ABC Company

Fire Sprinkler System
Corrosion / MIC Inspection Report

for

DEF Company

123 Any St
Denver, CO

Date: January 1, 2014

Prepared by:

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Executive Summary

SoniTech NDT performed an Ultrasonic LGW NDT inspection on the fire sprinkler pipe in ABC Company's facility located at 1234 Any Rd in Anywhere, CO. Total area was approximately 70k ft^2, including Risers, Mains and Sub Mains, as defined in Quote #ABC123.

Notes

North end - Areas of severe corrosion build-up and significant wall loss were found throughout the entire region. Only 9 areas of 114 were flagged yellow or green, the rest were red.

Overhead sprinkler pipe: All schedule 10

1. No leaks were discovered in this area, although branch location 6 did show a small brown spot on the paint, possibly indicating the onset of a leak.
2. A significant water pocket was found in the middle riser room, above the pre-action valve, in the pipe servicing the overhead system. Water pockets are indicated on the drawings by a blue outline.
3. Localized wall loss up to 29.2% was discovered, with 11 out of 55 areas showing loss of 20% or more.

Under floor sprinkler pipe: All schedule 10

1. No leaks were discovered in this area, although location 34 showed **50.8%** loss. 11 of 59 areas showed loss of 20% or more, and 3 of those were greater than 30%.
2. Significant water was discovered in the under floor piping in the middle riser room, along the west wall, and up to about 10' after each main turned to head east (locations 31 and 36).

South End – All schedule 10 (The south end did not have an under floor sprinkler system)

1. Several new leaks were discovered and immediately brought to the attention of ABC personnel. These areas are indicated by a rust colored oval on the drawings. Almost all of these previously undiscovered leaks were located directly over customer server racks, switches, and facility power distribution equipment (see picture of water dripping on power distribution conduit).
2. Localized wall loss up to 46.7% was discovered, with 14 out of 56 areas showing loss of 20% or more, and 4 of those were greater than 30%.
3. *Corrosion build-up and wall loss were discovered in the areas that were accessible for scanning on the wet system servicing the office area*.
4. The branch risers/lines showed no significant signs of corrosion build-up; however locations 32 and 49 were flagged yellow and red respectively, due to wall losses of 12.9% and 29.0%.
5. Water was found throughout two of the east-west main lines (indicated in blue outlines)

Measurements were only taken where FSP was accessible. SoniTech compiled 170 Localized Guided Wave (LGW) measurements, and conventional Ultrasonic Pulse Echo technology was use to confirm thickness measurements at most locations. It should be noted that thickness tests are pinpoint scans, so in a system as heavily corroded as this, nearby wall loss could be greater than that which was recorded.

Of the 170 points measured, 139 (or 81.8%) locations proved to be of concern and were marked in RED in the Graphics following this section.

SoniTech NDT cannot make a judgment as to replacement, however, it is recommended that existing leaks be repaired immediately and the worst of the remaining locations be removed and carefully examined as to the exact nature and extent of corrosive damage. If the corrosion is found to be significant enough to warrant replacement, then consideration should be given to treating the new system with a chemical MIC inhibitor to prevent or inhibit further corrosive activity.

Photo of water dripping on conduit, near a power distribution unit

Photos of seepage points discovered

The LGW Ultrasonic measurements in the following matrix summarizes the findings, identifying only areas of "moderate" to "significant" corrosion. The remaining locations have Zero to Moderate levels of corrosion/obstruction.

Summary of findings

Region	Date Gathered	Signatures Gathered	Water/Sludge pockets Identified*	Areas of concern- RED Areas only
North – Overhead	**02/10/09**	55	34, 35	1-10, 12, 13, 16-29, 34-55
North – Under floor	02/11/09	59	31-36	1-36, 38, 39, 41-59
South – Overhead	02/12/09	56	9, 10, 24, 29, 36, 37	1, 4, 9, 10, 16, 19, 21-25, 28-30, 33-39, 42-45, 47-51, 53-56
Total		**170**		**139 locations flagged RED**

Reports and Illustrations

SoniTech has compiled Graphical Results for each location measured. Following the Graphical diagrams are LGW waves for each of the measured areas. Where Real Time LGW waves lost significant energy, SoniTech performed thickness tests to support the LGW data. No thickness measurements were taken where LGW waves looked similar to the baseline signature pattern.

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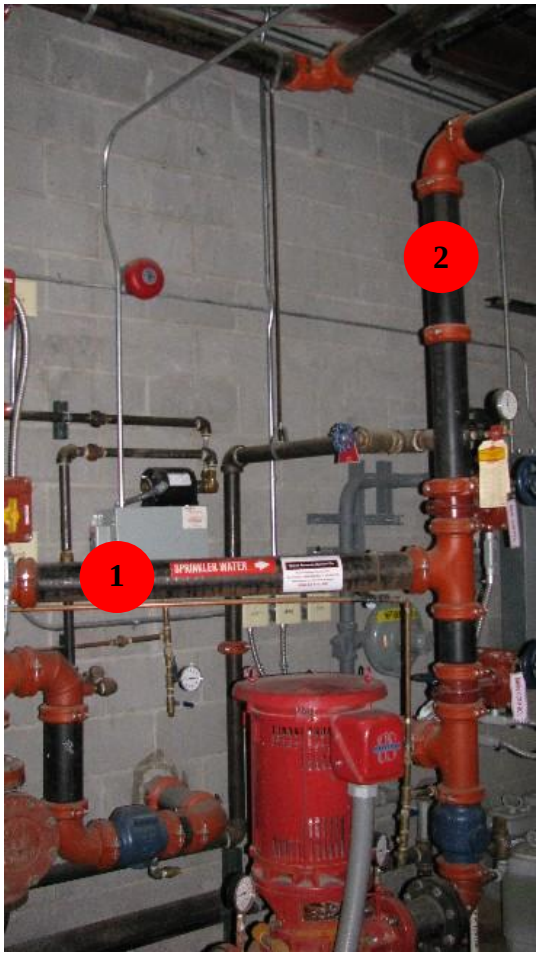
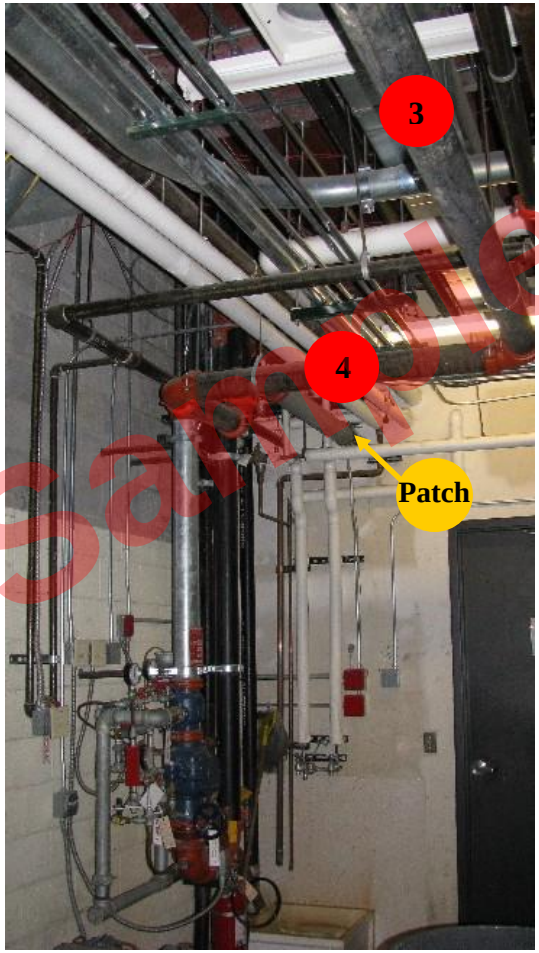
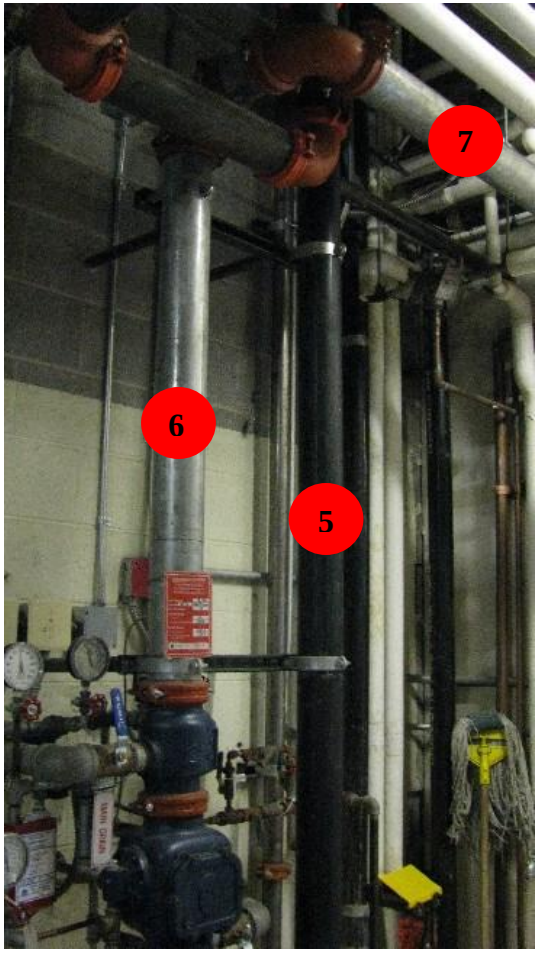
First Floor Mechanical Room

