Sonatest

Application Note Title: **Using the VEO for AWS D1.1 Inspection**

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Introduction

This document provides a guide to using the Sonatest veo 16:64 for compliance with weld inspection to the AWS D1.1 standard. As with any Phased Array inspection, careful judgement must be used when configuring an inspection instrument. This Application Note clarifies the important paragraphs of the inspection code, and how the veo can be configured for AWS inspection to meet the requirements of the standard.

Scope of AWS D1.1/D1.1M:2010

The AWS D1.1 code covers the welding requirements for any type of welded structure made from commonly used carbon and low-alloy constructional steels (except for bridges where AWS D1.5 applies). Section 6 covers the inspector's qualification and responsibilities, acceptance criteria for discontinuities, and procedures for NDT. The code also includes all of the requirements for the design, prequalification of WPSs, qualification, fabrication, stud welding, strengthening and repairing existing structures. The table below presents the constraints imposed on the instrument for the phased array module of the unit. The conventional UT module in the veo fully complies with AWS requirements.

Compliance of Sonatest veo 16:64 unit and DAAH probes

Paragraph	Title	Explanation
Part C	**Acceptance Criteria**	
6.8	Engineer's Approval for Alternate Acceptance Criteria	The veo can be used in a proposed procedure that the Engineer has to approve. Phased array can show "experimental evidence" that the required beams can be provided as per code requirements. S-scan and L-scan imaging just happen to offer more beams than those requested.
6.13.x.x	Acceptance Criteria	Planar defects (LoF) that are mis-oriented with the sound beam will provide unreliable dB amplitude rating. Phased array can be used for a more detailed evaluation ("alternative UT technique").
6.15.x	Extent of Testing	**Phased array can provide a much higher productivity with reduced probe swapping, electronic rastering, and full data recording. Full Testing (6.15.1) is now feasible in the same time frame as conventional partial or spot testing**

Part F	**Ultrasonic Testing (UT) of Groove Welds**	
6.22.1	**Equipment Requirements**	The veo is fully capable of operation from 1 to 6 MHz with A-scan rectified display.
6.22.2	**Horizontal Linearity**	The veo horizontal linearity is measured and certified at manufacturing time and can be re-tested at any time.
6.22.3	**Requirements for Test Instruments**	The veo amplitude readings are stable to within ± 1 dB. The veo has a battery meter, one LED alarm per battery and a warning message when the batteries are too low.
6.22.4	**Calibration for Test Instruments**	The veo has a gain control precision of 0.1 dB with a gain range of 84.5 dB in Phased Array and 110 dB in conventional UT.
6.22.5	**Display Range**	When using the Sscan1+Ascan1+Ascan2+Ascan3 screen layout, the veo A-scans have 155 pixels for amplitude height, which is enough to display 1 dB amplitude differences. Each A-scan can be maximized to occupy the whole screen, therefore having more than 520 pixels in height.
6.24.1	**Horizontal Linearity**	The instrument should be re-qualified at two-month intervals in each of the distance ranges that the instrument will be used.
6.24.2	**Gain Control**	The instrument should be checked every 2 months.
6.24.3	**Internal Reflections**	The instrument and search unit (PA probe and wedge) should be checked every 40 hours of use.
6.24.4	**Angle Beams**	The wedge delay wizard should be completed every 8 hours of use to ensure that contact surface is flat, that the sound entry point is correct and that refracted angles are within ± 2°.
Part G	**Other Examination Methods**	
6.34	**General Requirements**	Phased array can be approved as an alternative method as long as the following documents are provided: procedure, qualification criteria, and acceptance criteria.
6.36	**Advanced Ultrasonic Systems**	Phased array and TOFD are explicitly mentioned.
6.36.1	**Procedures**	The veo provides for permanent recording of the essential parameters related to the instrument, transducer, wedge and part.
Paragraph	**Title**	**Explanation**
6.22.6	**Straight-Beam (LW) Search Unit**	The T1-PE-2.25M20E1.2P DAAH has an aperture of 24mm wide (15/16”) by 12mm high (4/8”). The shape is rectangular (12 x 24mm) with an active area of 288mm^2. A small derogation is required.
6.22.7.1	**Frequency**	The T1-PE-2.25M20E1.2P DAAH has a centre frequency of 2.25 MHz.

