

USFD OF RAILS AND WELDS

I. CHARACTERISTICS CHECKING OF MACHINE & PROBES

1. Objective

To check the proper functioning of the equipment and probes.

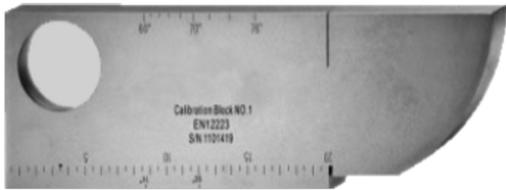


Fig. 1: IIW Block - V1



Fig. 2: 0° 2/2.5 Mhz Single Crystal Probe



Fig. 3: Soft grease or Thick Oil for couplant.

Soft grease of RDSO Specification No. WD-17-Misc-92 or WD-24 Misc-2004 or Thick Oil having high viscosity grade of 150 cst or more.



Fig. 4: USFD Equipment



Fig. 5: Angle probe to check the probe index and beam angle



Fig. 6: Step Gauge

3. Reference

IS 12666 – 2018: Methods for Performance Assessment of Ultrasonic Flaw Detection Equipment

4. Frequency of Test

Once in a month

5. Characteristics of Equipment and Probe

The following are the characteristics of Equipment and Probe to be checked as mentioned in Para No. 4.1.1 (d) of USFD Manual - Revised 2022

- Machine (Equipment)
 - Linearity of Time Base
 - Linearity of Amplification
 - Resolving Power
 - Penetrative Power
- Probe
 - Probe Index
 - Beam Angle

6. Procedure to check the Characteristics

1. Procedure to check the Linearity of Time Base

1. Switch on the Machine.
2. Connect the 0°, 2 Mhz or 2.5 Mhz, Single Crystal Probe.
3. Select any Range between 100 mm to 500 mm. (for example here range is selected 500mm)
Note: - Select range as minimum 5 echoes should appear on screen.
4. Set Probe Angle 0°.
5. Set Mode of Single Crystal probe – (T + R).
6. Set Velocity of Longitudinal Wave – 5920 m/sec.
7. Apply couplant and Place the Probe on IIW Block at a position from where, minimum 05 peaks shall appear from the opposite surface of the IIW Block.
8. Put the Gate on First peak and Notice the height(H) of the peak.
Set the height of First peak at more than 50% on vertical scale. (for example 70%)
Set the First peak on 100 mm depth(D) on horizontal scale by adjusting the value of Probe Zero.
9. Put the GATE on Second Peak and Notice the Height(H).
Set the height of second peak at 70% by adjusting the Gain. (same as first peak)
10. Notice the Value of Depth(D) for the second peak and measure the Deviation with respect to its ideal position of 200 mm.
11. Measure the Deviation for all the echoes appearing on screen with respect to their ideal position after adjusting the height at same level of 70 %.
Notice the maximum deviation found among all the echoes.
12. Calculate the Linearity of Time base
$$Lb = \frac{a_{max}}{b} \times 100$$
Where, "a_{max}" is the Maximum deviation among all the echo in terms of number of small division and
"B" is the Total number of small divisions on the horizontal scale i.e. 100 Nos.
13. Permissible limit is ±1 % as per the RDSO Specifications of machine.
14. Repeat this procedure for at least 03 different ranges. (like 125 mm, 250 mm, 500 mm)



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LINEARITY OF TIME BASE

$$L_b = \frac{a_{max}}{b} \times 100$$

Where,

a_{max} = Maximum deviation found among all the echos in terms of No. of small divisions

b = Total no. of small divisions in Timebase

$$L_b = \frac{0.6}{100} \times 100$$

$$L_b = 0.6 \%$$

Permissible limit is $\pm 1 \%$

2. Procedure to check the Linearity of Amplification

1. Switch on the Machine.
2. Connect the 0°, 2 Mhz or 2.5 Mhz, Single Crystal Probe.
3. Select any Range between 100 mm to 500 mm. (for example here range is selected 500mm)
Note: - Select range as minimum 5 echoes should appear on screen.
4. Set Probe Angle 0°.
5. Set Mode of Single Crystal probe – (T + R).
6. Set Velocity of Longitudinal Wave – 5920 m/sec.
7. Set the Reject value at minimum i.e. '0'.
8. Apply couplant and Place the Probe on IIW Block at 100 mm height for range selected 500 mm and at thickness of 25 mm for range selected 250 mm or less.
9. Put the Gate on First peak and Notice the height(H) of the peak.
Set the height of the First peak at more than 90% on vertical scale and notice the required gain.
Consider this height as h1 for the first peak.
10. Reduce the gain by 6db and notice height of the peak, consider this height as h2 for the first peak.
11. Again reduce the gain by 6db and notice Height of the peak, consider this height as h3 for the first peak.
12. Calculate the Linearity of amplification

