# USFD TEST

# BOOKLET

## AS PER MANUAL FOR ULTRASONIC TESTING OF RAILS AND WELDS - Revised 2022





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**A. Schedule of equipment and accessories checking, Calibration and sensitivity setting:**

a) Characteristics checking : - Once in a month
b) Calibration setting : - Once in a week
c) Sensitivity setting : - Once in three days
d) Temperature variation setting : - Once in a month
e) Visual examination of machine, tools and equipment: - Daily

**B. Procedure for ultrasonic testing of rails (Para 5.1 of USFD Manual)**

**1. Before Testing**

f) Check the battery condition before the start of work. Only fully charged battery is to be used.
g) Check the proper functioning of all controls in the electronic unit i.e., depth range, gain, reject etc.
h) Check the proper functioning of trolleys and probes.
i) Check the junction box, water outlet, connecting cable, and probe contact and ensure smooth movement of trolley wheels.
j) Maintain a gap of 0.2 mm between the probing face and probe shoe.
k) Check probe alignment by keeping the rail tester on the rails.
l) Calibrate the instrument weekly as per the procedure given in Para 4.1.1(b) of the USFD manual.
m) Set the equipment for proper sensitivity as per para 4.1.1(c) of the USFD Manual.
n) Check the Characteristics of machine and probe as per IS Code 12666-2018 and ensure their performance is within the permissible limits as mentioned in RDSO Specifications of machine.

**2. During Testing**

a) Conduct the test as per the procedure mentioned in chapter 6 of the USFD manual.
b) Maintain proper alignment of all probes during testing to avoid false echoes.
c) Ensure an adequate supply of water for coupling.
d) Check the proper functioning of 70° probes by touching the probe bottom with your fingers. A noise pattern should appear on the screen.
e) Look out for a back wall echo corresponding to the normal probe throughout the testing.
f) Lift the machine at crossings/change of rail table height at joints to protect the probes.
g) Mark the locations found defective as per classification.

**3. After testing**

a) Enter proper testing records, observations, echo patterns and amplitude of defects in TMS. The details should be supplemented with A-scan recorded.
b) Charge the battery after every day's work.
c) Data of B-scan should be kept preserved as permanent records for last 3 recordings of the section and in case of fracture the same should be analyzed and action taken accordingly.

## CHART SHOWING THE CODE OF PROCEDURE FOR USFD TESTING

| Probe Used & Freq. | Sensitivity setting | Location of testing | Rejection criteria (Flaw Peak Pattern) | Classification | Type of defect to be Detected | USFD Manual para |
|---|---|---|---|---|---|---|
| **Through Rail testing** | | | | | | |
| 0° 4 MHz | 100% back Wall signal height from Rail bottom | Within Fish Plated area | No back echo before or after the appearance of bolt-hole echo with flaw echo with or without multiple | IMR X X X | Any horizontal defect in rail head, web or foot of length equal to the distance between the rail end and first bolt hole and connected with the railhead | Para 6.3 Annexure-IIA Sr. No.1 |
| | | | Drop in back echo before or after the appearance of bolt hole echo with flaw echo with or without multiple | IMR X X X | | |
| | | | No back echo between bolt holes echo, with flaw echo with or without multiples | IMR X X X | Any horizontal defect connecting both bolt holes | |
| | | | No back echo before or after the appearance of bolt hole echo with or without flaw echo | IMR X X X | Any defect originating from bolt holes and progressing at an angle towards the head web junction or web foot junction | |

| Probe Used & Freq. | Sensitivity setting | Location of testing | Rejection criteria (Flaw Peak Pattern) | Classification | Type of defect to be Detected | USFD Manual para |
|---|---|---|---|---|---|---|
| **Through Rail testing** | | | | | | |
| 0° 4 MHz | 100% back Wall signal height from Rail bottom | Outside Fish plated area | No back echo with flaw echo (shifting/without shifting) for any horizontal length | IMR X X X | Any horizontal defect progressing at an angle in a vertical plane in the rail at the following location* | Para 6.3 Annexure-IIA Sr. No.1 |
| | | | No back echo and no flaw echo | IMR X X X | | |
| | | | No back echo with flaw echo (shifting/without shifting) for Horizontal Length ≥ 20 mm | IMR X X X | Any horizontal defect progressing at an angle in a vertical plane in the rail other than above | |
| | | | No back echo with or without shifting flaw echo for Horizontal Length < 20 mm | OBS X | | |
| | | Side probing on rail head Gauge/ Non-Gauge face side | In case of partial/complete loss of back echo from rail top, side Probing to be done and if any flaw echo found with or without multiples in any length during side probing. | IMR X X X | Vertical longitudinal split (piping) | |

