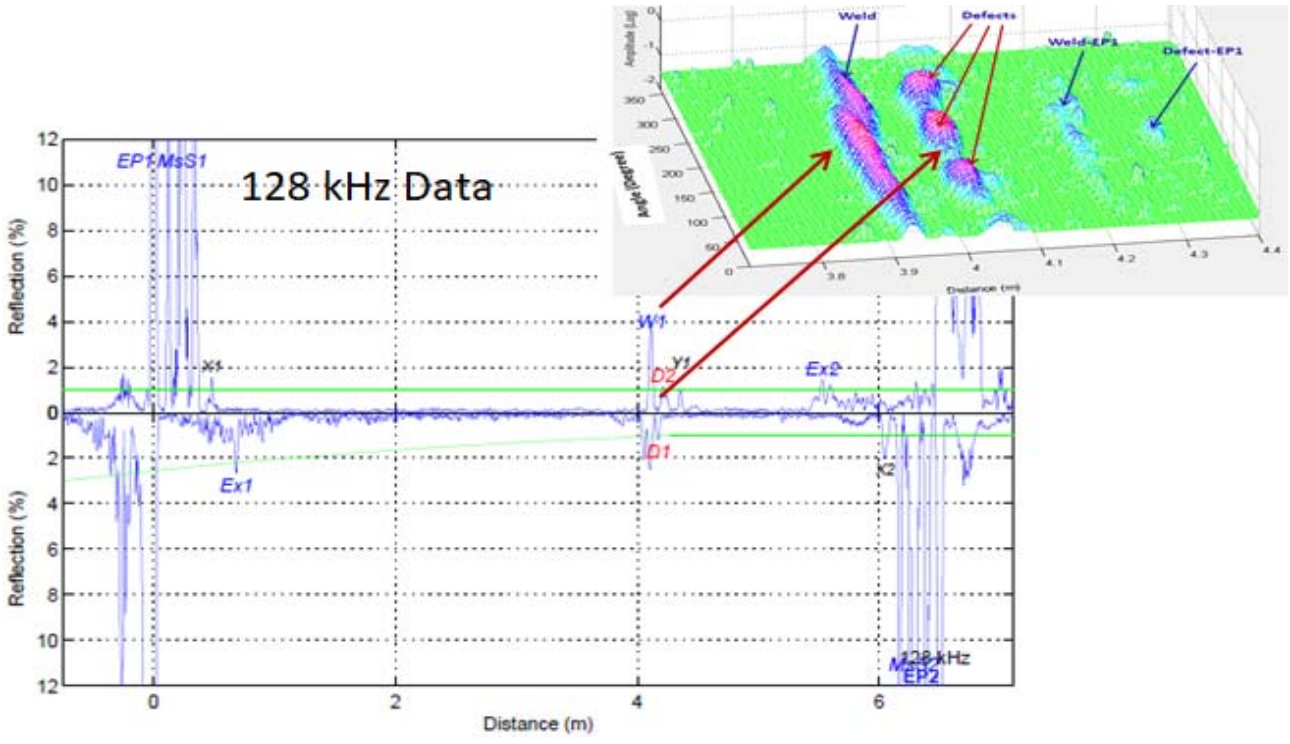


Figure 2: Data collected, from the Guided Wave Testing MsS System, of the pipe in Figure 1.

High Temperature Pipeline Inspection

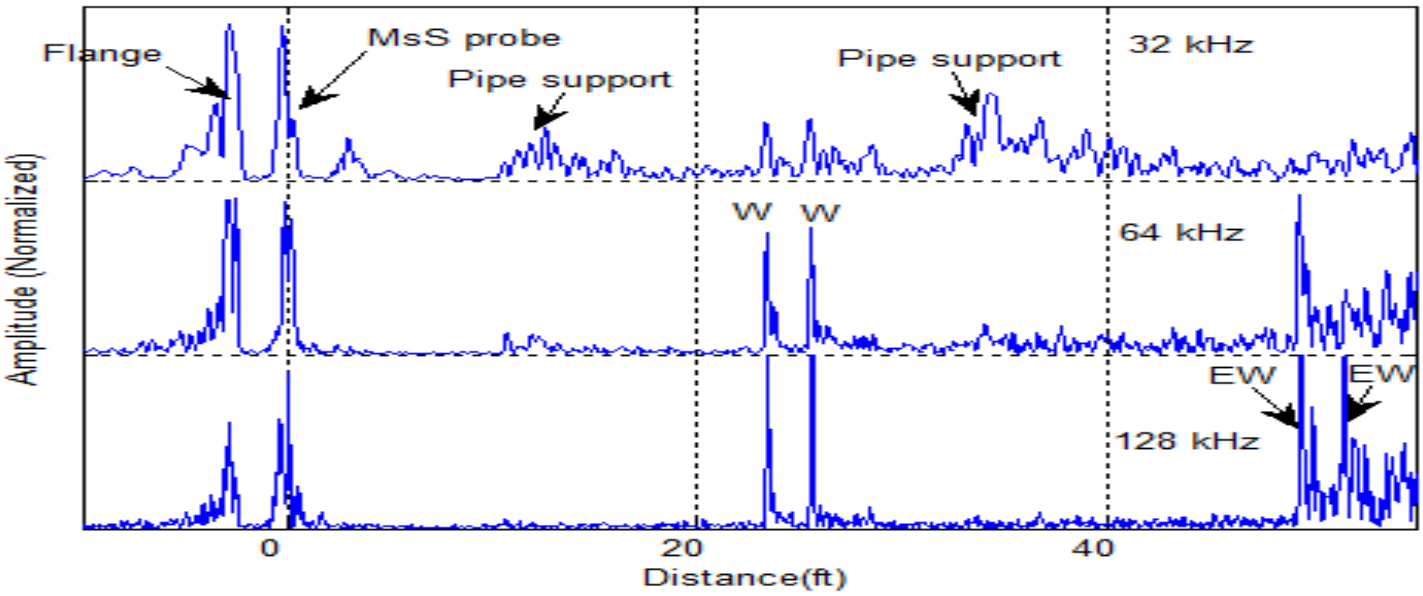
High temperature pipelines are an important component of plant operation. Therefore, the pipelines' structural integrity is essential for safety of the plant. Due to insulations and high-temperature environment, on-line inspection of the high-temperature pipeline is difficult. Guided wave testing using the magnetostrictive sensor (MsS) system is a cost-effective method of inspecting the high-temperature pipeline. High Curie temperature of the FeCo strip (938°C) allows MsS system to inspect a pipe with a surface temperature up to 500°C.