$$La = \frac{h1 - 2 \times h2}{h1} = \frac{h2 - 2 \times h3}{h2}$$

13. Similarly, the Linearity of amplification (La) shall be calculated for all the echoes appearing on screen.
14. Permissible limit is ±3 % as per the RDSO Specifications of machine.
15. Repeat this procedure for at least 03 different ranges. (like 125 mm, 250 mm, 500 mm)



LINEARITY OF AMPLIFICATION

$$La = \left[\frac{h1 - (2 \times h2)}{h1} \times 100 \right] = \left[\frac{h2 - (2 \times h3)}{h2} \times 100 \right]$$

Where,

h1 = Height of the any selected Echo (set above 90 %)

h2 = Height of the same Echo (After reducing the Gain by 6db)

h3 = Height of the same Echo (After reducing the Gain again by 6db)

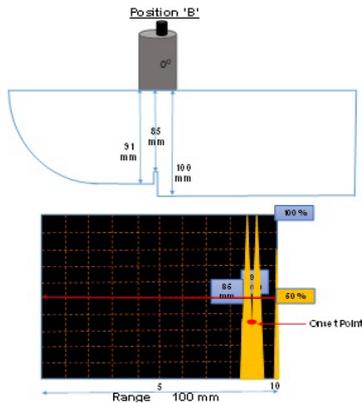
$$La = \left[\frac{92 - (2 \times 47)}{92} \times 100 \right] = \left[\frac{47 - (2 \times 23)}{47} \times 100 \right]$$

$$La = 2.17 \%, \quad La = 2.12 \%$$

Permissible Limit is ± 3 %

3. Procedure to check the Resolving Power

1. Connect the 0°, 2 Mhz or 2.5 Mhz, Single Crystal Probe.
2. Set Range 100 mm.
3. Set Probe Angle 0°.
4. Set Mode of Single Crystal probe – (T + R).
5. Set Velocity of Longitudinal Wave – 5920 m/sec.
6. Set the Reject value at minimum i.e. '0'.
7. Apply couplant and Place the Probe on IIW Block above the 6mm deep saw cut, situated at the bottom of IIW Block.
Three peaks will appear at 85 mm, 91 mm & 100 mm depth from three different surfaces of 6mm deep saw cut.
8. Equalize the Height of 85 mm & 91 mm echo by adjusting the Probe. Now Make the height 100 % of both the echoes by increasing the Gain.
9. Notice the Onset Point of Both the echoes (85 mm and 91 mm), whether it is above or below the half of full screen height i.e. 5 Divisions on vertical scale.
10. If the onset point is below the 5 Divisions, the resolution power of Machine is O.K.

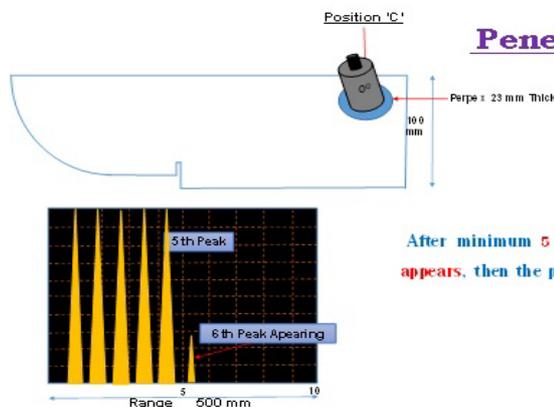


Resolution Power

After Increasing the Height of 85 mm & 91 mm echoes up to 100 %, The Onset point of both the echoes should be below 5 Division.