| Probe Used & Freq. | Sensitivity setting | Location of testing | Rejection criteria (Flaw Peak Pattern) | | Classification | Type of defect to be Detected | USFD Manual para |
|---|---|---|---|---|---|---|---|
| **Through Rail testing** | | | | | | | |
| 70° Central 2 MHz | 60% height from 12mm ø Dia. hole in rail head 25 mm from rail top (Additional gain of 10db for D marked rails or all rails on Single line section. | | **For Non 'D' Marked Rails on double line** | **For 'D' Marked Rails on a double line & all rails on a single line** | | | Para 6.3 Annexure-IIA Sr. No. 2 & 3 |
| | | Rail head | i) H ≥ 30%<br>ii) V ≥ 20% | i) H ≥ 0<br>ii) V≥ 20% | **IMR**<br>**X X X** | Any transverse defect in the rail head at the following location* | |
| | | | i) H≥50%<br>ii) V≥60% | i) H≥50%<br>ii) V≥20% | **IMR**<br>**X X X** | Any transverse defect in the rail head other than above | |
| | | | i) 30%≤H<50%<br>ii) V≥20% or<br>i) H≥50%<br>ii) 20%≤V<60% | i) H< 50%<br>ii) V≥20% | **OBS**<br>**X** | | |
| 70° 2 MHz GF & NGF side | 60% Height from 5 mm ø flat bottom hole | Railhead on gauge face side & non-gauge face side | i) H≥ 15%<br>ii) V≥ 20% | | **IMR**<br>**X X X** | Any transverse defect in the rail head on gauge face side/non-gauge face at the following location* | Para 6.3 Annexure-IIA Sr. No. 4 |

| Probe Used & Freq. | Sensitivity setting | Location of testing | Rejection criteria (Flaw Peak Pattern) | Classification | Type of defect to be Detected | USFD Manual para |
|---|---|---|---|---|---|---|
| **Through Rail testing** | | | | | | |
| 70° 2 MHz GF & NGF side | 60% Height from 5 mm ø flat bottom hole | Railhead on gauge face side & non-gauge face side | i) H ≥ 30% ii) V ≥ 60% | IMR X X X | Any transverse defect in the rail head other than above | Para 6.3 Annexure-IIA Sr. No. 4 |
| | | | i) 15% ≤ H < 30% ii) V ≥ 20% | OBS X | | |
| | | | i) H ≥ 30% ii) 20% ≤ V < 60% | OBS X | | |
| 45° Two probes (One Pair) mounted in the Test Rig | 100% with respect to reflecting signal received from the opposite face of the rail head | Rail head with scabs, wheel burn on the top surface | Loss of signal height equal to or more than 20% | IMR X X X | Any transverse defect in the rail head, at the following locations* | Para 6.3 Annexure-IIA Sr. No. 5 |
| | | | Loss of signal height equal to or more than 80% | IMR X X X | Any transverse defect in the Rail head other than above | |
| | | | Loss of signal height equal to or more than 20% but less than 80% | OBS X | | |
| 37° 2MHz Centre Probe | 60% Height from 5mm saw cut on bolt hole | Web, head-web junction and web- foot junction. | Any moving signal observed in web region (i.e. beyond 2.3 div in horizontal scale) other than standard peak from bolt hole, bond wire hole etc. | IMR X X X | Any defect originating from bolt holes and progressing at an angle | Para 6.3 Annexure-IIA Sr. No. 6 |
| Any sweeping signal on a horizontal baseline that does not extend beyond 25% (i.e. 2.5 Div) from the left edge of the screen or vice versa | | | | GCC | Any transverse defect in rail head | Note of Annexure- IIA |