ABC Company







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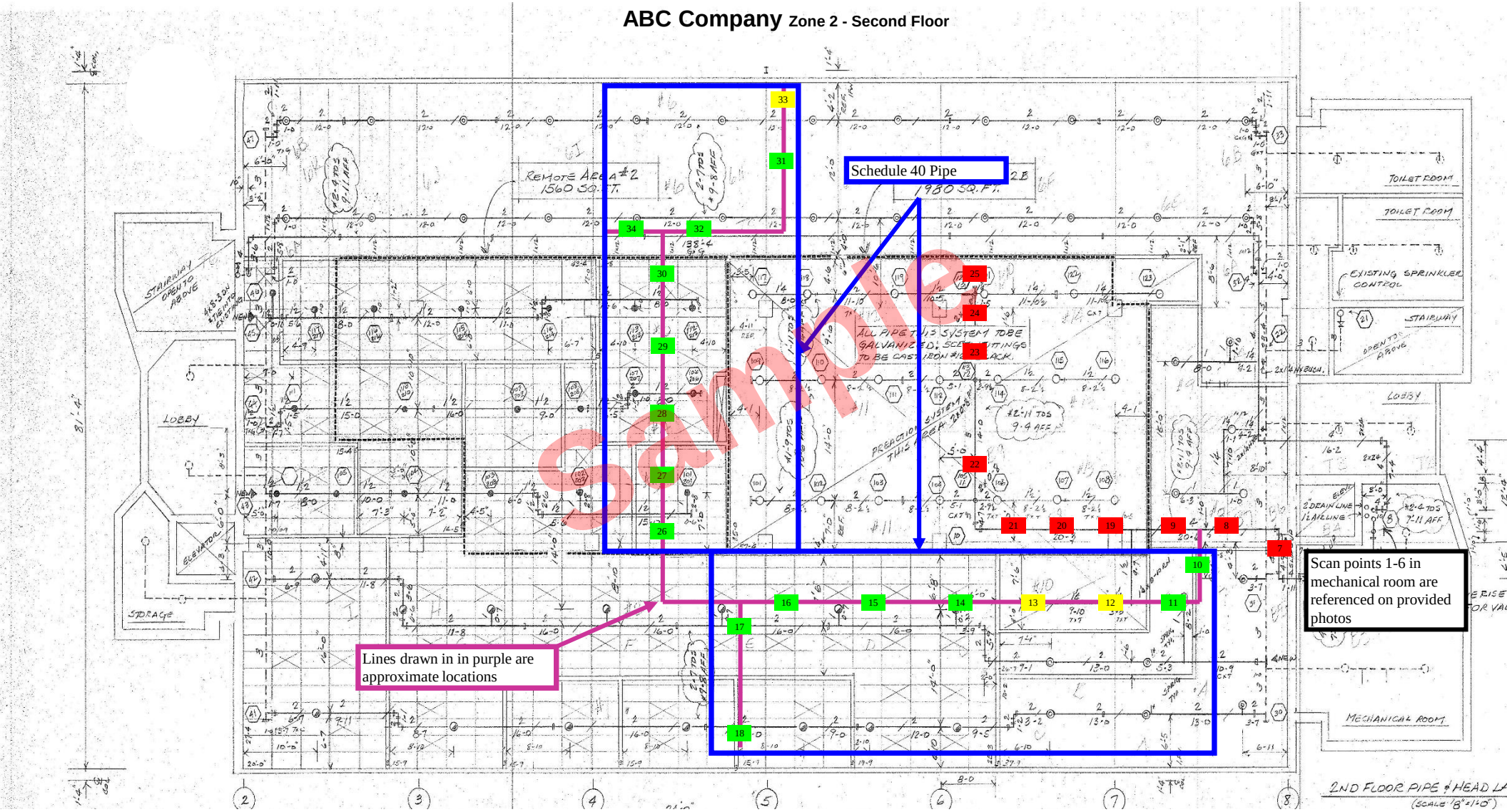
ABC Company Zone 2 - Second Floor



SoniTech NDT will overlay the color-coded scan results on the drawing when a “soft copy” is available.

Actual resolution is much higher than in this sample.

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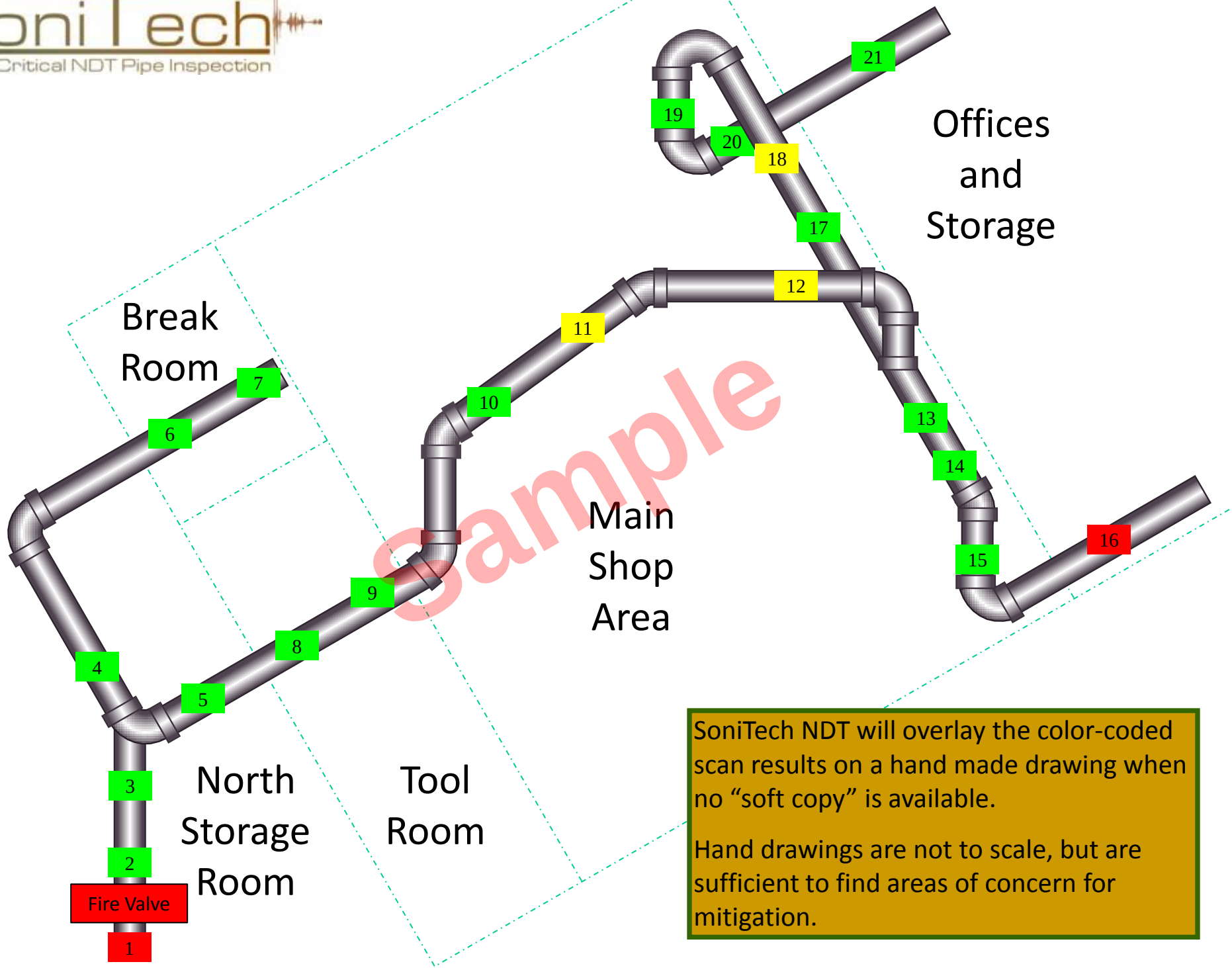
Mission Critical NDT Pipe Inspection



SoniTech NDT will overlay the color-coded scan results on a hand made drawing when no “soft copy” is available.