4. Procedure to check the Penetrative Power

1. Connect the 0^0 , 2 Mhz or 2.5 Mhz, Single Crystal Probe.
2. Set Range 500 mm.
3. Set Probe Angle 0^0 .
4. Set Mode of Single Crystal probe – (T + R).
5. Set Velocity of Longitudinal Wave – 5920 m/sec.
6. Set the Reject value at minimum i.e. '0'.
7. Apply couplant and Place the Probe on IIW Block above the Perspex having thickness of 23 mm.
A Peak will appear from the base of Perspex.
8. Increase the gain continuously until the Fifth echo becomes 100 % of full screen height. Now notice the Sixth peak is clearly appearing or not on the screen.
9. If Sixth peak is clearly appearing at the time of Fifth echo becomes 100%, the Penetrative Power of Machine is O.K.

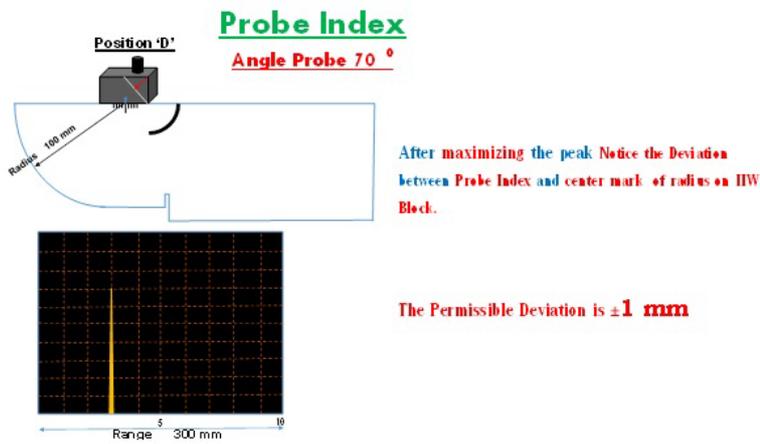


Penetration Power

After minimum 5 Full Peaks Appearing if the 6th Peak appears, then the penetration power of Machine is OK.

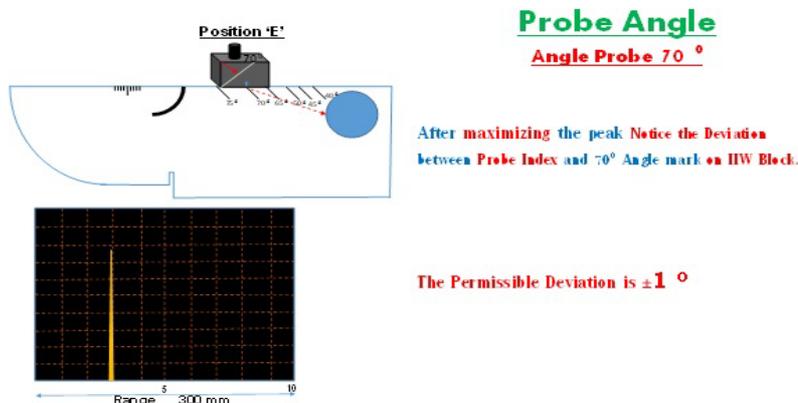
5. Procedure to check the Probe Index

1. Connect any angle probe with the machine (For example 70^0 , 2 Mhz, Single Crystal Probe)
2. Set Range of 300 mm.
3. Set Probe Angle 70^0 .
4. Set Mode of Single Crystal probe – (T + R).
5. Set Velocity of Shear Wave – 3230 m/sec.
6. Set the Reject value at minimum i.e. '0'.
7. Apply couplant and place the Probe on IIW Block at center mark of the Arc, directing towards 100 mm radius Arc.
8. The Peak will appear from 100 mm radius.
Move the probe in forward and backward direction to get peak of maximum height. Stop the probe at point from where maximum echo height is appearing.
9. Now Notice the deviation between the probe index marked on probe and center mark of the Arc marked on IIW Block.
10. The Permissible limit of Deviation is ± 1 mm as per the RDSO specifications.



6. Procedure to check the Beam Angle

1. Connect any angle probe with the machine (For example 70°, 2 Mhz, Single Crystal Probe)
2. Set Range of 300 mm.
3. Set Probe Angle 70°.
4. Set Mode of Single Crystal probe – (T + R).
5. Set Velocity of Shear Wave – 3230 m/sec.
6. Set the Reject value at minimum i.e. '0'.
7. Apply couplant and Place the Probe on IIW Block at respective angle mark i.e. 70°, directing towards the Perspex of 50 mm dia.
8. The Peak will appear from the surface of from 50 mm Diameter Perspex. Move the probe in forward and backward direction to get peak of maximum height. Stop the probe at point from where maximum echo height is appearing.
9. Now Notice the Deviation between probe index marked on probe and respective Angle mark of 70° marked on IIW Block.
10. The Permissible limit for deviation in Beam angle is ± 1 as per the RDSO specifications.



