



SOUTHWEST RESEARCH INSTITUTE



High-Resolution Defect Imaging in Industrial Components

Using Guided Wave Magnetostrictive Transducer Arrays

Southwest Research Institute® (SwRI®) has developed a new system for imaging defects in large structures such as storage tanks, ship hulls, and pipe supports. The MsT 8x8™ was initially developed to inspect above-ground storage tanks from the tank skirt (chime) on the tank exterior.

The MsT 8x8™ system consists of:

- Multi-segment magnetostrictive transducer probe
- MsSRv5M™ guided wave instrument with integrated signal multiplexer
- Full matrix capture (FMC) acquisition software
- Advanced analysis software, including the synthetic aperture focusing technique (SAFT) and total focusing method (TFM)

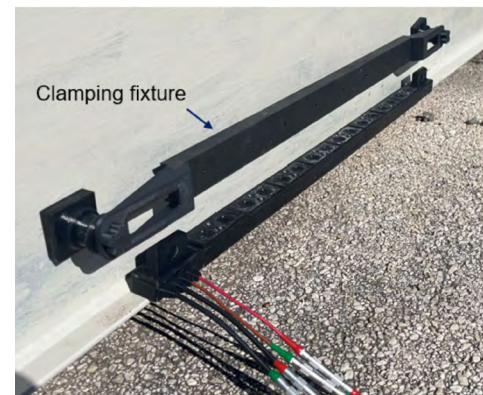
The system can generate a 2D map showing the distribution of anomalies. After overlapping the map with the geometry of the structure, inspectors can get an intuitively clear report of anomaly location as well as anomaly ranking information. The system has been tested on various mockups, on actual storage tanks, and on pipes.



MsSRv5M instrument and -segment array on MsT 8x8 probe



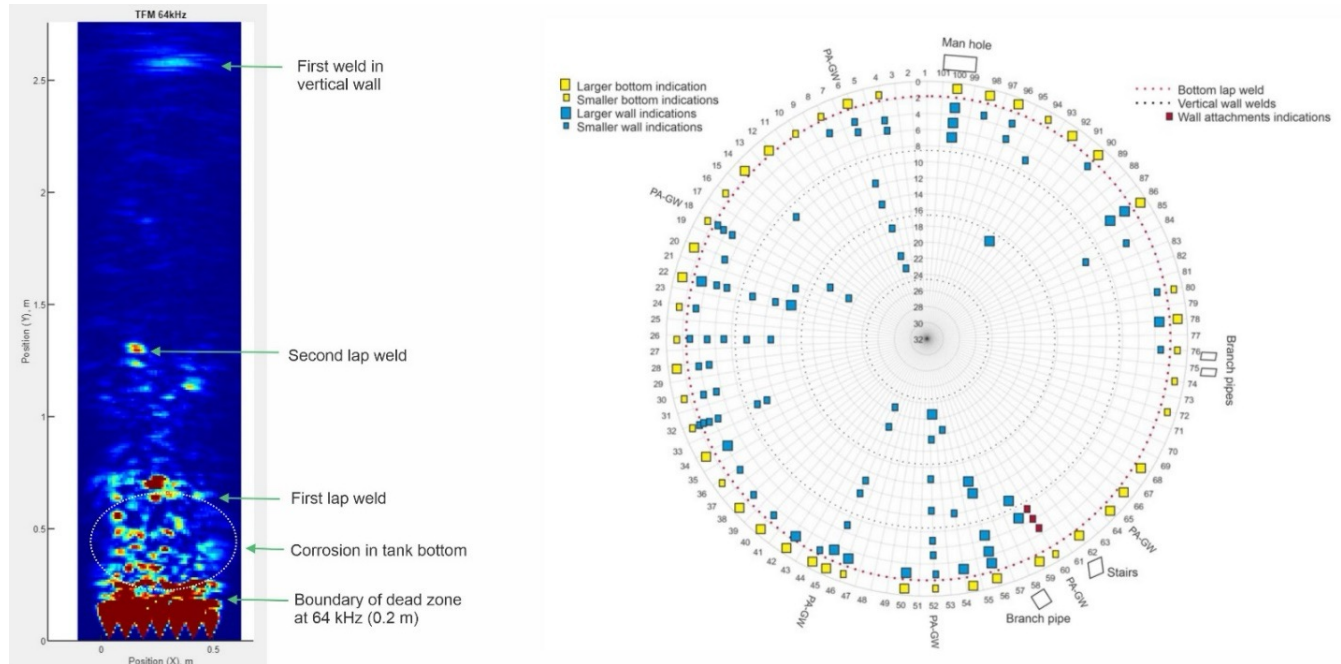
MsT probe for permanent monitoring installed on a pipe