6.22.7.2	**Transducer Dimensions**	The T1-PE-2.25M20E1.2P DAAH is a rectangle measuring 24mm wide (15/16”) by 12mm high (4/8”), which is a ratio of 2. A compliant ratio of 1.2 can obtained by adjusting the number of active elements down to 12, but we recommend a derogation to use 20 for the thicker components, to achieve a tighter focus point.
6.22.7.3	**Angles**	The T1-PE-2.25M20E1.2P-35W0D probe head is capable of generating beams at 45, 60 and 70 degrees in SW, within the ± 2° tolerance.
6.22.7.4	**Marking**	The PE-2.25M20E1.2P probe head has the number “2.25M” in the model number, which is clear. Also, the color code is “yellow”, to confirm the frequency range, as per industry convention. The T1-35W0D-REXO wedge is marked with “35W” indicating the cut angle and “REXO” for the nominal velocity of 2.33 mm/s, which are the most important information for phased array wedges. The nominal refraction angle is not marked, but the possible angular range is reported in the documentation. The nominal index point span is also marked for angles ranging from 35° to 75°.
6.22.7.5	**Internal Reflections**	The performance of the PE-2.25M20E1.2P-35W0D probe is under assessment.
6.22.7.6	**Edge Distance**	The PE-2.25M20E1.2P probe head has its furthest index point at 33mm back from the search unit leading edge at 45° (lowest angle = 35°).

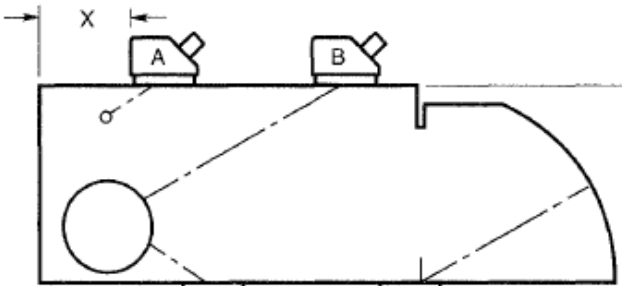
General guidelines for AWS inspection using the Sonatest veo

The AWS readings provide a convenient method of automatically calculating the “Indication Rating (IR)” or "D" value as defined by the standard. The procedures and standards set for AWS inspection govern the UT of groove welds and HAZs between the thicknesses of 5/15 in and 8 in (8 mm and 200 mm). Below is some generic guidance on how the Sonatest veo 16:64 can be used for AWS inspection.

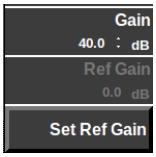
Performing AWS inspection using the UT channels

To set up the AWS measurements in conventional UT, the following steps are recommended:

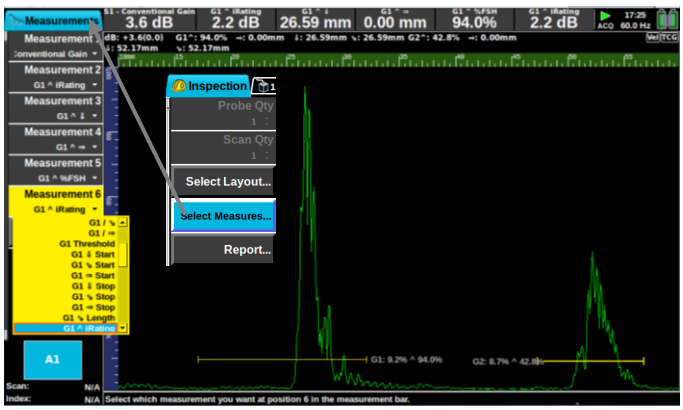
1. The velocity and probe zero shall be calibrated following instructions of section 9.3 of the veo User Guide.
2. Make sure to select a layout that includes an A-scan by pressing  .
3. Couple the transducer to the reference block and maximize the reflector response. The 0.06" (1.5mm) SDH of the IIW block is typically used. AWS code refer to transducer position A.



4. Press  to adjust the gain so that the A-scan amplitude peaks at 80%[1] full screen height.
5. In the Scan menu, press  on the "Set Ref Gain" key to record this gain as being the zero reference level or "B" value.