Hand drawings are not to scale, but are sufficient to find areas of concern for mitigation.

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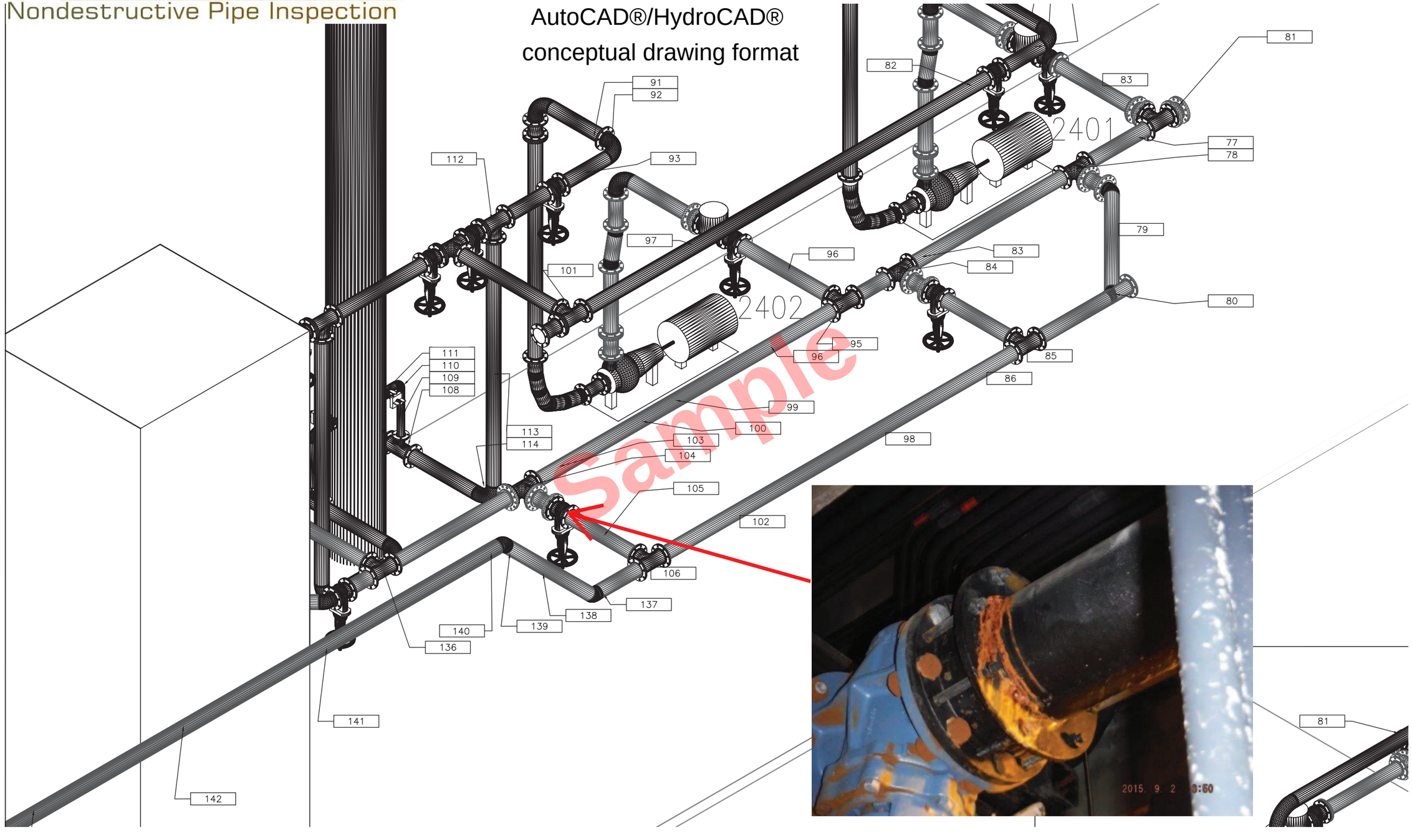
Nondestructive Pipe Inspection

Optional

AutoCAD®/HydroCAD®

conceptual drawing format



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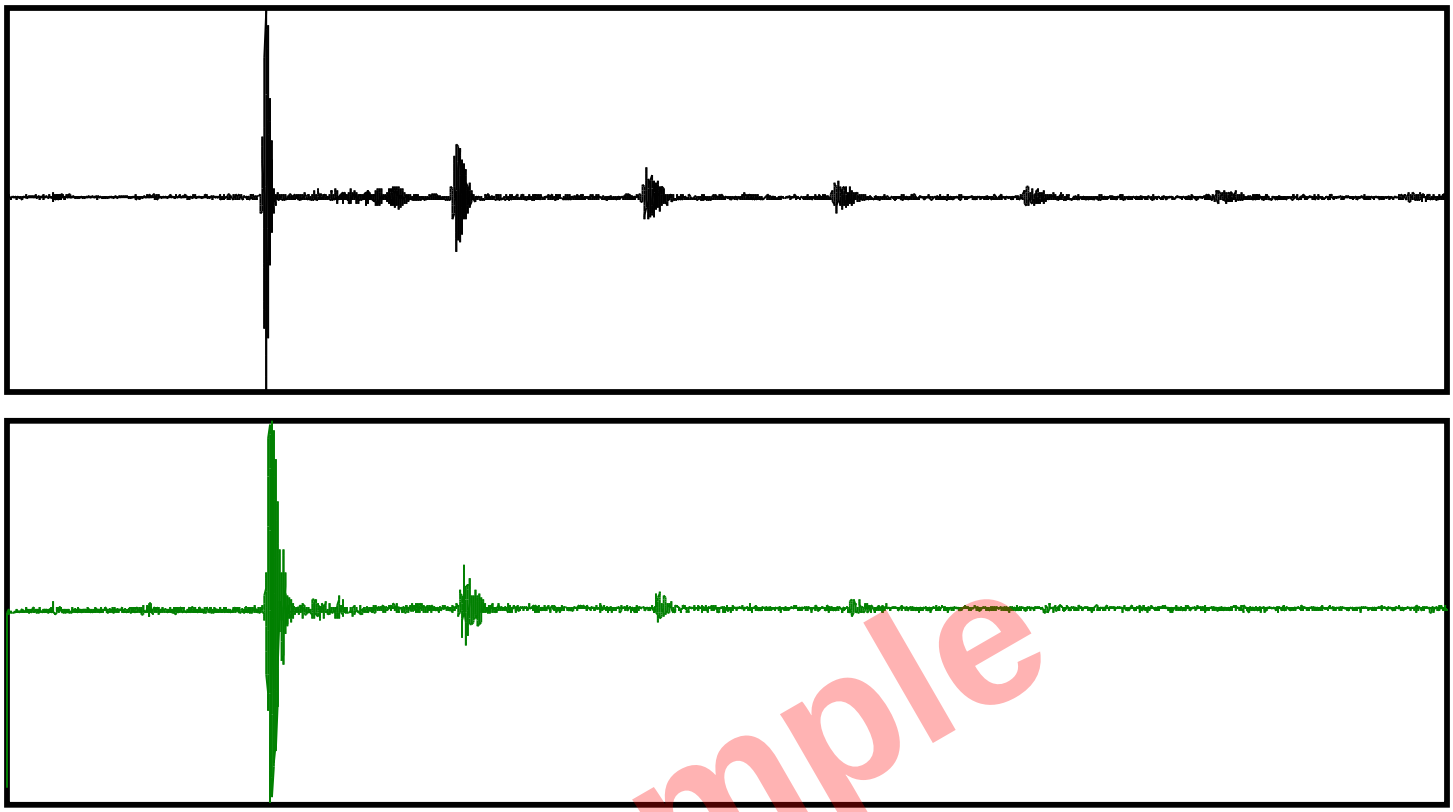
Nondestructive Pipe Inspection