7. DEAD ZONE

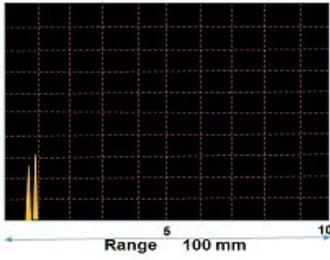
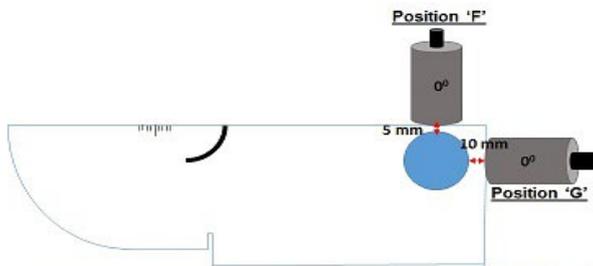
A. Dead Zone for Single Crystal Probe - 5 To 7 MM

B. Dead Zone for Double Crystal Probe - 3 To 4 MM

1. Procedure to check the Dead Zone

1. Connect the 0°, 2 Mhz, Single Crystal Probe.
2. Set Range 100 mm.
3. Set Probe Angle 0°. Set Velocity of Longitudinal Wave – 5920 m/sec. Set Mode of Single Crystal probe – (T + R).
4. Apply couplant and Place the Probe on IIW Block at Position 'F'.
5. Notice The Peak is appearing or not from 5 mm side. It may not appear. Apply couplant and Place the Probe on IIW Block at Position 'G'. Notice The Peak is appearing or not from 10 mm side. It Should appear.
6. It means that Dead zone is within 5mm to 10 mm. Now Place the Probe on Step Gauge to check the exact Dead zone.
7. Notice the exact Dead zone at which Step the peak appear.

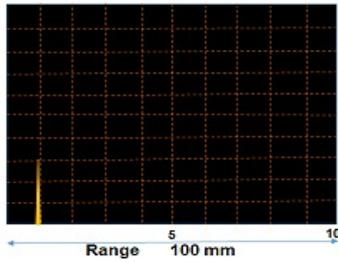
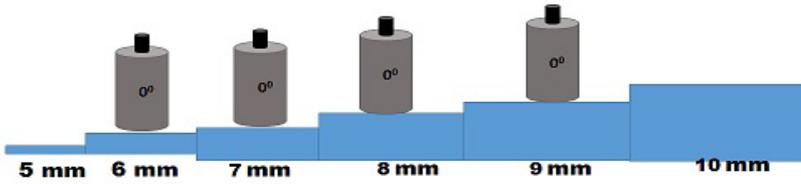
DEAD ZONE