MsT probe with tank bottom extension

Application example 1: Corrosion mapping in storage tank bottom and walls

The figure below shows results obtained from a 70-year-old 18 m (60 ft) diameter storage tank with a lap-welded bottom. The lap weld was located approximately 60 cm (2 ft) from the tank wall. The aperture of the MsT 8x8 probe used for the test was 60 cm (2 ft). The data was acquired at 3 frequencies: 16, 64, and 256 kHz. The data presented in the figure was acquired at 64 kHz. Most indications were located in the area before the lap weld and were clearly mapped in reference to the probe position.



Summary report showing indications in a tank bottom and wall

The right figure is an example of a summary report showing indications identified in the tank bottom and in the wall. Indications in the tank bottom are marked with yellow squares and indications in the tank wall are marked with blue squares. The size of the marks indicates the ranking information; larger indications indicate more severe damage.

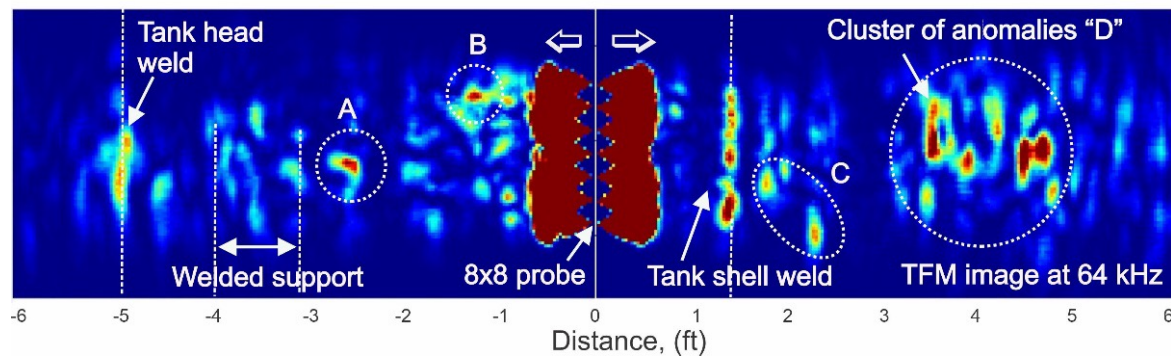
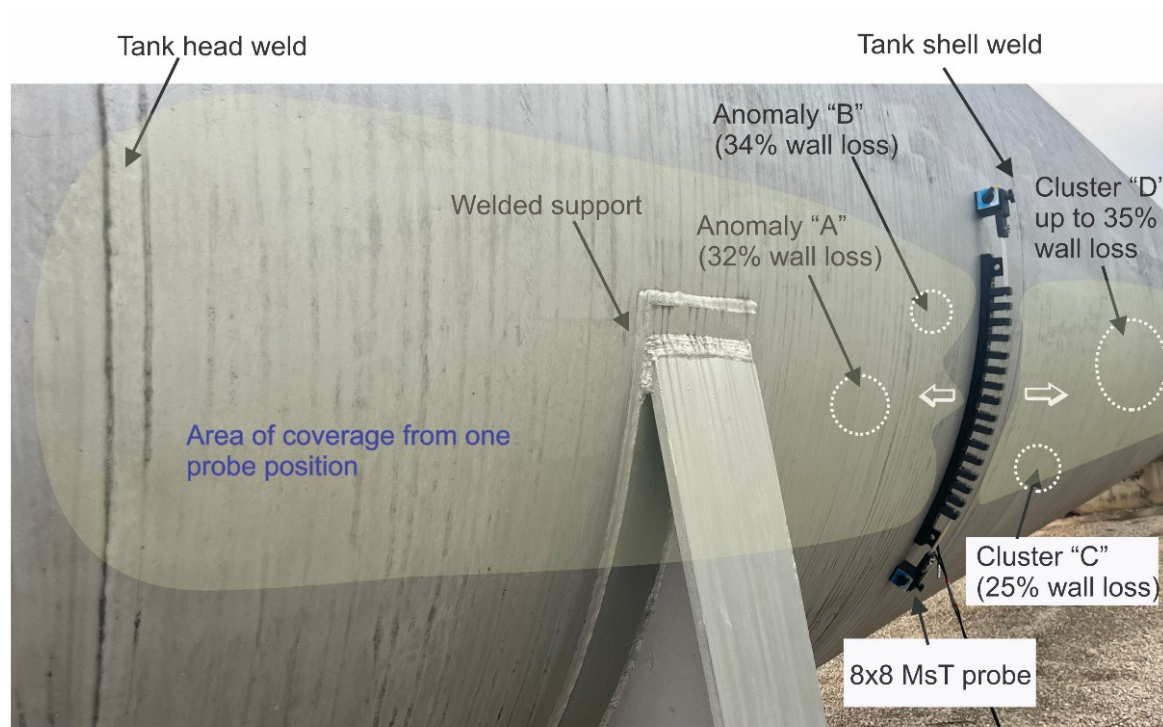
The MsSRv5M™ is the 6th generation of magnetostrictive sensor guided wave instruments designed and developed by SwRI, based on 12 years of MsSR3030R® field experience. Advantages include reduced size, lighter weight, longer battery life, water resistance, and more ruggedized design with overcurrent and overtemperature protection. The major advantage of the MsSRv5M is a built-in multiplexer allowing operation of up to 16 individual sensors.