SoniTech NDT Inspection Report

File	Loc	Cat	DIA(in)	Schedule	Type	REI	CEI	LEI	MaxLoss(%)	MinThick(in)
	1	STD	6.00	40	DRY	24.4	7.4	93.9	68.6	0.088
	2	STD	6.00	40	DRY	23.1	4.3	95.1	72.1	0.078
	3	STD	4.00	40	DRY	15.0	2.8	141.3	60.8	0.093
	4	STD	4.00	40	DRY	17.7	5.2	147.1	57.8	0.100
	5	STD	4.00	40	DRY	45.9	39.5	150.2	20.7	0.188
	6	STD	4.00	40	DRY	33.1	22.9	120.6	28.3	0.170
	7	STD	2.00	40	DRY	44.8	36.7	160.2	27.9	0.111
	8	STD	2.00	40	DRY	48.8	42.9	102.7	27.9	0.111
	9	STD	2.00	40	DRY	32.7	22.8	94.8	18.8	0.125
	10	STD	2.00	40	DRY	44.1	37.0	126.9	17.5	0.127
	11	STD	2.00	40	DRY	42.3	35.4	117.8	5.8	0.145
	12	STD	2.00	40	DRY	30.3	19.7	116.8	18.2	0.126
	13	STD	2.00	40	DRY	25.0	17.6	97.0	5.2	0.146
	14	STD	2.00	40	DRY	15.1	9.1	79.6	24.7	0.116
	15	STD	6.00	40	DRY	31.1	14.1	79.6	16.1	0.235
	16	STD	6.00	40	DRY	22.3	3.8	74.4	65.0	0.098
	17	STD	2.00	40	DRY	54.1	28.4	937.1	19.5	0.124
	18	STD	2.00	40	DRY	35.8	24.0	320.3	13.0	0.134
	19	STD	4.00	40	DRY	48.2	44.1	120.2	24.5	0.179
	20	STD	4.00	40	DRY	28.1	18.7	110.6	26.6	0.174
	21	STD	2.00	40	DRY	53.0	37.6	445.4	8.4	0.141
	22	STD	2.00	40	DRY	49.9	28.3	741.7	13.0	0.134
	23	STD	2.00	40	DRY	60.4	35.5	971.8	20.8	0.122
	24	STD	2.00	40	DRY	39.9	27.3	488.3	13.0	0.134
	25	STD	4.00	40	DRY	16.3	12.8	65.9	29.5	0.167

Example of a good dry 4" schedule 10 pipe



File Name: \Data\

Location: 36

Diameter: 4

Schedule: 10

System Type: DRY

Nominal Thickness: 0.12

Relative Energy Index: 100.0

Circumferential Energy Index: 100.0

Leak Energy Index: 100.0

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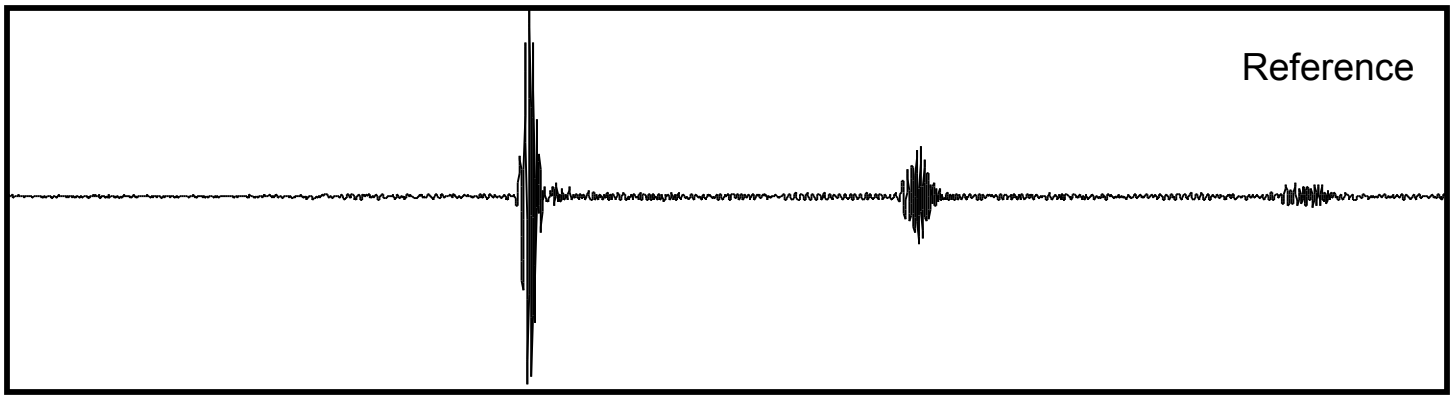
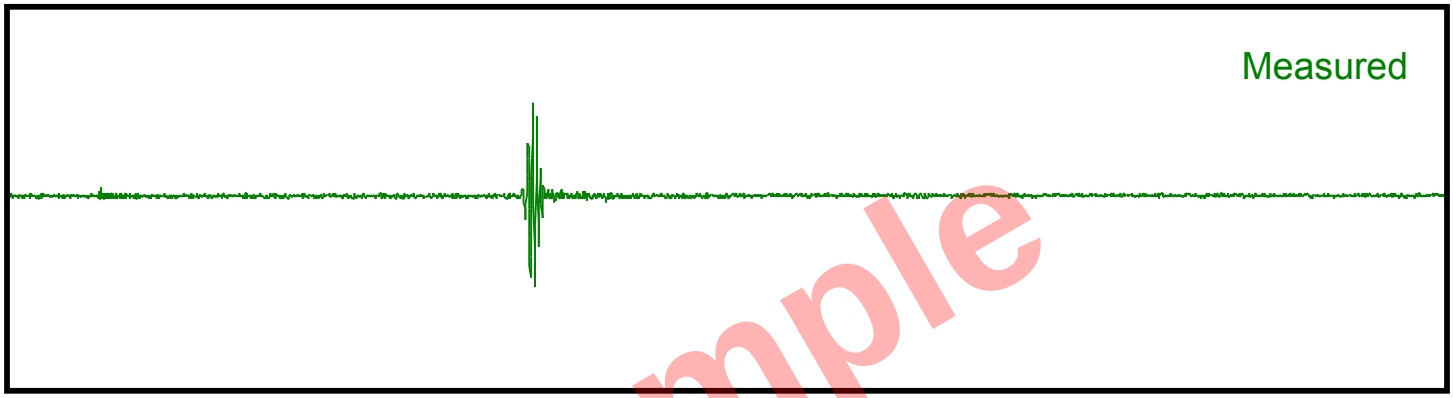
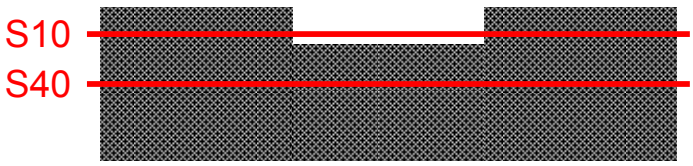
Example of a bad dry 4" schedule 10 pipe