1) Notice The Peak Appearing or not from 5 mm side

2) Notice the Peak Appearing or not from 10 mm side

3) Then Check the Exact Dead Zone at Step Gauge

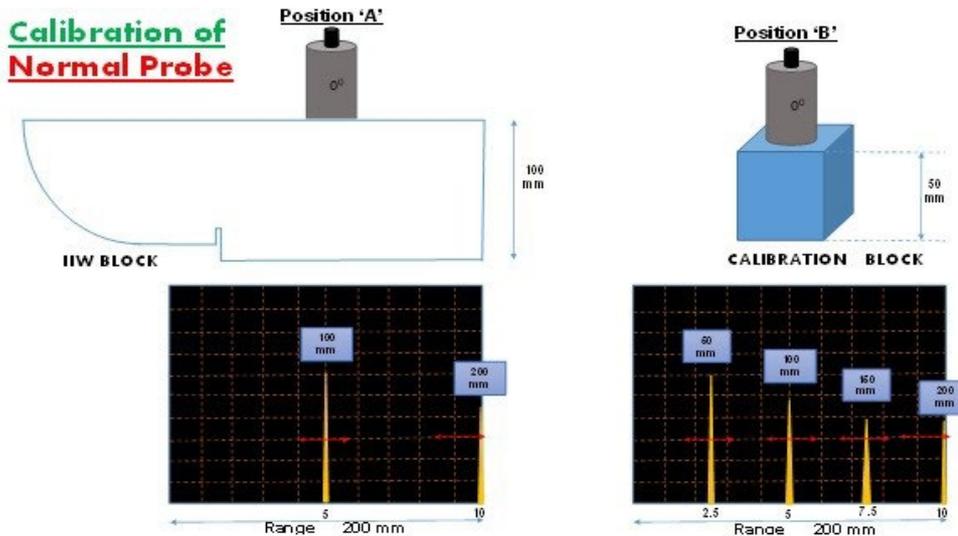


Dead Zone for
Single Crystal Probe - 3 to 4 mm.
Double Crystal Probe - 7 mm

A. Calibration of Machine and Probe

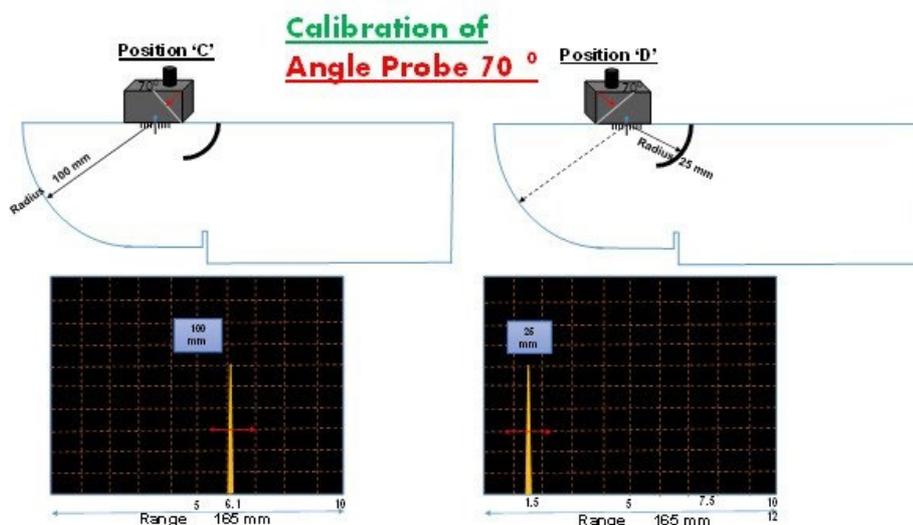
1. For Calibration of Normal Probe

1. Connect the 0^0 , 2 Mhz, Double Crystal Probe.
2. Set Range 200 mm.
3. Set Delay 0.0. Set Probe Zero 0.0. Set Probe Angle 0^0 .
4. Set Velocity of Longitudinal Wave – 5920 m/sec. Set Mode of Double Crystal probe – (T - R).
5. Apply couplant and Place the Probe on IIW Block at Position 'A'. Appears 2 peaks at 100 mm and 200 mm i.e. on 5 div. and 10 div.
6. Put the GATE on 1st Peak and notice the Depth (D) in Machine. If D is not 100 mm. Adjust the peak by Probe Zero Key and make it at 100 mm.
7. To Verify, Put the Probe on Calibration Block and Notice the Depth (D).