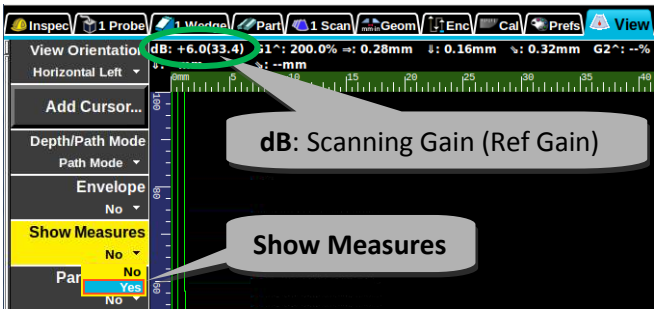


6. To have the indication rating (D value) displayed, go to the Inspection menu, press  on the "Select Measures", then select iRating for the desired gate, as per example **G1^ iRating** for gate 1.



[1] For software version 3.1.35R1, the reference has to be set 80% FSH to ensure valid indication rating values.

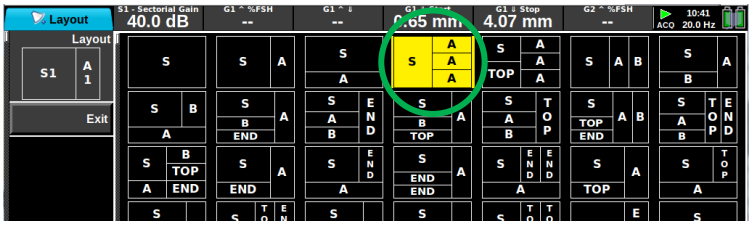
7. AWS code requires the addition of a certain amount of gain for scanning. This additional gain is displayed in the top left corner of the A-scan view. If the value is not displayed, highlight the A-scan view by pressing VIEW, go to the view menu and turn "Show Measures" to yes.



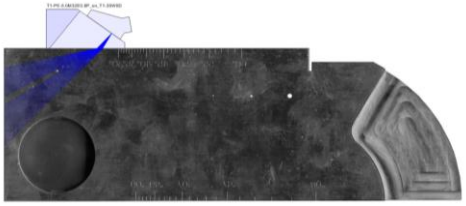
Performing AWS inspection using the PA channels

AWS explicitly states that advanced ultrasonic systems, including TOFD and phased array, can be used provided that they meet the qualification requirements. To set up the AWS measurements in PA, perform the following steps:

1. The velocity and wedge delay can be calibrated following instructions of section 9.3 of the veo User Guide.
2. Make sure to select a layout that includes an A-scan by pressing . With PA, it can be advantageous to choose a layout showing 3 A-scans so that the 45°, 60° and 70° angles can be seen simultaneously.

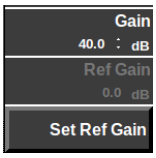


3. Couple the transducer to the IIW reference block and maximize the reflector response.
   i. Transducer at position A



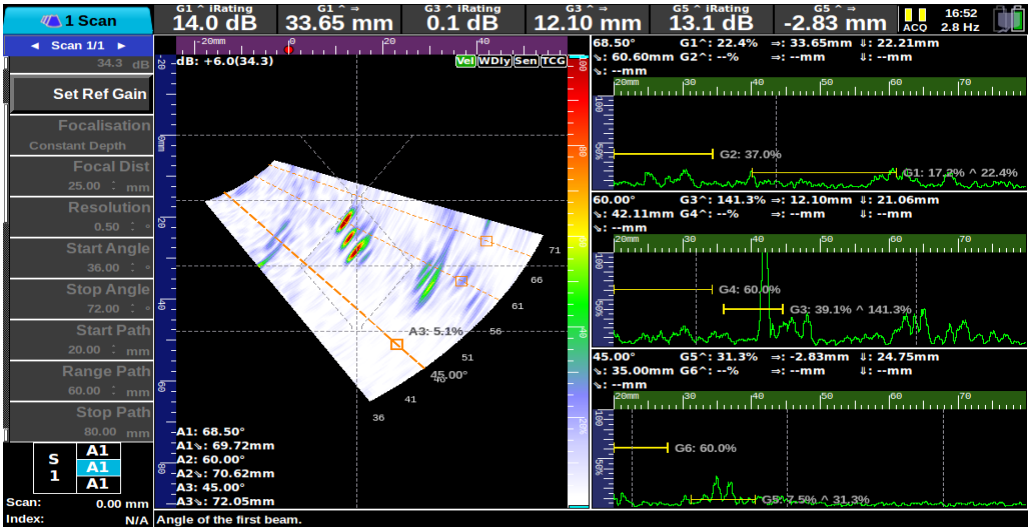
   ii. Sensitivity calibration
   It is recommended to go through the sensitivity calibration wizard using the 0.06" (1.5mm) SDH of the IIW block. This will ensure a uniform response to the hole target for all angles, hence a good D value. Go to the Calibrate menu and select the Sensitivity/ACG Wizard.

