skygauge robotics

SKYGAUGE REPORT

Skygauge Spot Thickness Test vs Testing by Hand

A comparison report in partnership with Paul Holloway

OVERVIEW

This report compares two methods of ultrasonic nondestructive testing of a carbon steel surface - a test conducted using the Skygauge Inspection Drone and a test conducted by hand.

Readers will see that the results of the two tests are functionally equivalent, meaning there is no tradeoff in quality when choosing the Skygauge over a conventional NDT method.

Scope:

Ultrasonic thickness testing of three (3) locations on a test vessel located at the Skygauge facility (see pictures on page 3).

Locations were labeled bottom, middle and top.

Summary:

- Material: Carbon Steel
- Location: Skygauge Test Facility

Skygauge Spot Thickness Test vs. Testing by Hand Comparison Report

HOLLOWAY NDT & ENGINEERING INC

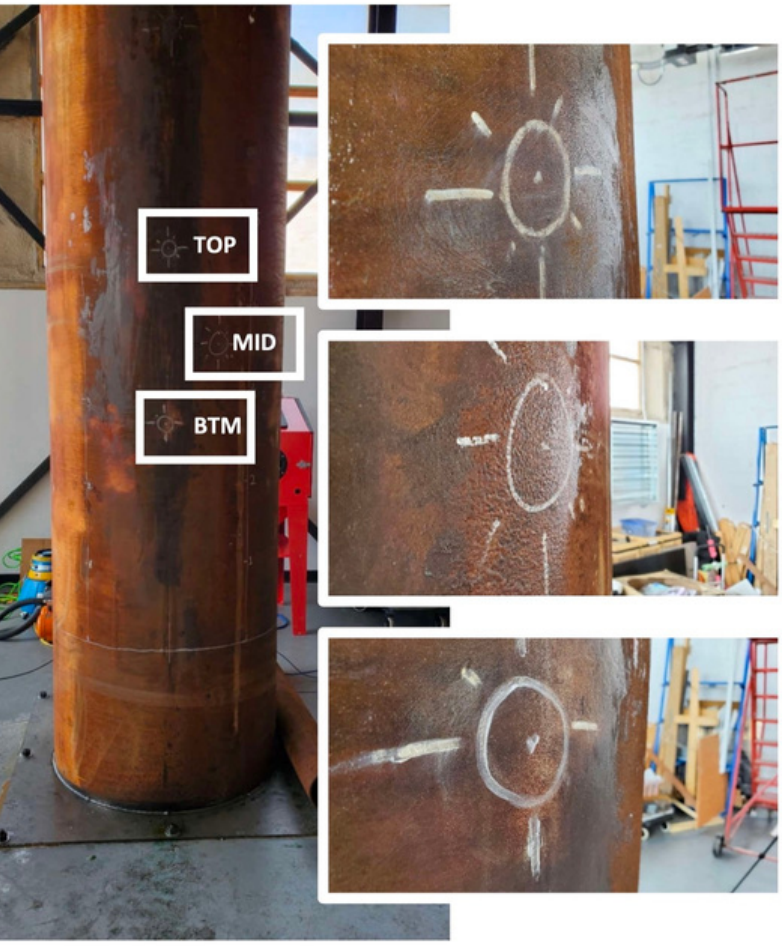
Skygauge Robotics partnered with Paul Holloway of Holloway NDT & Engineering Inc for this study. Paul completed the manual test while the Skygauge Drone was flown by Skygauge's Chief Pilot Duran Young.

APPARATUS

Both tests used a D7906 model transducer, and were calibrated on a suitable test sample of carbon steel.

Paul utilised a Sonatest Wave hand gauge, while the other transducer was connected to a proprietary gauge from Evident Scientific mounted on the Skygauge Inspection Drone.

Skygauge Spot Thickness Test vs. Testing by Hand Comparison Report



TEST SURFACE

The test surface was a carbon steel segment of industrial chimney stack located at the Skygauge test facility in Hamilton, ON.