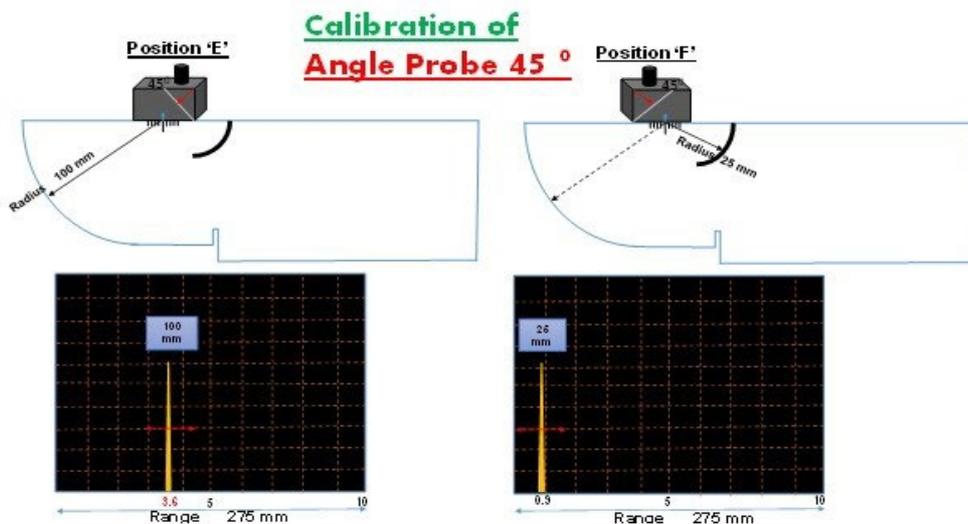
2. For Calibration of 70^0 Probe

1. Connect the 70^0 , 2 Mhz, Single Crystal Probe.
2. Set Range 165 mm.
3. Set Delay 0.0. Set Probe Zero 0.0. Set Probe Angle 70^0 .
4. Set Velocity of Transverse Wave – 3230 m/sec. Set Mode of Single Crystal probe – (T + R).
5. Apply couplant and Place the Probe on IIW Block at Position 'C'. Maximize the peaks from 100 mm Radius.
6. Put the GATE on Peak and notice the Beam Path (B) in Machine. If (B) is not 100 mm. Adjust the peak by Probe Zero Key and make it 100 mm. To Verify, Put the Probe on IIW Block at Position 'D'.
7. Notice the peaks from 25 mm Radius which appears between 1 and 2 div. It should be 25 mm.



3. For Calibration of 45⁰ Probe

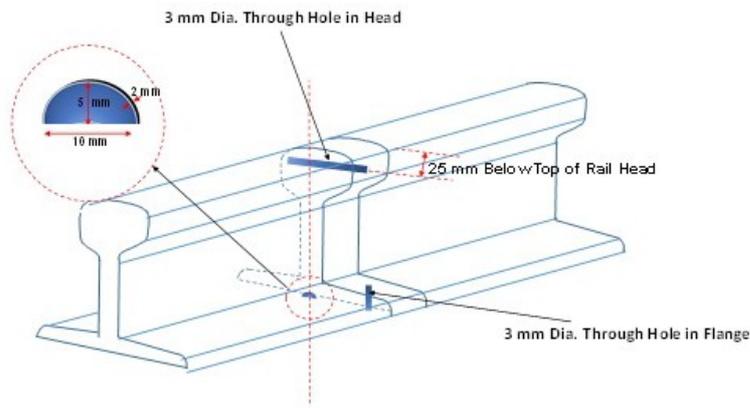
1. Connect the 45⁰, 2 Mhz, Single Crystal Probe.
2. Set Range 275 mm.
3. Set Delay 0.0. Set Probe Zero 0.0. Set Probe Angle 45⁰.
4. Set Velocity of Transverse Wave – 3230 m/sec.
Set Mode of Single Crystal probe – (T + R).
5. Apply couplant and Place the Probe on IIW Block at Position 'E'. Maximize the peaks from 100 mm Radius.
6. Put the GATE on Peak and notice the Beam Path (B) in Machine. If (B) is not 100 mm. Adjust the peak by Probe Zero Key and make it 100 mm. To Verify, Put the Probe on IIW Block at Position 'F'.
7. Notice the peaks from 25 mm Radius which is appears between 0 and 1 div. It should be 25 mm.



3. For Calibration of 37⁰ Probe

1. Connect the 37⁰, 2 Mhz, Single Crystal Probe.
2. Set Range 275 mm.
3. Set Delay 0.0. Set Probe Zero 0.0. Set Probe Angle 37⁰.
4. Set Velocity of Transverse Wave – 3230 m/sec. Set Mode of Single Crystal probe – (T + R).
5. Apply couplant and Place the Probe on IIW Block directing towards 100 mm radius Arc at the center mark of the Arc.
The Peak will appear from 100 mm radius. Move the probe in forward and backward direction to get the peak of maximum height. Stop the probe at point from where maximum echo height is appearing.
6. Put the GATE on the Peak and notice the Beam Path(B) in Machine. If Beam Path(B) is not 100 mm. Adjust the peak at 100 mm by adjusting the value of Probe Zero.
7. To Verify the calibration, Place the Probe on IIW Block directing towards 25 mm radius Arc at the center mark of the Arc.
Notice the peak appearing from 25 mm radius Arc, which appears between 0 and 1 div. The Beam path(B) should be 25 mm for this peak. If the peak is not appearing at Beam path(B) of 25 mm, repeat the procedure again until it is not confirmed from both side.