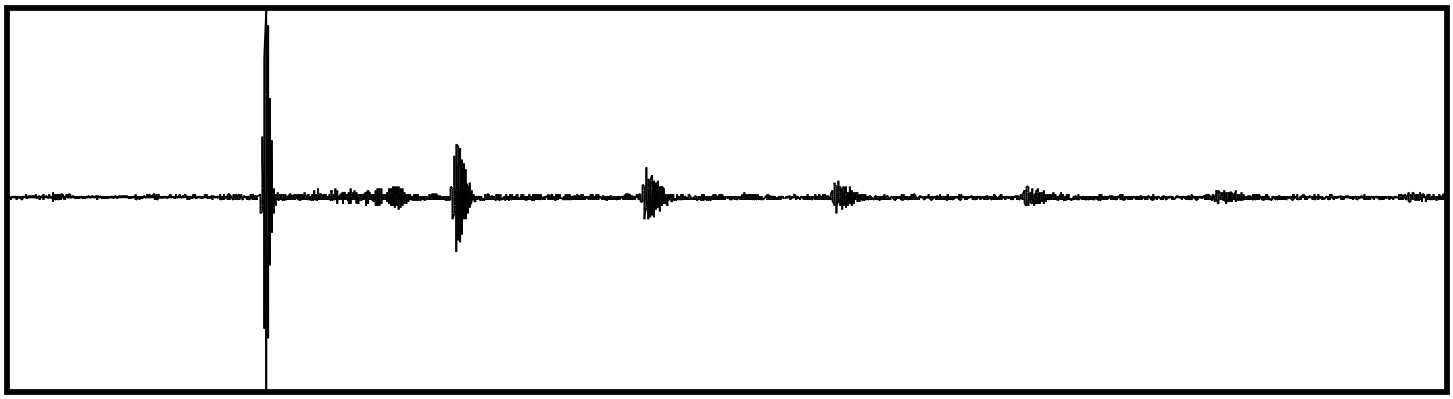


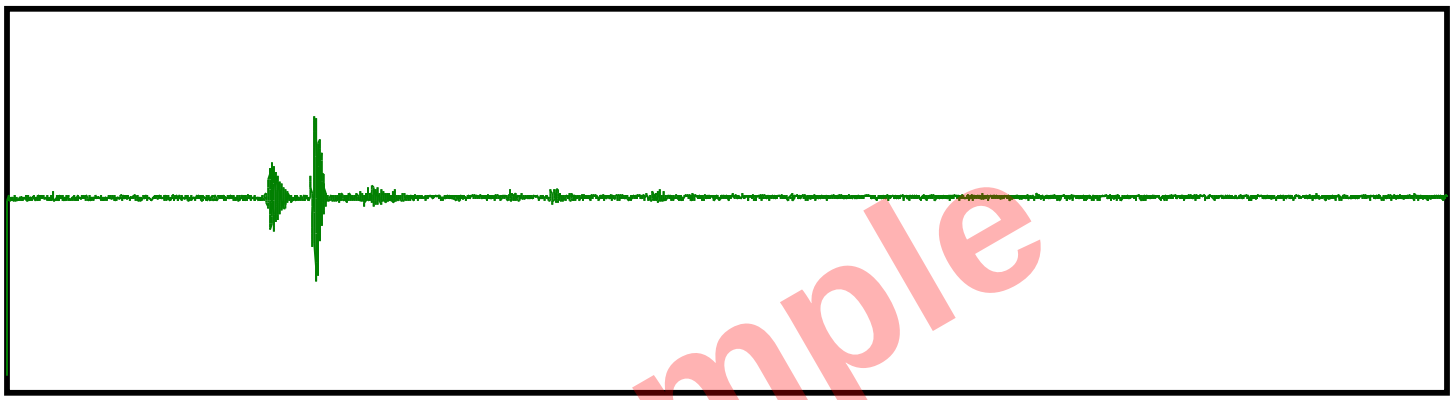
File Name:	
Location:	8
Diameter:	4
Schedule:	10
System Type:	DRY
Nominal Thickness:	0.12



Relative Energy Index:	25.8	Minimum Thickness:	0.091 in.
Circumferential Energy Index:	20.1	Maximum Wall Loss:	24.17 %
Leak Energy Index:	79.1		

Example of a moderately bad dry 4" schedule 10 pipe with trapped water





File Name: \Data

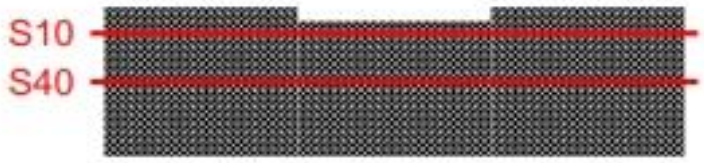
Location: 1

Diameter: 4

Schedule: 10

System Type: DRY

Nominal Thickness: 0.12



Minimum Thickness: 0.109 in.
Maximum Wall Loss: 9.17 %

Relative Energy Index: 51.8

Circumferential Energy Index: 6.6

Leak Energy Index: 100.0

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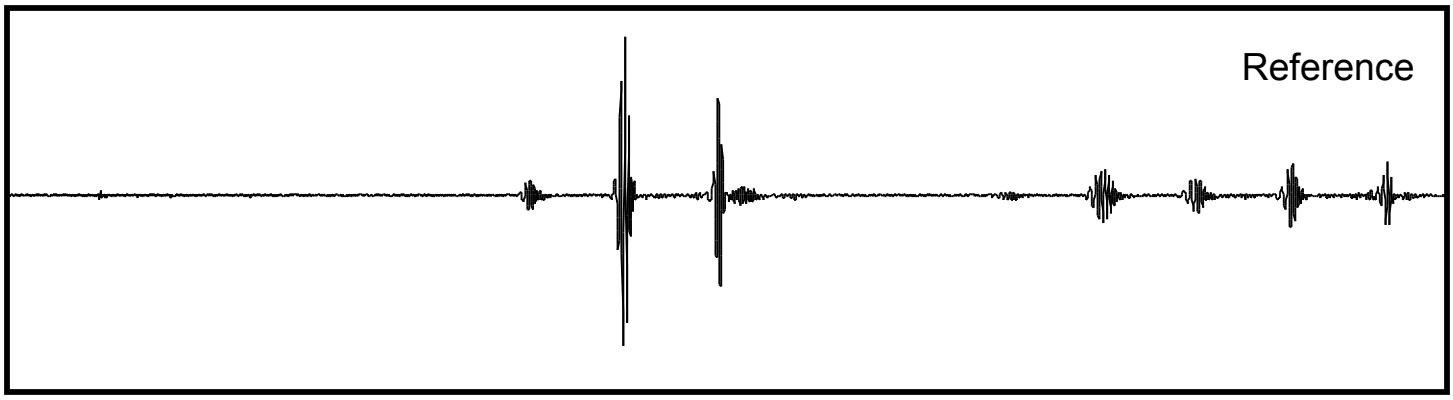
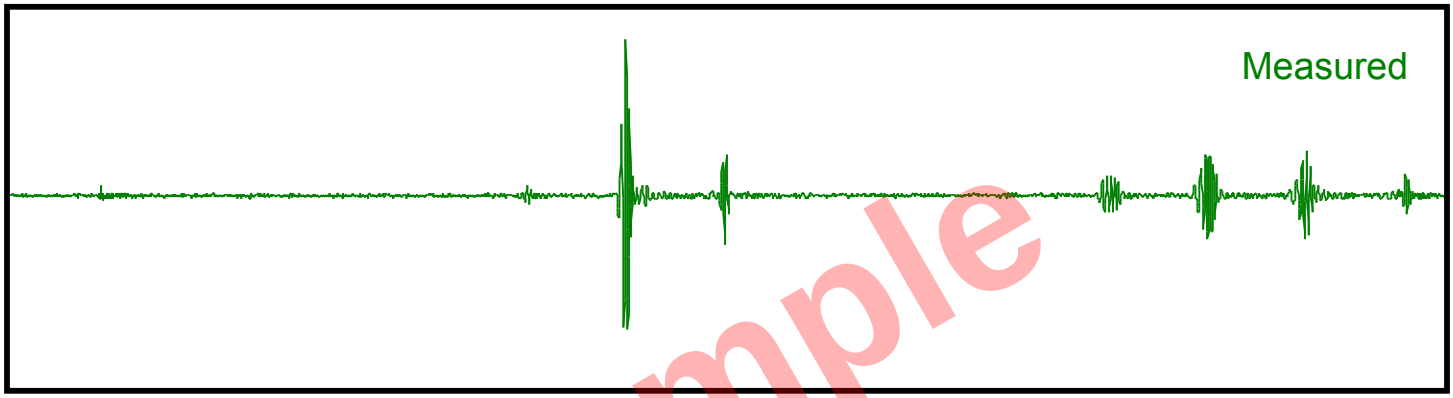
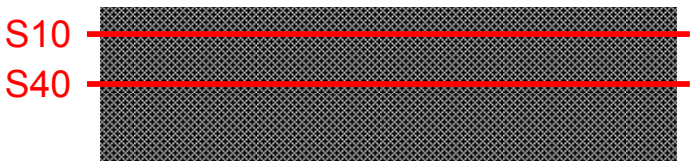
Example of a good wet 4" schedule 10 pipe