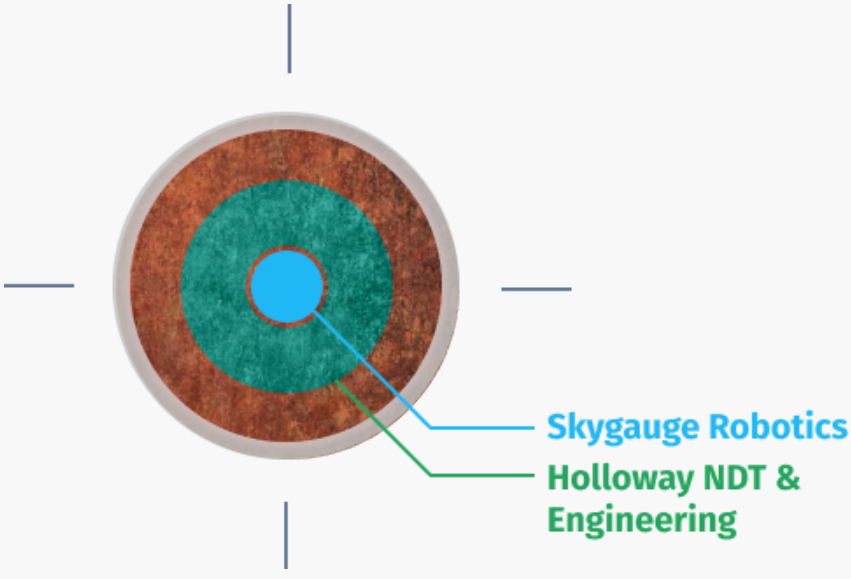
Targets 2” across were painted at 3 pre-selected condition monitoring locations (CMLs) on the test surface, and the targets were wiped clean. Paul then swept the manual sensor in a 2” radius circle within each target site to get a range of readings from each point.

Here is an image of the target sites, which were labelled TOP, MID, and BTM respectively:

SCANNING METHOD

After Paul took his readings, the Skygauge inspection drone took three point readings, one at each CML.

Each target site was therefore scanned in this manner:



SCANNING METHOD cont'd

Tests were taken using the echo-to-echo method, with readings taken off the first peak on waveforms of identical polarity. This methodology was chosen because of its repeatability, and because this kind of test is less sensitive to variations in contact pressure.

The results for each site were as follows:

Target	Holloway NDT Test	Skygauge Test
TOP	9.16mm (min) to 9.21mm (max)	**9.21mm**
MID	8.86mm (min) to 9.12 mm (max)	**9.04mm**
BTM	9.09mm (min) to 9.21 mm (max)	**9.21mm**

INSPECTION RESULTS

The Skyguage results were all within the lower and upper bounds designated by Paul's hand test.

The reasoning behind choosing a range for the hand tests was to demonstrate that there will always be some variance in results, even within a small target area, due to minute variations in density, porosity, and cleanliness of the target.

This test shows that Skygauge's results have sufficient accuracy to be useful, as they fall within the same range as results obtained by hand.

HOLLOWAY NDT & ENGINEERING INC.

NON-DESTRUCTIVE TEST REPORT

ULTRASONIC INSPECTION

SKY-23-03
HNEI PROJECT NUMBER

ver 2.003

Skygauge — CLIENT
Mar 21, 2023 — DATE

Hamilton, ON — SITE
NA — WO / PO

SCOPE

Ultrasonic thickness testing of three (3) locations on a test vessel located at the Skygauge facility (see pictures). Locations were labeled bottom, middle and top. The transducer was moved throughout a 50mm diameter circle at each position to measure the minimum and maximum readings.

Carbon steel — MATERIAL
9.5mm — THICKNESS

U-T1 Rev.1 — PROCEDURE
Measurement only — ACCEPTANCE

TEST EQUIPMENT

ULTRASONIC INSTRUMENT

☐ SONATEST VEO3
■ SONATEST WAVE
☐ OTHER:

9001038 — SERIAL NUMBER
05-Feb-23 — CALIBRATION DUE

REFERENCE BLOCKS

C.Steel 5-step — TYPE
A29164 — S/N
TYPE
S/N

COUPLANT & CABLE

Echopure — COUPLANT TYPE
415-02 — BATCH
BNC-MD — CABLE TYPE
6' — LENGTH

TRANSDUCERS & SETTINGS

	ANGLE	MHz	SIZE	MODEL	S/N	VEL	ZERO	REF REFLECTOR	REF dB	+	XFER VALUE	+	SCAN GAIN	=	dB	RANGE
1	0	5	0.312"	D7906	1384910	5890	9.228	BW	60.1		0		0		60.1	23
2																
3																