II. Sensitivity

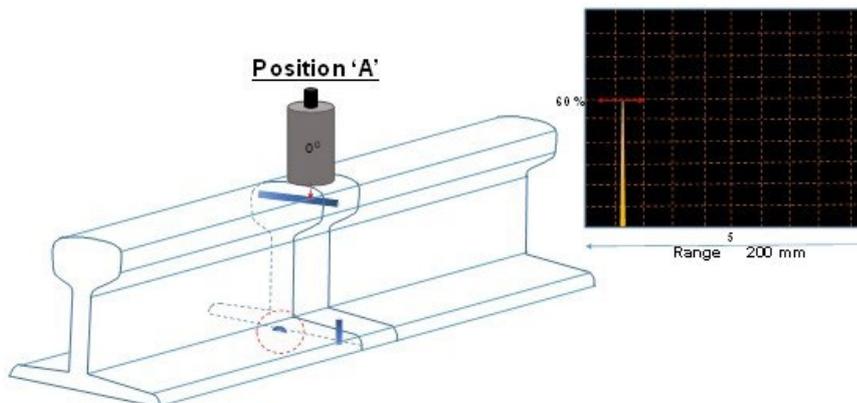


Standard Test Piece of Weld with Artificial Flaw

Fig. 7: Standard Test Piece of AT Weld

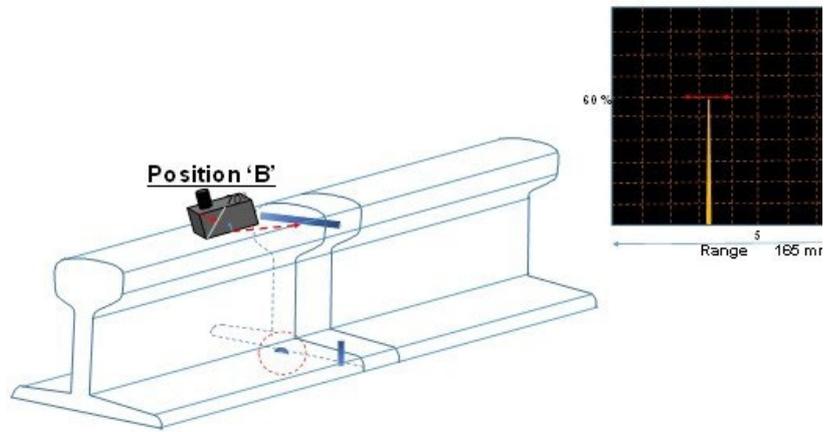
1. For Sensitivity Setting of Normal Probe

1. Connect the 0^0 , 2 Mhz, Double Crystal Probe.
2. Set Range 300 mm.
3. Set Probe Angle 0^0 .
4. Set Velocity of Longitudinal Wave – 5920 m/sec. Set Mode of Double Crystal probe – (T - R).
5. Apply couplant and Place the Probe on Standard Test Piece on Position 'A'.
6. Peak will appear from 3 mm Dia. Hole in Rail Head.
7. Make the Height of the Peak 60 % by adjusting the Gain.



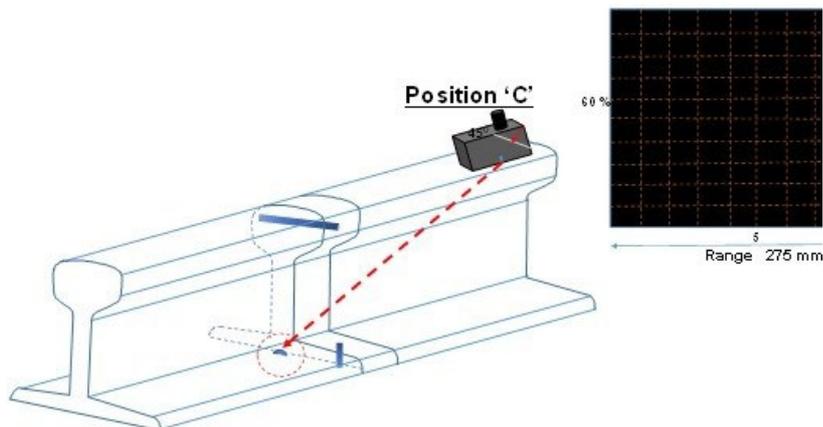
2. For Sensitivity Setting of 70^0 Probe

1. Connect the 70^0 , 2 Mhz, Single Crystal Probe.
2. Set Range 165 mm.
3. Set Probe Angle 70^0 .
4. Set Velocity of Transverse Wave – 3230 m/sec. Set Mode of Single Crystal probe – (T + R).
5. Apply couplant and Place the Probe on Standard Test Piece on Position 'B'.
6. Maximize the peak by moving the probe receiving from 3 mm Dia. Hole in Rail Head.
7. Make the Height of the Peak 60 % by adjusting the Gain.