File Name:	
Location:	3
Diameter:	4
Schedule:	10
System Type:	WET
Nominal Thickness:	0.12



Relative Energy Index:	76.1	Minimum Thickness:	0.120 in.
Circumferential Energy Index:	124.9	Maximum Wall Loss:	0.00 %
Leak Energy Index:	75.2		

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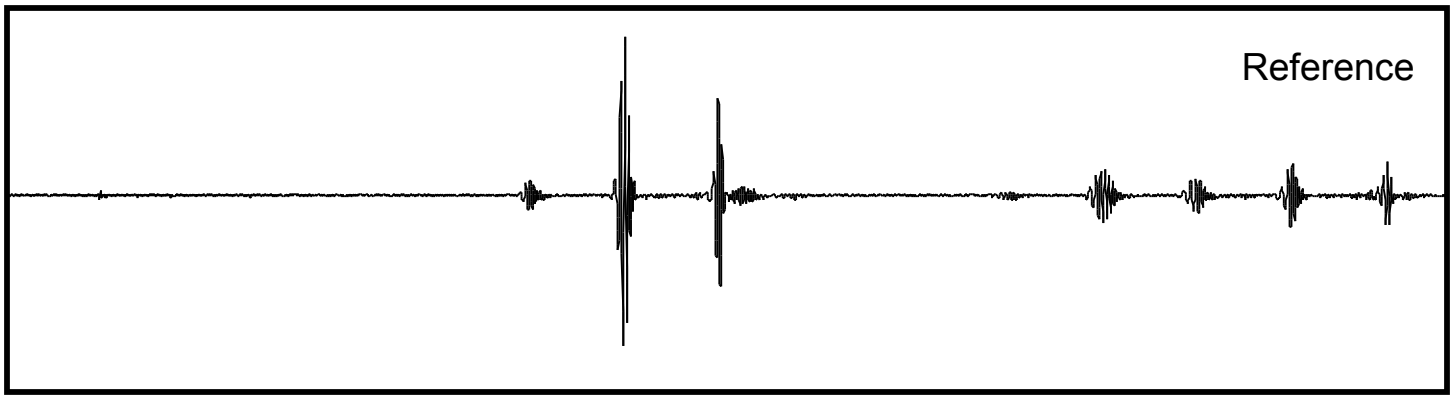
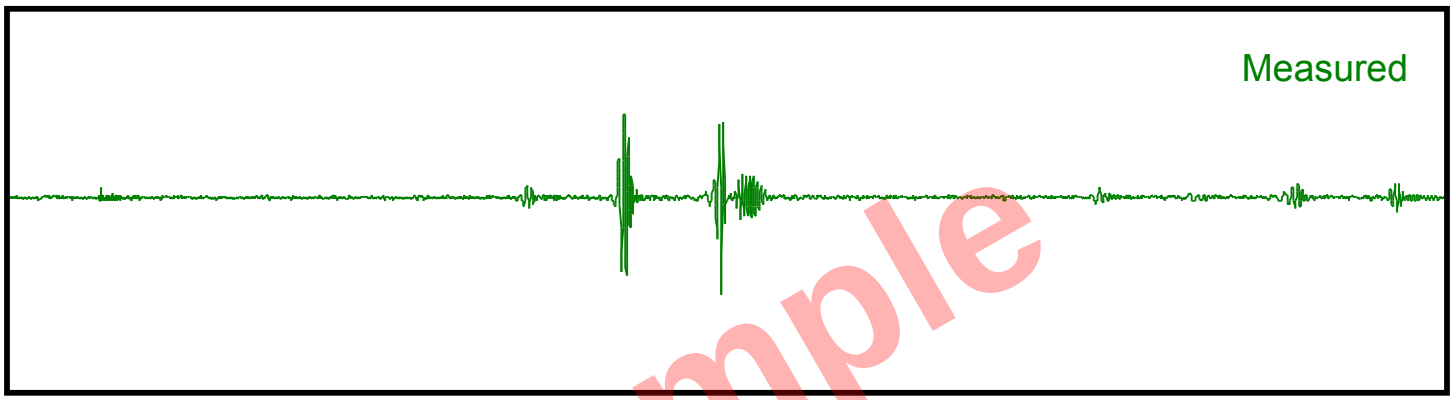
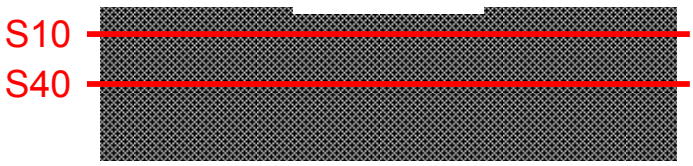
Example of a moderately bad wet 4" schedule 10 pipe





File Name:	
Location:	1
Diameter:	4
Schedule:	10
System Type:	WET
Nominal Thickness:	0.12



Relative Energy Index:	50.4	Minimum Thickness:	0.114 in.
Circumferential Energy Index:	48.9	Maximum Wall Loss:	5.00 %
Leak Energy Index:	49.9		

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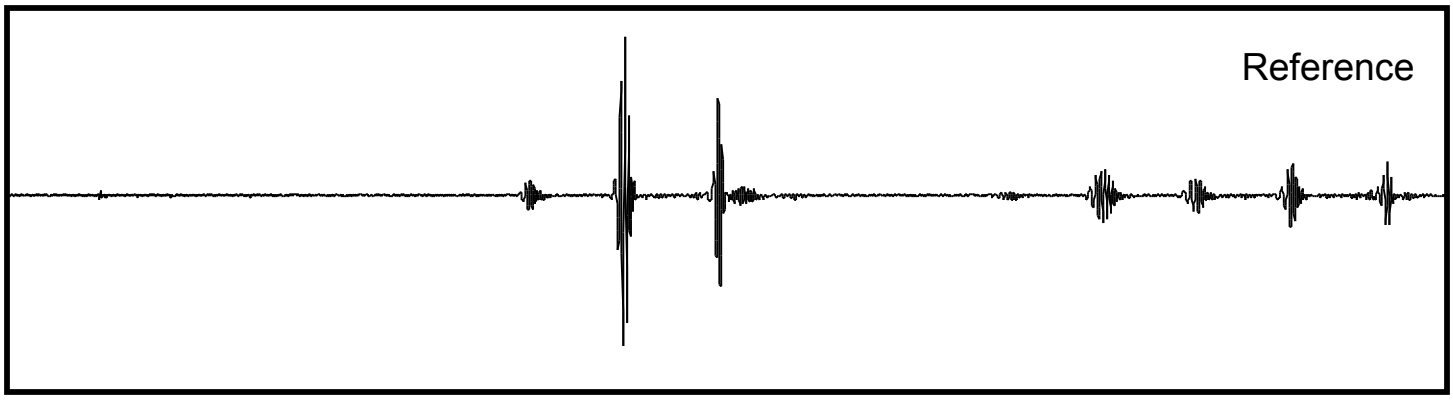
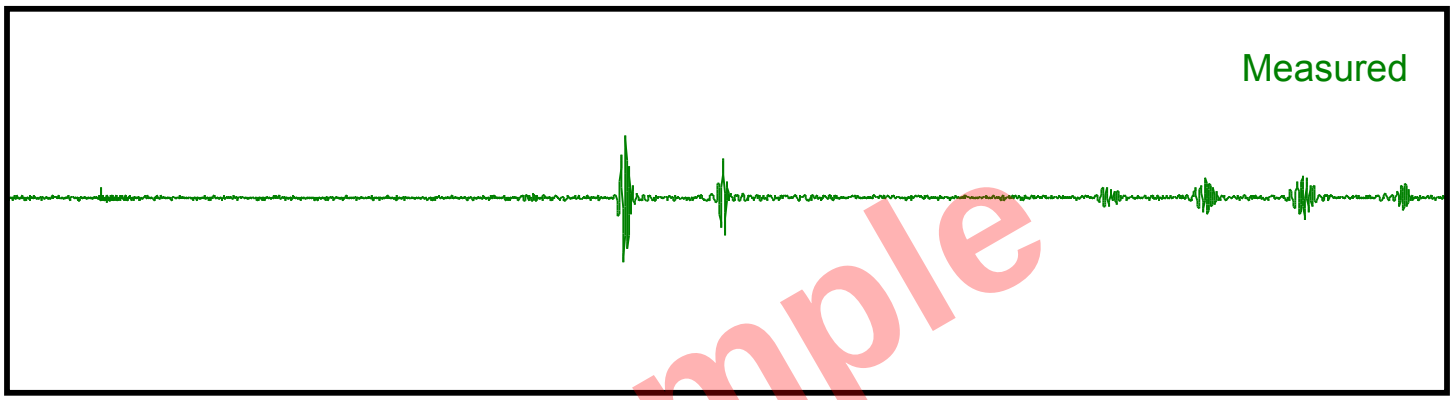
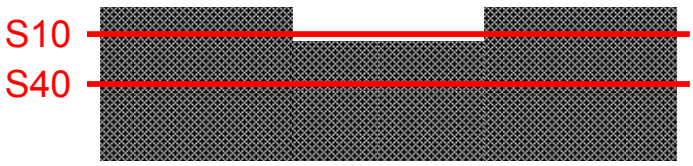
Example of a bad wet 4" schedule 10 pipe