| Probe Used & Freq. | Sensitivity setting | Location of testing | Rejection criteria (Flaw Peak Pattern) | Classification | Type of defect to be Detected | USFD Manual para |
|---|---|---|---|---|---|---|
| **Through Rail testing (Weld Defects)** | | | | | | |
| 0° 4 MHz | 100 % back wall signal height from Rail bottom | Weld | No back echo with flaw echo, shifting or without shifting | IMRW X X X | Any horizontal defect progressing at an angle in a vertical plane in the weld at the following location* | Para 6.5.1 Annexure- IIB Sr. No. 1 |
| | | | No back echo with flaw echo, shifting or without shifting | OBSW X | Any horizontal defect progressing transversely in the weld other than above | |
| 70° Centre 2 MHz | 60% height from 12mm Ø hole in Rail head at 25mm depth from Rail top | Weld Head | i) H≥ 30%<br>ii) V≥ 20% | IMRW X X X | Any transverse defect progressing at an angle in a vertical plane in the weld at the following location* | Para 6.5.1 Annexure- IIB Sr. No. 2 |
| | | | i) H≥ 50%<br>ii) V≥ 60% | IMRW X X X | | |
| | | | i) 30%≤H<50%<br>ii) V≥20% or<br>i) H≥ 50%<br>ii) 20%≤V<60% | OBSW X | Any horizontal defect in the weld head other than above | |

| Probe Used & Freq. | Sensitivity setting | Location of testing | Rejection criteria (Flaw Peak Pattern) | Classification | Type of defect to be Detected | USFD Manual para |
|---|---|---|---|---|---|---|
| **Through Rail testing** | | | | | | |
| 70° 2MHz GF & NGF side | 60% height from 5 mm Flat bottom hole | Weld Head on the gauge face side | i) H≥ 15%<br>ii) V≥ 20% | IMRW<br>X X X | Any transverse defect progressing at an angle in a vertical plane in weld at following location* | Para 6.5.1 Annexure-IIB Sr. No. 3 |
| | | | i) H≥ 30%<br>ii) V≥ 60% | IMRW<br>X X X | Any transverse defect in the weld head other than above | |
| | 60% height from 5 mm Flat bottom hole | Weld Head on the gauge face side | i) 15% ≤ H < 30%<br>ii) V ≥ 20% | OBSW<br>X | | |
| | | | i) H ≥ 30%<br>ii) 20% ≤ V < 60% | OBSW<br>X | | |
| **SEJ Stock / Tongue testing** | | | | | | |
| 45° 2 MHz Hand probe | 45% height from 5x3mm Cut in the bottom of SEJ's stock rail | Web & Foot of Stock/ tongue rail of SEJ | V > 20% | IMR<br>X X X | Any defects originating from bolt hole and machined edge of SEJ Stock/ tongue rail bottom | Para 11.8.4.4 |
| 70° 2MHz Hand probe | 60% height from 5 mm ø hole in rail head at depth 25 mm | Head of SEJ Stock/ tongue rail | V > 20% | IMR<br>X X X | Any transverse defect in the SEJ Stock/ tongue rail head and gap avoiding rail | Para 11.8.5.4 |
| 0° 4MHz Double Crystal Hand probe | 60 % height of back wall signal from Rail bottom | Head, web and web-foot junction of SEJ Stock/ tongue rail | Any flaw peak of V > 20%<br>or<br>Partial/complete loss of backwall echo shall be classified as IMR. | IMR<br>X X X | Any horizontal defects in head, web and web-foot junction of stock/tongue rail | Para 11.8.6.4 |