4. After successful completion of the Sensitivity wizard, adjust the gain as required so that the A-scan amplitude peaks at 80%[2] full screen height.
5. Press the "Set Ref Gain" key to record this gain as being the zero reference level. If the Sensitivity Wizard has been completed successfully with a reference level of 80%, you can skip steps 4 and 5.

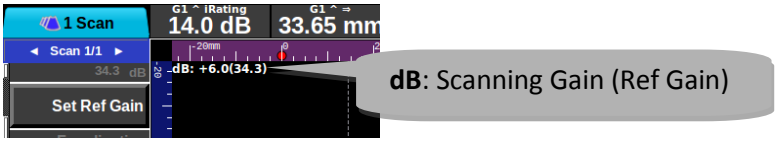


6. To have the indication rating (D value) displayed, go to the Inspection tab, press 

on the "Select Measures", then select **G1^ iRating, G3^ iRating and G5^ iRating** .



7. AWS codes require the addition of a certain amount of gain for scanning. This additional gain is displayed in the top left corner of the S-scan view. If the value is not displayed, highlight the S-scan view, go to the view tab and turn "Show Measures" to yes.



Defining the Weld Geometry and Scan Plan

AWS requires a detailed drawing showing an "X" and "Y" line (refer to section 6.26 of AWS D1.1 2010) from which the discontinuity location will be marked. Thanks to the 3D Scan Plan offered on the Sonatest veo 16:64, the scanning direction and scanning pattern can be defined directly on the unit. General guidance is provided below.

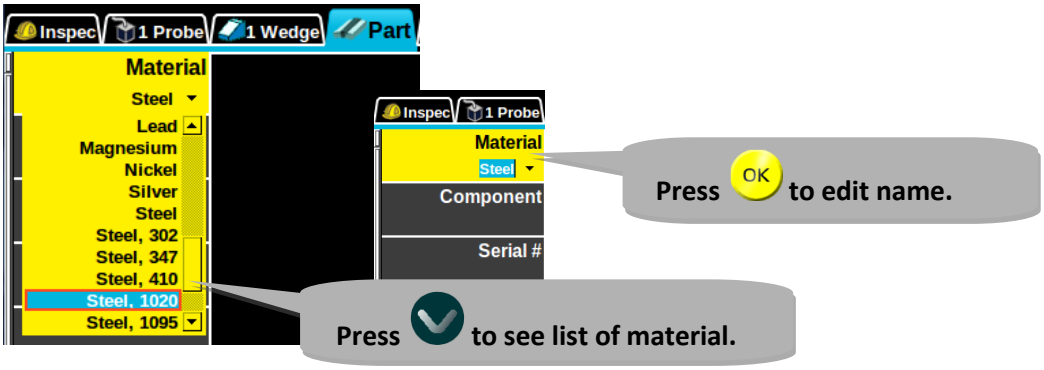
Weld Geometry

A wide variety of weld geometries can be inspected in accordance with the requirements of AWS D1.1. Sonatest has incorporated a set of tools to define the most common weld geometries encountered. The weld geometry is defined by accessing the Part menu.

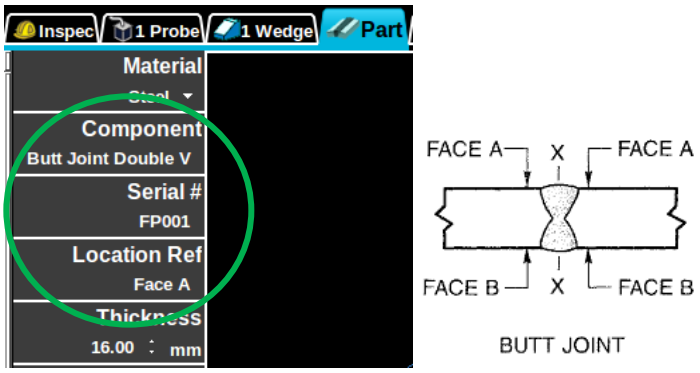
[2] For software version 3.1.35R1, the reference has to be 80% FSH to ensure valid indication rating values.