EXAMINATION SURFACE

Bare metal — SURFACE CONDITION
Wiped clean — PREPARATION FOR TESTING

RESULTS

Bottom: 9.09mm (min) to 9.21mm (max) — Drone UT: 9.21mm

Middle: 8.86mm (min) to 9.12mm (max) — Drone UT: 9.04mm

Top: 9.16mm (min) to 9.24mm (max) — Drone UT: 9.23mm

See following pages for discussion of results and summary.

TECHNICIAN

Paul Holloway — NAME (PRINT)
SIGNATURE
MT2 UT3 — CGSB LEVEL
15393 — REG.#

Three (3) locations on the test pipe were identified for comparison using manual UT and readings via Skygauge drone. The locations were marked with a 50mm dia. (approximate) circle, and the manual UT was performed to identify minimum and maximum thicknesses within each location. Due to the rolled geometry and inherent local thickness variations, some degree of variance was expected. Readings on both manual and drone UT were performed using the echo-to-echo technique to maximize repeatibility and control variances due to contact force.

All readings performed via drone were within the maximum and minimums recorded using manual UT.

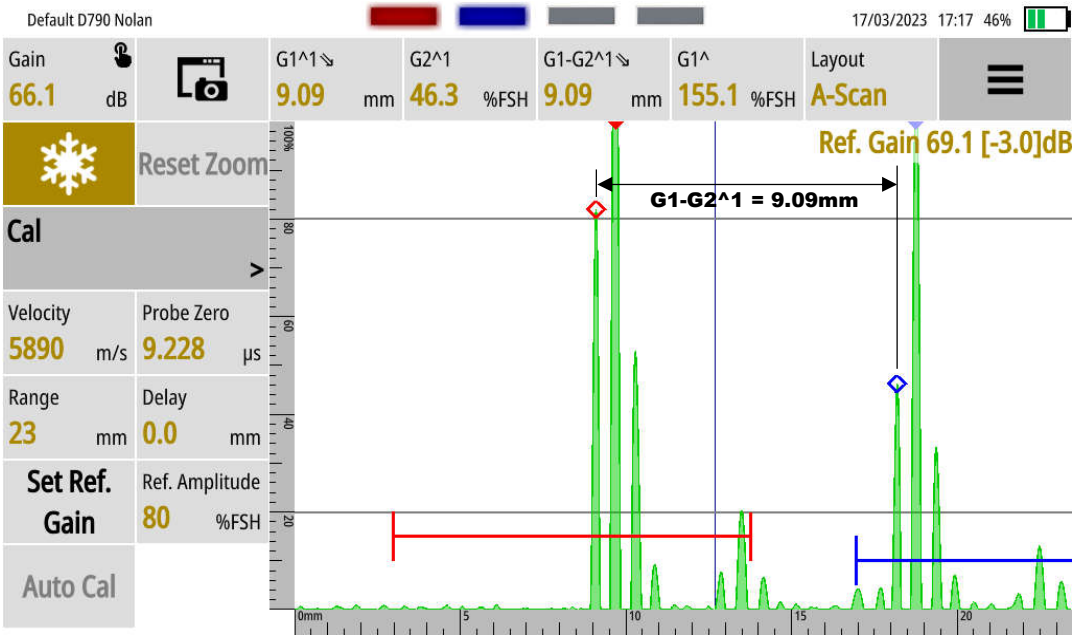
Commentary:
Establishing repeatable UT thickness readings depends upon a number of variables, many of which can be easily controlled during setup. Two of the key variables, and the methods by which they were addressed for this comparison, are detailed below.

Firstly, an ultrasonic gauge is essentially a stopwatch which converts time to distance using the setting for material velocity. Thus it is essential that any comparison between techniques uses the same value for velocity in their respective instruments. A nominal material velocity for carbon steel of 5,890 m/s was set on both the manual UT instrument and the drone software. Correct calibration is demonstrated on a suitable reference block, but deviations from nominal values for material velocity, within temperature limits, should not be made.