File Name:	
Location:	5
Diameter:	4
Schedule:	10
System Type:	WET
Nominal Thickness:	0.12



Relative Energy Index:	28.8	Minimum Thickness:	0.093 in.
Circumferential Energy Index:	58.3	Maximum Wall Loss:	22.50 %
Leak Energy Index:	23.6		

Description of Measurements

SoniTech NDT used both patented guided wave Ultrasonic inspection techniques and conventional Ultrasonic thickness measurements to identify and locate corrosion, wall thinning, and/or MIC in the system. MIC is an industry term standing for Microbiologically Influenced Corrosion. The guided wave Ultrasonic technology is used to detect the presence of corrosion and foreign objects, such as tubercles, attached to the inside pipe wall. Whether the cause is ordinary corrosion or MIC, the Ultrasonic method can assess the pipe much more rapidly than any other technique currently available, and does not require taking the FPS out of service. Since ultrasound is used, there is no hazardous radiation or other safety concerns. Ultrasound provides quantitative pipe wall thickness, which again, is something no other technique provides.

Patented Guided Wave Technology

SoniTech NDT's patented guided wave Ultrasonic inspection technology has proven to be fast and accurate since its inception in 2004. The technique uses a patented scanning head that excites guided Ultrasonic waves around the circumference of the pipe and the waveforms are then measured with a receiving sensor. The received signals are compiled in SoniTech's proprietary software and displayed next to a reference waveform that was taken from a pristine pipe.

REI – CEI – LEI

As a simplified overview, and to provide a numeric representation of sound energy, SoniTech breaks the sound wave energy into 3 segments, Relative Energy Index (REI), Circumferential Energy Index (CEI), and Leak Energy Index (LEI). The numeric representation is derived from a comparison between the scan point wave energy and wave energy measured on a pristine pipe matching the alloy, diameter, and internal contents of the scanned pipe. A reading at or near zero means "heavily corroded" and at or near 100 being "perfect".

- REI represents the TOTAL amount of sound energy received by the scanner during the data collection onsite. Severe integrity issues are revealed in the REI.
- CEI represents only the portion of the sound energy that travels through the pipe wall within 3 revolutions (see red boxes below). Pipe wall loss and other dry pipe issues are revealed in the CEI.
- LEI represents only the portion of the sound energy that travels through water within the pipe (see green boxes below). Corrosion build up, trapped air/water, and other wet pipe issues are revealed in the LEI.

Dry Pipe

The signatures for Dry systems show the guided waves propagating around the circumference of the pipe. Each time the wave wraps around the circumference of the pipe the signal loses energy as shown in Figure 1 below.

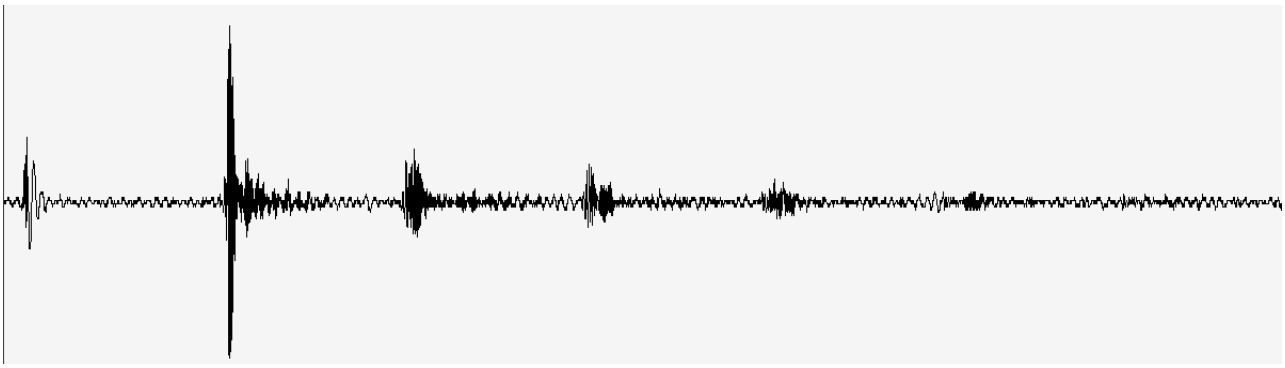


Figure 1: Dry Guided Wave Signature

Corrosion on the interior wall of the pipe will reduce the Ultrasonic energy that is transmitted, and therefore both the initial wrap and subsequent wraps will show reduced signal amplitudes.

Wet Pipe

The signatures for Wet systems show both circumferential waves and leaky Lamb waves as shown in Figure 2 below.

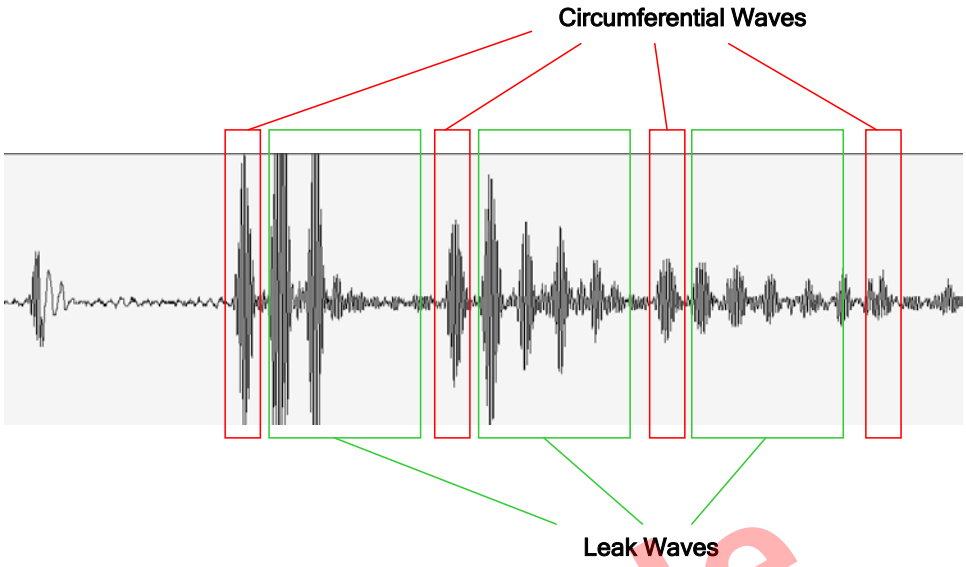


Figure 2: Wet Guided Wave Signature

Any corrosion on the interior of the pipe drastically reduces the amplitude of the leak waves and, depending on the severity of the corrosion can also reduce the amplitude of the circumferential waves similar to the Dry system measurements.