1. From the Part menu, the material being inspected can be selected. Default velocities will be set accordingly.

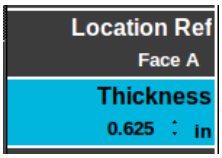
   Press OK once to edit the name. Press the down arrow to see the list of material available.



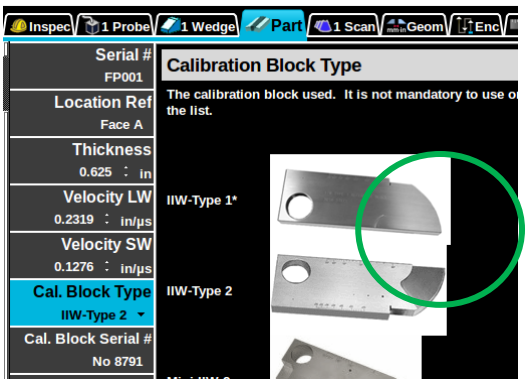
2. Among the different items to be reported are the type of weld joint; the weld identification as well as the inspection face. The Part menu offers three identifier fields for these items.



3. The thickness of the part can be entered directly in millimetres or inches according to unit system selected in the Preferences menu.

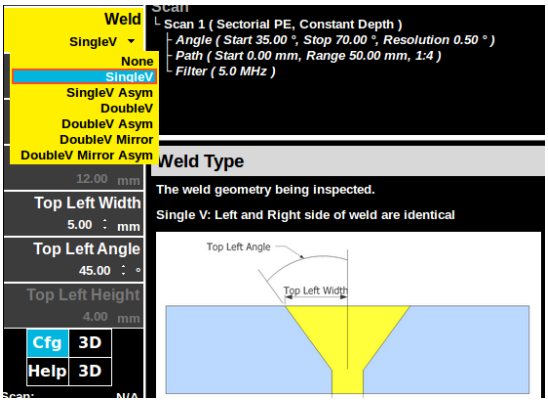


4. For reporting purposes, the type of calibration block and its serial number can be entered.

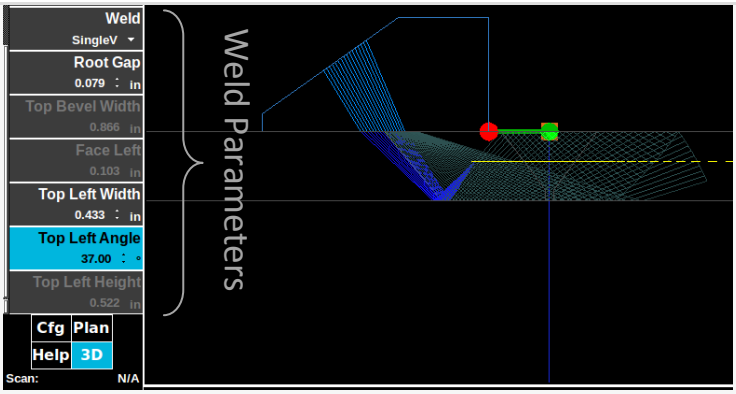


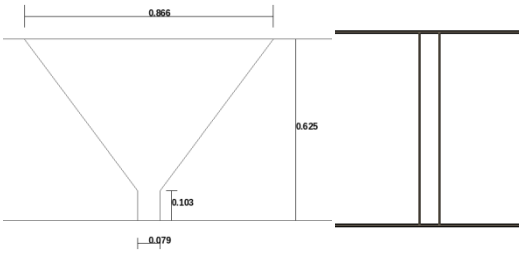
5. The type of weld can then be selected and defined.

- Select the type of geometry from the weld parameter.

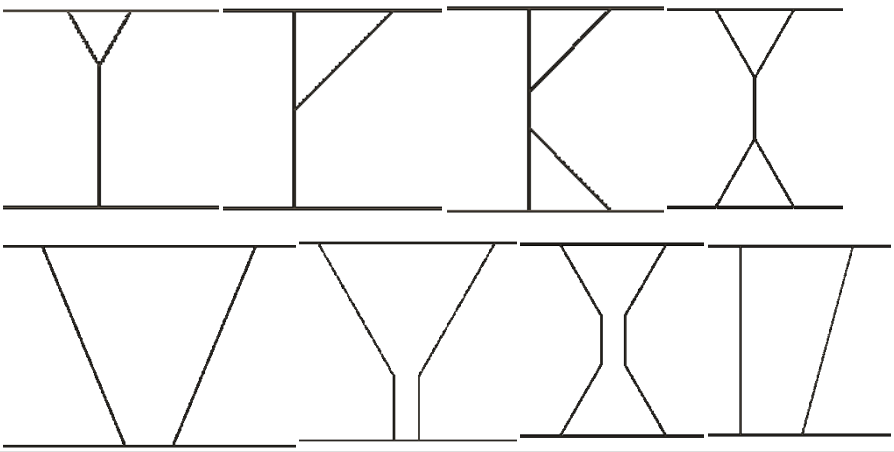


- Define the geometry using the weld parameters.