CUI and PMI Inspection using MsS Guided Wave System

Magnetostrictive Sensor (MsS) guided wave testing is effective in maintaining the mechanical integrity of pipelines with insulation and jacketing. MsS probes are only 2 inches wide and insulation only needs to be removed at the probe's installation location. The dead zone length of the MsS probe is about 4 inches from the center of the probe along each direction with no near field length with a 360° continuous probe. The MsS guided wave testing uses high-frequency ultrasonic waves of 64-, 90-, 128-, 180-, and 250-kHz center-frequency to reduce the interaction between traveling guided wave and geometric features such as simple pipe supports, welded pipe supports, and clamps, thus increasing inspection range. Using high frequency increases sensitivity of defect detection and spatial resolution. Due to these merits, MsS guided wave system is used for PMI inspection in order to find weld locations and also used for CUI and internal wall corrosion inspection to detect defects over a long distance.

Welded Pipe Support

The illustration below shows guided wave testing data acquired at 32-, 64-, and 128-kHz center frequencies. The 32-kHz data shows strong reflection and trailing signals from the welded pipe supports at about 10 and 30 ft, but the 128-kHz data shows an elbow signal around 50 ft due to much less interaction with the pipe supports. High-frequency guided waves provide both a longer inspection range and higher defect detection sensitivity if piping is attached or welded with many geometric features.



MsS Permanently Installed Monitoring Sensor (PIMS)

MsS PIMS is an ultrasonic transducer that is installed on piping, pipeline, and plate structure for structural health monitoring (SHM). The MsS PIMS consists of thin ferromagnetic strip and MsS coils for generating ultrasonic wave. In general, the 0.004-inch-thick ferromagnetic strip is boned using an epoxy on the structure under testing and the prefabricated MsS coils are placed over the strip. The MsS coils are wired to an easily accessible connection box and covered with an approximate protective tape layer. This is excellent for monitoring of buried pipeline and pipelines of high elevation, high temperature, or inaccessible area.

If the location is readily accessible, permanent installation of the thin ferromagnetic strip is sufficient for SHM and, thus, the installation of the MsS coils is not necessary. Data are acquired by placing MsS coils over the permanently installed strips. In this case, the structure can be monitored using multiple center frequencies of 32, 45, 64, 90, 128, 180, and 250 kHz for finding different sizes of defects, checking the buildup of surface corrosion, and SHM. This monitoring method is much economical for monitoring a large structure of refineries, chemical and electric power plants.

MsS PIMS manufactured at Guided Wave Analysis LLC

- Generates pure torsional mode in cylindrical and pure shear-horizontal mode in plate structure
- Uses continuous probe for removing near field length and has short dead zone length
- Has high sensitivity by increasing signal amplitude and reducing background noise
- Operates multiple center frequencies for finding different sizes of defects
- Is used for monitoring pipeline, pressure vessel, tank wall, and other structure in facility
- Has very low profile
- Is fabricated for easy installation and the best performance with low cost
- Detects small changes in condition and finding defect initiation and growth on geometric features
- Allows condition of structure to be measured and evaluated on continuous basis
- Significantly saves overall operating and maintenance costs

Defect Mapping with Guided Waves Using MsS Sector Probe

Defect mapping of pipeline and plate structures has been performed using ultrasonic, eddy current, and laser methods. However, all of these methods require access to the defect location as a local inspection method. Using a sector probe, MsS guided wave can perform defect mapping without access to the defect location and can detect defects located at inner and outer surface of the structure. The figure below depicts a 24-inch-OD pipe with a MsS probe on the top of the pipe and the corresponding 3-D mapping plot. The 3-D plot shows the severity of the defects with a spectrum of colors: green, cyan, blue, magenta, and red. The red color represents the highest reflection from the defects and green the least. The mapping was done with 1-cycle, 128-kHz center-frequency, and 4-inch-long MsS sector probe for high spatial resolution. This guided wave mapping of defects can be applied to inspect simple pipe support, welded pipe support, precast concrete pipeline supports, hold-down/anchor straps, saddle support for horizontal pressure vessel, insulated tank wall, soil-air interface, concrete-air interface, insulated elbow area, insulated T-joint, and complex geometric area