# CHART SHOWING THE CODE OF PROCEDURE FOR AT WELD TESTING

| Probe Used & Freq. | Sensitivity setting | Location of testing | Rejection criteria (Flaw Peak Pattern) | Classification | Type of defect to be Detected | USFD Manual para |
|---|---|---|---|---|---|---|
| 0° 2 MHz Hand probe | 60% height from 3 mm dia. hole in weld head 25 mm from rail top | Weld head & up to neutral axis in Web | **Initial Weld Testing** | | Porosity, Blow hole, Slag inclusion in head and up to mid of the AT Weld | Para 8.5.4 |
| | | | i) 30% ≤ V from head region.<br>ii) 20% ≤ V from web or foot region. | DFWN<br>X X N | | |
| | | | **Periodical Weld Testing** | | | |
| | | | i) 40% ≤ V ≤ 60% from head region.<br>ii) 20% ≤ V ≤ 40% from the web or foot. | DFWO<br>O | | |
| | | | i) V > 60% from weld head region<br>ii) V > 40% from the web or foot | DFWR<br>X X | | |
| 70° 2 MHz Hand Probe | 60% height from 3 mm dia. hole in weld head 25 mm from rail top | Weld head | **Initial Weld Testing** | | Lack of fusion, porosity, blow hole, slag inclusion and crack in head of the AT weld | Para 8.6.2, 8.6.4 |
| | | | i) V > 30% (Moving signal)<br>ii) V > 10% (A bunch of Moving signal) | DFWN<br>X X N | | |
| | | | **Periodical Weld Testing** | | | |
| | | | i) On vertical scale : Moving signal of 40% or more and up to 60% | DFWO<br>O | | |
| | | | i) V > 60% (Moving signal )<br>ii) A bunch of moving signal V >10% | DFWR<br>X X | | |

| Probe Used & Freq. | Sensitivity setting | Location of testing | Rejection criteria (Flaw Peak Pattern) | Classification | Type of defect to be Detected | USFD Manual para |
|---|---|---|---|---|---|---|
| 70° 2 MHz Hand Probe | 60% height from 3 mm dia. hole in middle of the weld flange | Weld flange | **Initial Weld Testing** | | Lack of fusion, porosity, blow hole, slag inclusion and crack in foot of the AT weld | Para 8.6.2, 8.6.4 |
| | | | V > 30% (Moving signal) | DFWN X X N | | |
| | | | **Periodical Weld Testing** | | | |
| | | | 40% ≤ V ≤ 60% (Moving signal) | DFWO O | | |
| | | | V > 60% (Moving signal) | DFWR X X | | |
| 45° 2 MHz Hand probe | 60% height from 10x5x2 mm Halfmoon cut in bottom of the weld | Bottom of the weld foot | **Initial Weld Testing** | | Clustered defects, micro porosities and Halfmoon shaped defect at the bottom of weld foot | Para 8.7.1.4 |
| | | | V ≥ 20% from bottom of the weld foot | DFWN X X N | | |
| | | | **Periodical Weld Testing** | | | |
| | | | V ≥ 20% from bottom of the weld foot | DFWR X X | | |
| Pair of 70° 2 MHz side looking | | Bottom of the weld foot | **Initial Weld Testing** | | Halfmoon shaped transverse defects at the bottom of weld | Para 8.8.4 |
| | | | V ≥ 20% from bottom of the weld foot | DFWN X X N | | |
| | | | **Periodical Weld Testing** | | | |
| | | | V ≥ 20% from bottom of the weld foot | DFWR X X | | |

| Probe Used & Freq. | Sensitivity setting | Location of testing | Rejection criteria (Flaw Peak Pattern) | Classification | Type of defect to be Detected | USFD Manual para |
|---|---|---|---|---|---|---|
| Pair of 45° 2 MHz (Tandem rig) | 100% with respect to signal received from bottom of rail + 10 dB | Head–web junction, complete web & up to web-foot junction | **Initial Weld Testing** | | Vertically oriented defects like lack of fusion located at head web junction, complete web and upto web foot junction. | Para 8.7.2.4 |
| | | | V ≥ 30% | DFWN X X N | | |
| | | | **Periodical Weld Testing** | | | |
| | | | V ≥ 40% | DFWR X X | | |