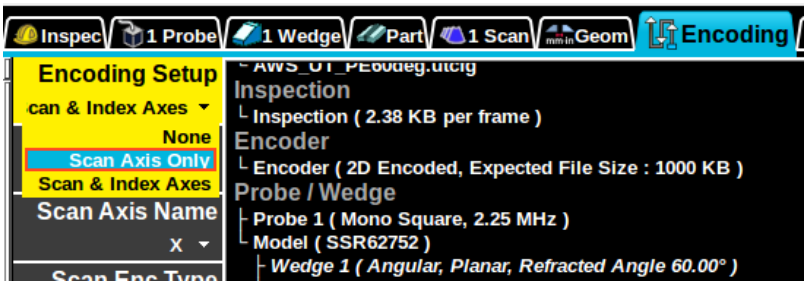


- A wide variety of weld profiles can be defined to suit your needs.

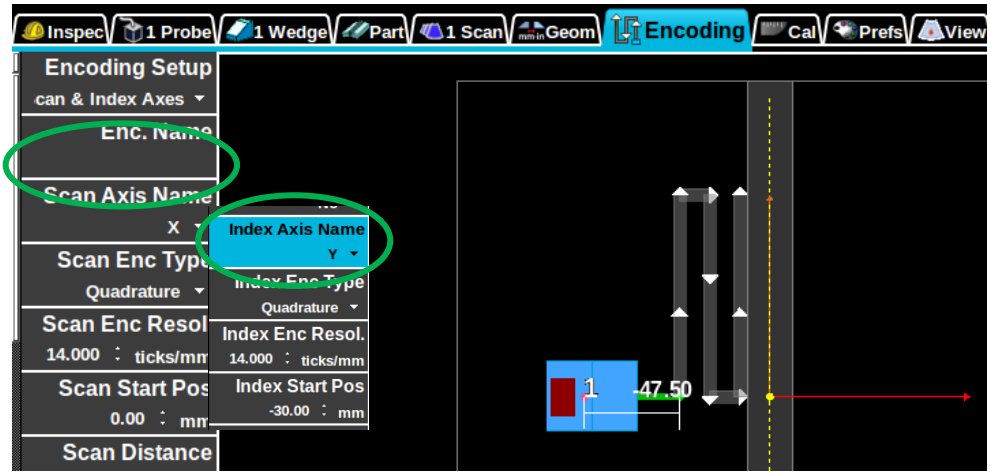


Scan Plan

1. Assuming the probe, wedge and scan parameters have been defined (refer to section 7 of veo User Guide), a detailed scan plan can be defined if the Encoding Setup is set to Scan Axis only or Scan & Index Axes. This is done by accessing the Encoding menu.

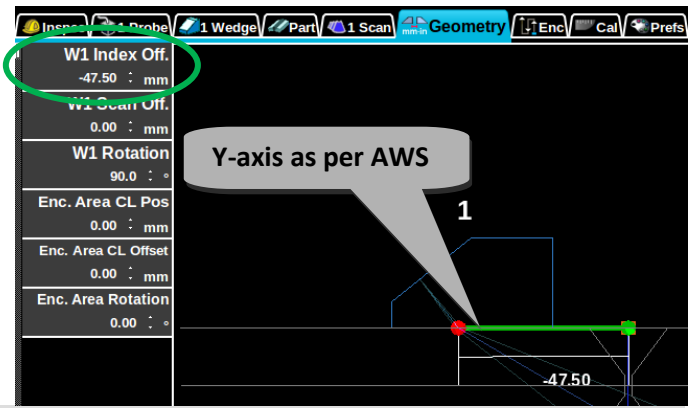


2. Each axis can be given its proper name from the Encoding menu. For AWS, the Scan Axis is referred to as the X-axis while the Index Axis is referred to as the Y-axis. See section 6.26 of AWS.