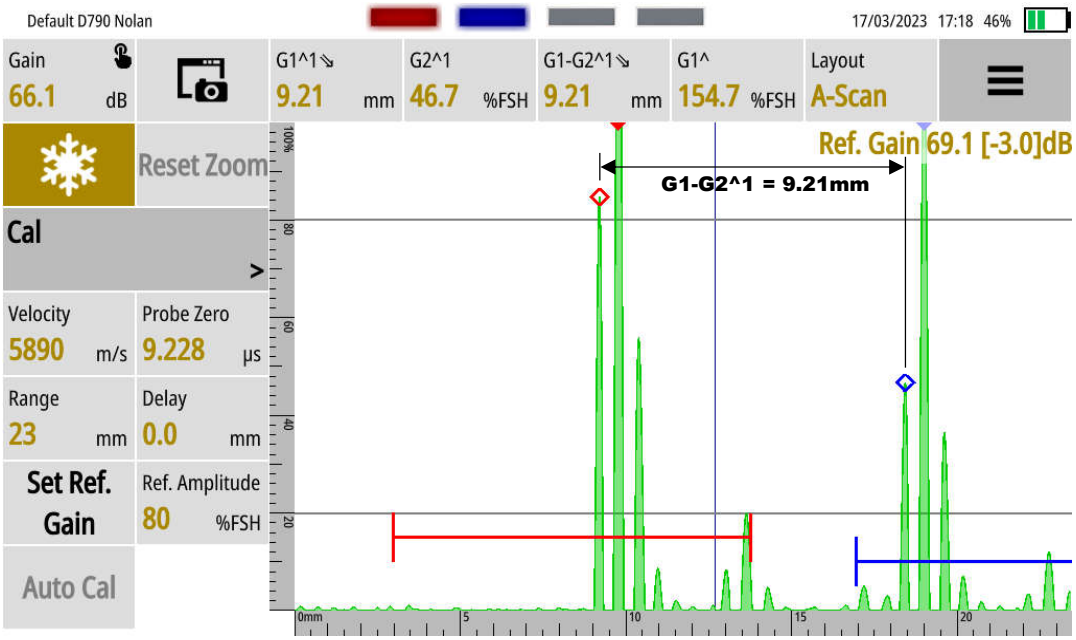
Secondly, the measurement must be made between similar points on consecutive waveform lobes. This is known as the echo-to-echo technique, and requires proper gate modes be set to correctly identify positive or negative lobes. In the comparisons, both the manual UT and drone readings were performed between waveform lobes of identical polarity.

It is expected that any UT thickness technique which uses a set value for material velocity, and correctly applies the echo-to-echo technique on consecutive reflections, and takes readings at the same location, should return measurements well within a reasonable tolerance window for nearly any application.

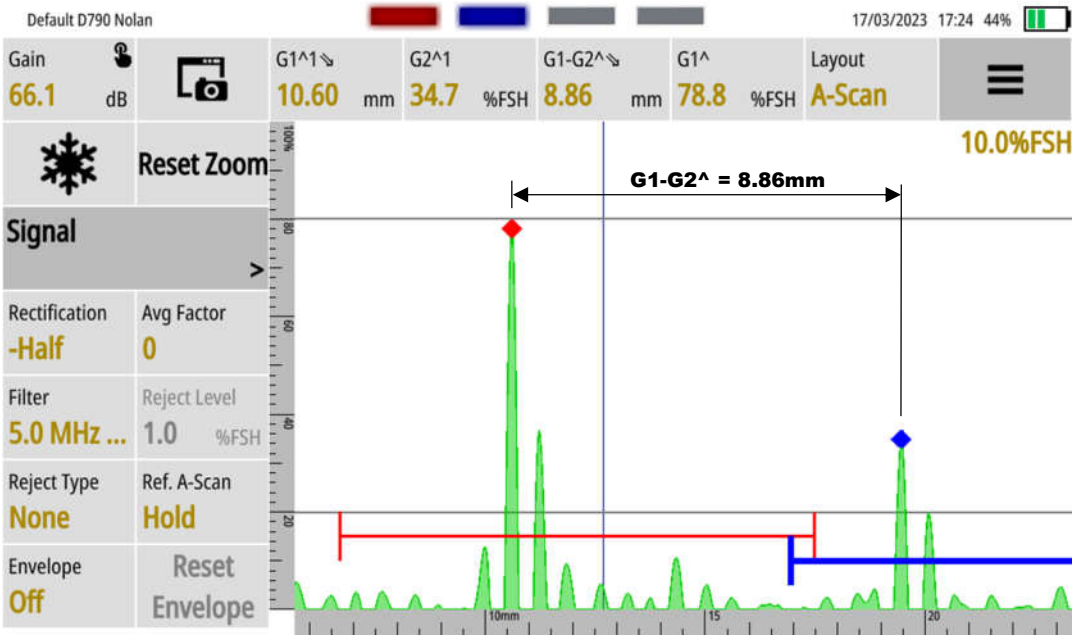
Layout of thickness reading locations (top, middle, bottom). Note middle location has visible signs of external wall loss.