The MsSRv5M and the MsSRv5 operate with a great variety of magnetostrictive sensors (MsS or MsT™) suitable for guided wave testing of pipes, plates, anchor rods, steel ropes, and heat exchanger tubes.

Application example 2: Corrosion mapping in storage tank supports and tank walls

The figure below shows an 8x8 MsT probe mounted on the 11 mm (0.45 in) thick wall of a 40-year-old water storage tank. The probe is mounted between a shell weld and a welded tank support, in order to screen the condition of the wall under the supporting structure.

The results of the test conducted at 64 kHz revealed the presence of at least 4 areas, marked as A, B, C and D, with suspect indications. Reference geometry features including the shell weld at the 1.3 ft (40 cm) distance mark and a head weld at the 5 ft (1.5 m) distance mark also produced clear indications. The suspect areas A, B, C and D were checked with manual UT; the wall loss in these areas was found to be in the range of 25 to 35%. The area covered by tank support produced only faint indications.



MsT 8x8 probe mounted on cylindrical tank (upper image) and TFM imaging results (lower image)

MsSRv5M™ Sixth-Generation Magnetostrictive Sensor Instrumentation System Specifications

Transmitter

- Outputs: Two high-voltage differentially driven, synchronous, burst-type outputs; may be operated in-phase or with ± 90 -degree phase displacement (for directionality control)
- Waveform Type: Square wave
- No. of Cycles: 1–14 cycles selectable
- Output Voltage: 240 Vpp max
- Output Current: 40 amps P-P
- Output Amplitude: 0, 25, 50, 100%
- Frequency: 1 kHz to 500 kHz
- Pulsing Rate (PRF): 1, 2, 4, 8, and 16 pulses/sec

Receiver

- Input: Two high-voltage differential inputs summed together; prior to summation, the signals may be electronically phase-shifted ± 90 degrees for directionality control; input overvoltage protection
- Programmable Gain: 0–80 dB (1-dB steps)
- Time-Controlled Gain (TCG): 0–80 dB linear ramp
- Filters: Eight 4-pole active filters with center frequencies of 16, 32, 45, 60, 90, 128, 180, 250 kHz standard; other choices available
- Operating Modes: Pulse-echo and pitch-catch

Multiplexer

- 16-channel relay type allowing transmit and receive on any combination of 16 channels

General

- Communication: USB 2.0
- Data Resolution: 12 bits
- Power Supply: One Li-ion battery
- Battery Life: Minimum 24 hours continuous pulsing (test condition: 25% power, 128 kHz, 3 cycle pulses, 4 Hz PRF, 3-inch pipe sensor)
- Overcurrent and overtemperature protection
- Temperature: -15°C to $+40^{\circ}\text{C}$ (operating); -20°C to $+60^{\circ}\text{C}$ (storage)
- Humidity: 10% to 80% relative humidity (operating, non-condensing)
- Dimensions: 41.1 x 32.3 x 16.8 cm (16.2 x 12.7 x 6.6 inches)
- Weight: 6 kg (13 lbs) including battery (without laptop PC)
- Water-resistant



We welcome your inquiries. For more information, please contact:

Sergey Vinogradov, PhD

Staff Engineer

210.522.3342

sergey.vinogradov@swri.org

Nikolay Akimov

Research Analyst

210.522.5849

nikolay.akimov@swri.org

Jay Fisher, ScD

Program Director

210.522.2028

jay.fisher@swri.org

Sensor Systems and NDE Technology

Structural Engineering Department

Mechanical Engineering Division

ndesensors.swri.org

SOUTHWEST RESEARCH INSTITUTE

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210.522.2122

ask@swri.org

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