## CHART SHOWING THE CODE OF PROCEDURE FOR FB WELD TESTING

| | | | | | | |
|---|---|---|---|---|---|---|
| Pair of 45° 2MHz (T/R method) | 60% height from 5 mm Ø hole in head | Head of FBW | On vertical scale : Any flaw signal | **Defective weld** | Lack of fusion and oxide inclusion in head portion | Para 9.5.1.2 |
| 70° Hand probe | 60% height from 5 mm dia. hole in web | Web and foot of FBW | On vertical scale : Any flaw signal | **Defective weld** | Discontinuities due to lack of fusion and oxide inclusions in web and foot portion | Para 9.6.4 |

*** Vulnerable Locations-**

**(i) Tunnel and tunnel approaches (100 m either side)**

**(ii) Major bridge and its approaches (100 m either side)**

**(iii) In the vicinity of hole near the weld (50 mm for old AT weld and 75 mm for new AT weld from the centre of weld on either side of weld)**

## Note:

(i) Any defect or defects at any location which is detected by two or more probes and are considered to be classified as OBS/OBSW based on peak pattern of individual probe, should be classified as IMR/IMRW and action shall be taken accordingly as per para 6.4.

(ii) In case two or more OBS/OBSW defects are located within a distance of 4.0 meter from each other, such OBS/OBSW defect shall be classified as IMR/IMRW and action shall be taken accordingly as per Para 6.4.

## ACTION AFTER DETECTION OF DEFECTS:

| Sr. No. | Classification | Painting on both faces of web/ head | Interim action |
|---|---|---|---|
| 1 | IMR/IMRW | X X X<br>Three cross with red paint in web | SSE/JE (P.way)/USFD shall impose a speed restriction of 30 Kmph or stricter immediately and to be continued till the flawed rail/weld is replaced. |
| 2 | OBS/OBSW | X<br>One cross with red paint in web | SSE/JE (P.way)/USFD to advise sectional SSE/JE (P.way) within 24 Hrs about the flaw location. Keyman to watch during daily patrolling till it is joggled fish plated and joggled fish plate clamped within three days. |
| 3 | DFWN | X X N<br>Two Stars with N with red paint in web | SSE/JE/P.way shall protect the DFWN defect by joggle fish plate with two tight clamps immediately along with support on wooden block.<br>DFWN defect shall be removed within 1 month of detection. |
| 4 | DFWO | O<br>One circle with red paint in head | SSE/JE (P.way)/USFD shall impose a speed restriction of 30 Kmph or stricter immediately and communicate to sectional SSE/JE about the flaw location, who shall ensure the following:<br>Protection of defective weld by joggled fish plates using a minimum of two tight clamps immediately with a speed restriction of 30 Kmph. Speed restriction can be relaxed to normal after the protection of DFWO weld by joggled fish plates with 2 far-end tight bolts (one on each side) with chamfering of holes, within 3 days. The joint is to be kept under observation. |

| Sr. No. | Classification | Painting on both faces of web/ head | Interim action |
|---|---|---|---|
| 5 | **DFWR** | **XX**<br>Two cross with red paint in head | SSE/JE (P.way) USFD shall impose a speed restriction of 30Kmph or stricter immediately and communicate to sectional SSE/JE about the flaw location who will ensure the following: -<br>Protection of DFWR weld by joggled fish plates using a minimum of two tight clamps immediately. SR of 30 Kmph can be relaxed to normal after providing joggled fish plates with two far-end tight bolts one on each side with champhering of holes. The DFWR weld shall be replaced within three months of detection.<br>Adequate traffic block should be granted for the removal of DFWR welds. In case of non-removal within three months, a speed restriction of 75 Kmph for loaded goods trains and 100Kmph for passenger trains should be imposed. |
| | | | **In case of the defective weld (DFWO/DFWR) on major bridges & bridge approaches (100m on either side) and tunnel & on tunnel approaches (100m on either side), the following action will be taken:**<br>a) SSE/JE (P.way)/USFD shall impose a speed restriction of Kmph or stricter immediately and to be continued till the defective weld is replaced. He should communicate to sectional SSE/JE (P.way) about the flaw location who shall ensure the following: -<br>i) Protection of defective weld using clamped joggled fish plate within 24 Hrs.<br>ii) The defective weld shall be replaced within 3 days of detection. |