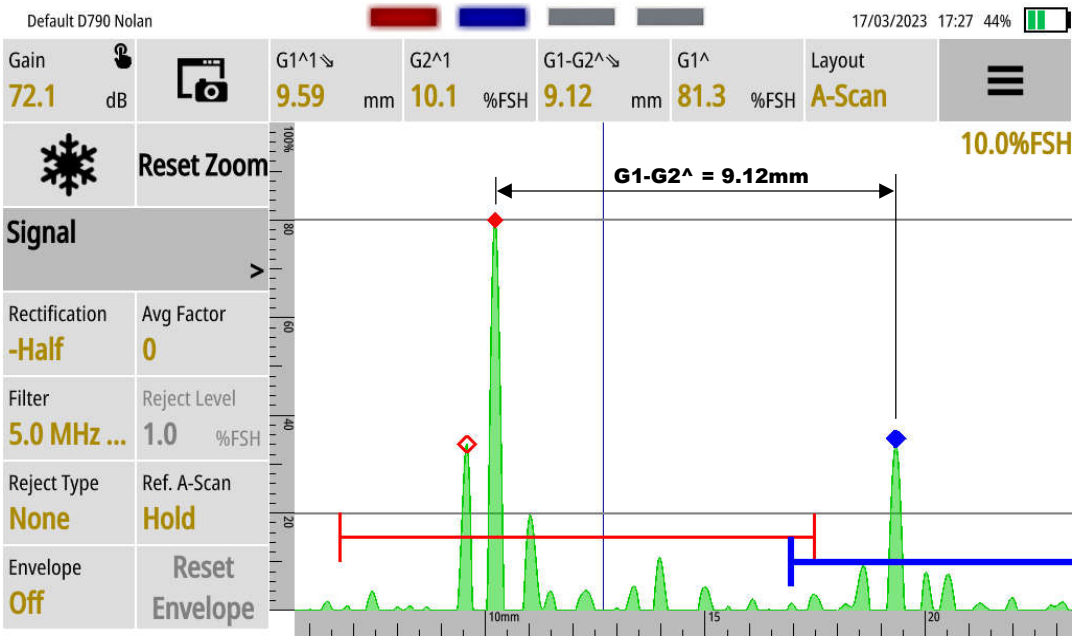
Manual UT
Bottom minimum reading: 9.09 mm (echo to echo, 1st peak)