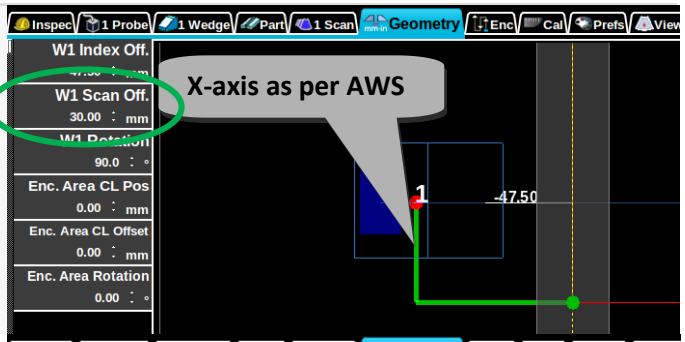


3. The probe stand-off distance can then be defined from the Geometry menu. By default, the probe is positioned on the weld centerline.

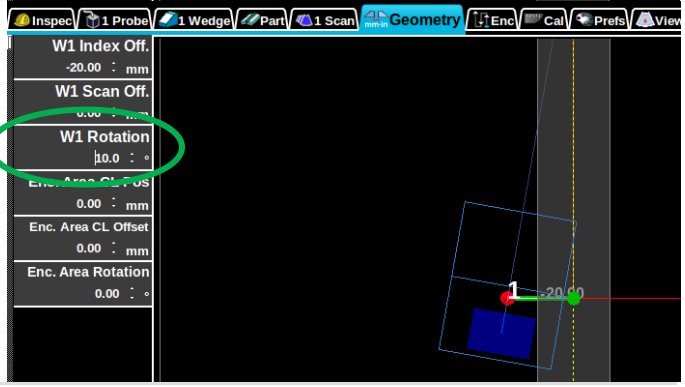
- Use W1 Index Off to translate the transducer along the Y-axis.



- Use W1 Scan Off. to translate the transducer along the X-axis (weld axis).



- Use W1 Rotation to skew the probe relative to the X-axis (weld axis).

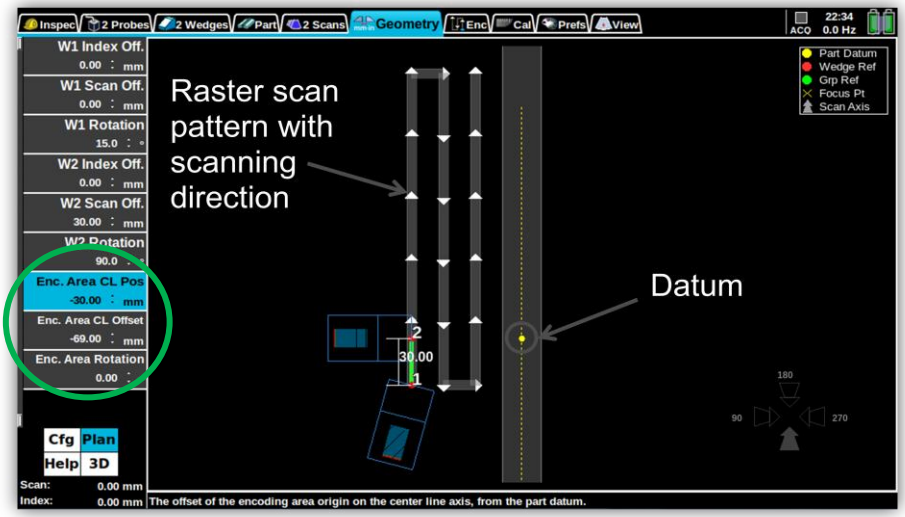


4. The scanning direction is controlled from the Geometry menu by using the Enc. Area Rotation.

- Use Enc. Area CL Pos to move the datum point along the AWS X-axis (weld axis).

- Use Enc. Area CL Offset to move the datum point along the AWS Y-axis (perpendicular to weld axis).

- Use Area Rotation to rotate the scan plan, which will also change the scanning direction.



Sonatest Products for AWS Inspection

Phased Array	Conventional UT
Unit	
Sonatest veo 16:64	Sonatest veo 16:64 - D-Series flaw detectors
Transducers	
T1-PE-2.25M20E1.2P	SSG62622 - 2.25M, 5/8" x 5/8"
Wedges	
T1-35W0D (angle), T1-25.4T0D (straight beam)	SNW6245, SNW6260 or SNW6270 Snail wedges