**Note: A thermit welding done in situ shall be joggled fish plated with two clamps and supported on a wooden block 300 to 450mm length until tested as good by USFD.**

## Frequency of Rail testing based on the need-based concept:

| Route | Routes having GMT | Testing frequency once in | |
|---|---|---|---|
| | | All Main line Routes | Main line BG on CC+8+2t routes, falling in temp. Zone IV and Zone III on track structure with 52 kg (90 UTS) rail |
| ALL MG Routes | <2.5 | 5 years | -- |
| | 2.5-5 | 3 years | -- |
| | > 5 | 2 years | -- |
| All BG Routes (rail head centre and gauge face corer/ non gauge face corner testing) | ≤ 5 | 2 years | 18 months |
| | > 5 ≤ 8 | 12 months | 09 months |
| | > 8 ≤ 12 | 9 months | 6½ months |
| | > 12 ≤ 16 | 6 months | 4½ months |
| | > 16 ≤ 24 | 4 months | 3 months |
| | > 24 ≤ 40 | 3 months | 2½ months |
| | > 40 ≤ 60 | 2 months | 1½ months |
| | > 60 ≤ 80 | 1½ moths | 1 months |
| | >80 | 1 month | 20 days |

**Reduced frequency period for rail testing:**

I) For the rails rolled before April 99 – 15% of stipulate service life in terms of GMT

II) For the rails rolled in April 99 and later- 25% of stipulated service life in terms of GMT

| Gauge | Rail Section | Assessed GMT service life for T-12 72 UTS rails | Assessed GMT service life for T-12 90 UTS rails |
|---|---|---|---|
| B.G. | 60 kg | 550 | 800 *(1000 for routes covered by rail grinding) |
| | 52 kg | 350 | 525 |
| | 90 R | 250 | 375 |
| M.G. | 75 R | 150 | - |
| | 60R | 125 | - |

*For reduced frequency testing period, 800 GMT service life shall be considered for 60 kg (90 UTS) and 60 kg (R260) grade rails.

**Note:**

i) During reduced frequency period, rails are to be tested at passage of 40 GMT or Eight (08) years, whichever is earlier.

ii) For other sections Principal Chief Engineer of the Railway may adopt a frequency at his discretion.

## Frequency of Weld testing In Main line of BG & MG routes based:

| Sr. No. | Type of welds | Type of testing | Testing schedule | |
|---|---|---|---|---|
| 1 | **Conventional AT weld** | Periodic test | Every 40 GMT or 5 years whichever is earlier | |
| 2 | **SKV weld** | Acceptance test | Immediately after welding (Within 1 Month) | |
| 3 | | Fist periodic test | 20 GMT or 1 year whichever is earlier | |
| 5 | | Further tests based on route GMT | **Routes having GMT** | **Frequency** |
| 6 | | | >80 | 1 year |
| 7 | | | >60 ≤80 | 1½ years |
| 8 | | | >45 ≤60 | 2 years |
| 9 | | | >30 ≤45 | 3 years |
| 10 | | | >15 ≤30 | 4 years |
| 11 | | | 0-15 | 5 years |

**Note:**

i. In case of welds on major bridges and bridge approaches (100 m either side) and in tunnels and on tunnel approaches (100 m either side), the minimum frequency of testing shall be once in a year.

ii. Due to unusually high weld failure or other abnormal development in some sections, Principal Chief Engineer may order testing of welds early, as per need.

iii. Testing interval of USFD testing of defective welds should be reduced by 50% of normal testing interval of AT welds as provided in the table above to avoid fracture of defective welds.

## Frequency of Weld testing for Loop lines:

| Sr. No. | Type of testing | Testing schedule |
|---|---|---|
| 1 | Acceptance test | Immediately after welding. (Within 1 Month) |
| 2 | First periodic test | After one year. |
| 3 | Further subsequent test | Once in every five years for passenger running loops. |

**Note:**

(i) Not to be carried out for non-passenger running loops.

(ii) Due to unusually high weld failure or other abnormal development in some sections, Principal Chief Engineer may order testing of AT weld for loop lines early, as per need.