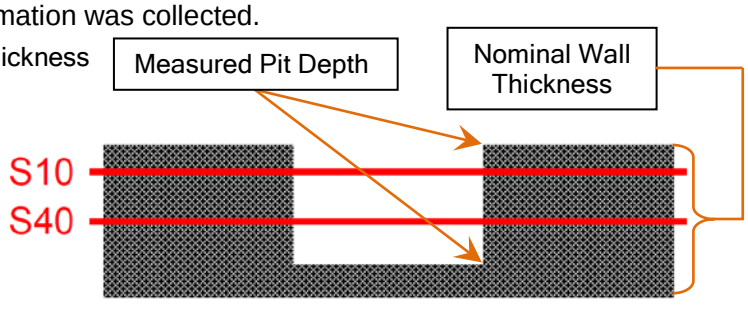
Ultrasonic Thickness Measurement Technology

Ultrasonic thickness (UT) measurements are performed using the pulse-echo technique. An Ultrasonic pulse is input into the wall of the pipe by a transducer coupled to the surface. The pulse is reflected from the ID of the wall back to the sensor on the OD. The difference in the time of flight from the OD to the ID is measured, and multiplied by the velocity of propagation. Typical accuracies are in the 0.001 to 0.003 inch range.

UT only measures thickness in a small area, about the size of a pencil lead, so it is likely that pits in the area will be deeper than those measured. Additionally, severe internal corrosion, particularly nodule build up over a pit, can slow and scatter the ultrasonic pulse, thereby simulating thicknesses greater than those actually present.

To help visualize the relation of measured wall loss to the nominal thickness of a new pipe, this graphic is included on each data page where thickness information was collected.

- The height of the gray box represents 100% wall thickness
- The notch cut-out represents the deepest pit found
- Based on SoniTech's experience with past clients
  - The S10 line represents the point at which leaks tend to occur in the very near future on Schedule 10 pipe (25% loss)
  - The S40 line represents the point at which leaks tend to occur in the very near future on Schedule 40 pipe (50% loss)



If the notch passes the red line for your schedule of pipe, as in the example above, there is a great likelihood a leak will manifest in the relatively near future.

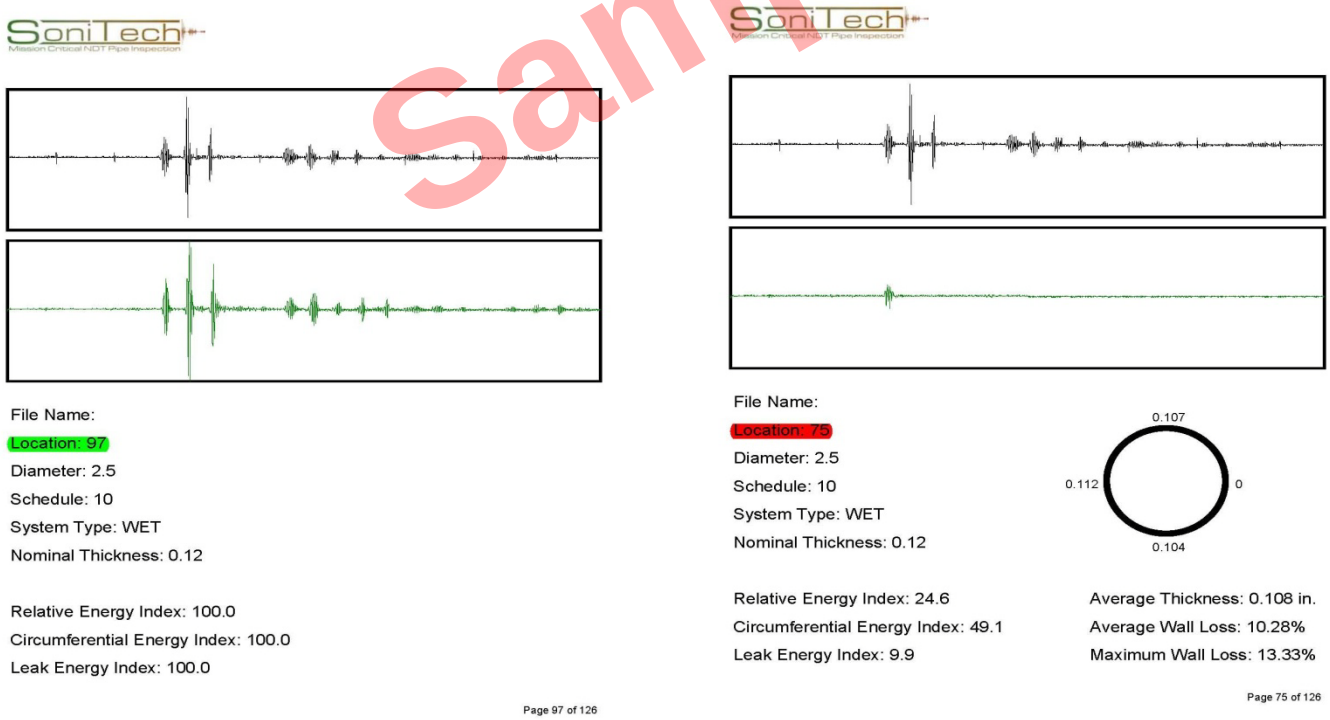
Interpreting Results

The inspection method combines the two Ultrasonic measurement methods described above to arrive at the final assessment category for pipe condition. The assessment is not meant to be dissected to the minutia of data, but rather be used in its entirety to develop an overview of specific areas within a pipe system.

NOTE: It is the combination of Ultrasonic waveform signature characteristics and measured wall thickness that determine the level of corrosion in the pipe. The Relative Energy Index is a simple energy calculation of the Ultrasonic waveform relative to the reference waveform of a pristine pipe. This value is a reasonable indicator of gross signal energy and allows for grouping signals into ranges, but cannot be used on its own to determine the condition of the pipe without further analysis of the waveform signature. Other factors that can influence the Relative Energy Index energy value are surface conditions (such as large amounts of uneven paint) and geometry effects (such as close proximity to pipe joints). These conditions affect signal strength but do not cause the waveform characteristics to change in the same way as corrosion.

Figure 3 below shows the results screen from SoniTech's analysis software package. The top waveform is the reference waveform for a pristine pipe. The lower waveform is the measured waveform at this particular location. The Relative Energy Index (REI) is shown on the left hand side directly below the location information. Additionally, the Circumferential Energy Index (CEI) and the Leak Energy Index (LEI) are shown below the REI. These provide additional information for WET systems as to the relative energy content within the circumferential and leak wave portions of the measured waveform.

Any thickness measurements are shown next to a circle representing the pipe cross-section where the thickness measurement was taken. Below this, the nominal thickness of the pipe, the average thickness, the average wall loss and the maximum wall loss.



Example on left represents good pipe. Example on right represents corroded pipe

Figure 3, Detailed Result Screen

Conclusions and Guidelines

The Ultrasonic Pipe Inspection methods used by SoniTech NDT follow ASTM E587-00 “Standard Practice for Ultrasonic Angle-Beam Examination by Contact Method” and ASTM E797-95 “Standard Practice for Measuring Thickness by Manual Ultrasonic Pulse-Echo Contact Method”.

All Ultrasonic testing equipment is calibrated before AND after each scanning project to assure data collected is accurate and that scan points are accurately coded.

The National Fire Protection Association (NFPA) has no recommendations or Guidelines on when to replace pipes due to corrosion or MIC. The NFPA 25 Handbook addresses the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems and contains specific requirements and Guidelines for investigating for obstructions including corrosion and MIC.

FM Global published a Property Loss Prevention recommendation in 2001 for “Prevention and Control of Internal Corrosion in Automated Sprinkler Systems”, which contains advisory guidelines investigating, identifying, and treating systems with corrosion and MIC.

Using the above engineering codes, standards, and industry Guidance, SoniTech NDT has established Guidelines for evaluating the level of corrosion in a fire sprinkler system using the Ultrasonic Pipe Inspection techniques described herein.

The results of the MIC / Corrosion inspection are shown graphically in the report with raw inspection data immediately following, broken down by zone.

The graphical results are color coded as follows:

GREEN indicates little to no degradation present

YELLOW indicates mild degradation

RED indicates moderate to significant degradation

BLUE indicates water trapped a dry system or air trapped in a wet system

The detailed results are color coded the same as in the graphical presentation. Note that the file name is shown in the detailed results and can be used to correlate the detailed results with the row of data on the graphical results.