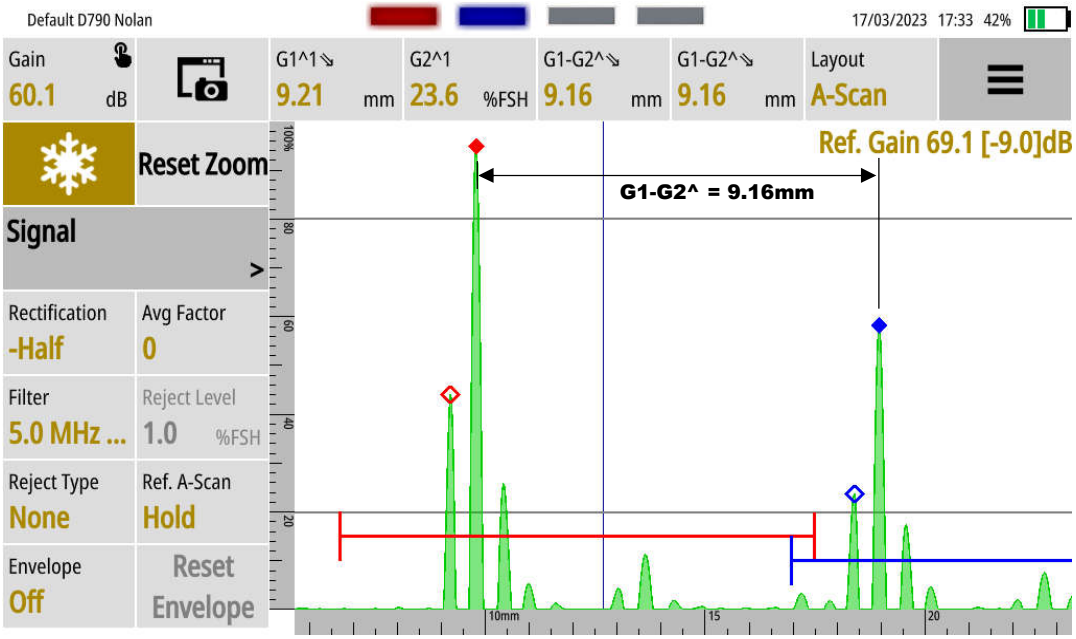
Manual UT
Bottom maximum reading: 9.21 mm (echo to echo, 1st peak)



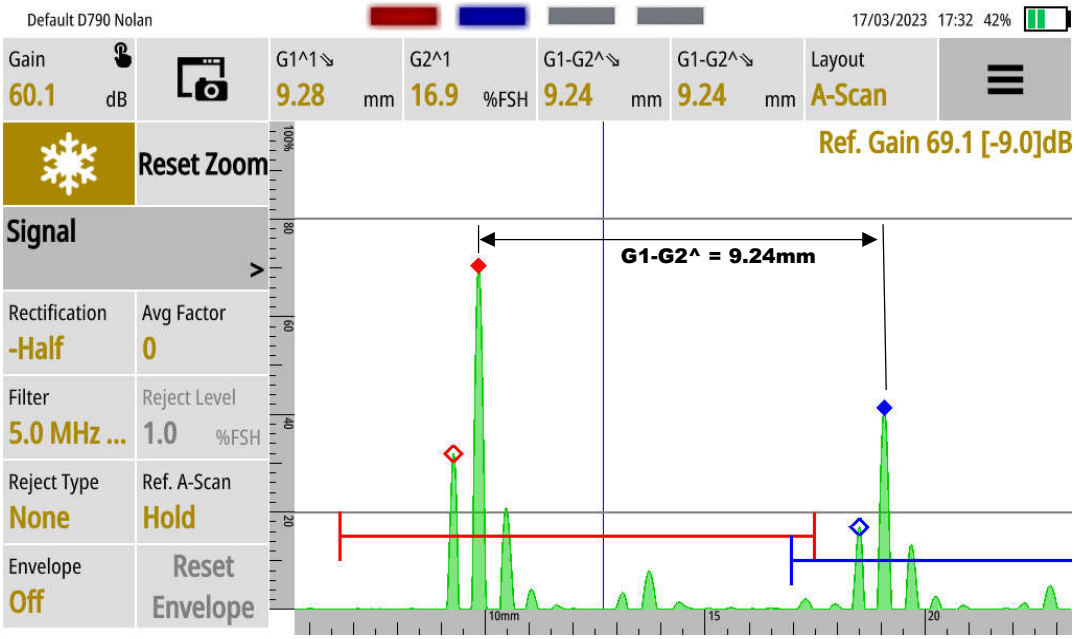
Manual UT
Middle minimum reading: 8.86 mm (echo to echo, peak)



Manual UT
Middle minimum reading: 9.12 mm (echo to echo, peak)



Manual UT
Top minimum reading: 9.16 mm (echo to echo, peak)



Manual UT
Top maximum reading: 9.24 mm (echo to echo, peak)

Bottom drone UT reading (9.21mm echo-to-echo)

Middle drone UT reading (9.04mm echo-to-echo)

Top drone UT reading (9.23mm echo-to-echo)