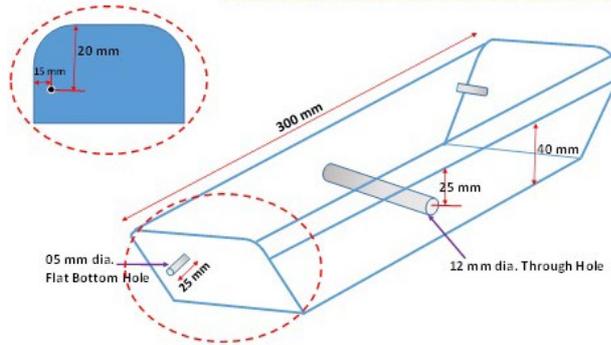
3. For Sensitivity Setting of 45⁰ Probe

1. Connect the 45⁰, 2 Mhz, Single Crystal Probe.
2. Set Range 275 mm.
3. Set Probe Angle 45⁰.
4. Set Velocity of Transverse Wave – 3230 m/sec. Set Mode of Single Crystal probe – (T + R).
5. Apply couplant and Place the Probe on Standard Test Piece on Position 'C'.
6. Maximize the peak by moving the probe receiving from 5 mm X 10 mm Artificial Halfmoon Cut.
7. Make the Height of the Peak 60 % by adjusting the Gain.



II. Sensitivity Setting for Rail Testing

Standard Test Piece of Rail with Artificial Flaw



1. For Sensitivity Setting of Normal Probe

1. Switch on the Machine and run the Calibration mode.
2. Move the Machine on Rail and notice the Back echo from bottom of rail.
3. Make the Height of Back Echo to 100 % by increasing the Gain.
4. Save This Gain for Testing in Section.

2. For Sensitivity Setting of 70⁰Probe Center

1. Move the Machine on Standard test piece of rail directing towards the 12 mm dia. through hole.
2. A Moving peak will appear on screen.
3. Maximize this Moving peak and set the height to 60 % by adjusting the Gain.
4. Repeat this Procedure for Backward Probe.

3. For Sensitivity Setting of 70⁰Probe Gauge Face and Non Gauge Face

1. Move the Machine on Standard test piece of rail directing towards the 05 mm dia. Flat Bottom hole.
2. Two Moving peaks will appear on screen 1st of Flat bottom hole and 2nd of inclined face.
3. Maximize this Moving peak of Flat Bottom hole and set the height to 60 % by adjusting the Gain.
4. Repeat this Procedure for Backward Probe.
5. Now Repeat the Same Procedure for Non Gauge Face Forward & Backward Probe.

Video

- [Introduction of PARAS make B-scan Single Rail Testing \(SRT\)Machine](#)
- [Basic Functions of USFD Machine](#)
- [Weld Testing Calibration of 45 Degree Probe](#)
- [Weld Testing Calibration of 70 Degree Probe](#)
- [Weld Testing Calibration of 0 Degree Probe](#)
- [Linearity of Amplification](#)
- [Linearity of TimeBase](#)
- [Penetration Power](#)
- [Resolution Power](#)
- [Probe Angle](#)
- [Probe Index](#)
- [Rail Testing Calibration for 0 Degree](#)
- [Rail Testing Calibration for 70 Degree](#)
- [Rail Testing Sensitivity Setting for 0 Degree](#)
- [Rail Testing Sensitivity Setting for 70 Degree Centre](#)
- [Rail Testing Sensitivity Setting for 70 Degree Gauge Face](#)

- [Weld Testing Sensitivity Setting of Probe 0 Degree](#)
- [Weld Testing Sensitivity Setting of Probe 70 Degree Flange](#)
- [Weld Testing Sensitivity Setting of Probe 70 Degree Head](#)
- [Weld Testing Sensitivity Setting of Probe 70 Degree Side Looking](#)
- [Weld Testing Sensitivity Setting of Tandem Rig](#)

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