

**Government of India
Ministry of Railways**



**MANUAL FOR RECONDITIONING OF
MEDIUM MANGANESE (MM) STEEL POINTS & CROSSINGS,
SWITCH EXPANSION JOINTS (SEJs) AND
CAST MANGANESE STEEL (CMS) CROSSINGS-1996**

(First Revision' November 2020)

Document No. CT-57

**TRACK DESIGN DIRECTORATE
RESEARCH DESIGNS AND STANDARDS ORGANISATION
Manak Nagar, LUCKNOW-226 011**

PREFACE

'Manual for reconditioning of P&C, SEJ & CMS crossing' was prepared by RDSO in 1996. The procedure for welding using H3 Class IRS electrodes including precautions and tests during reconditioning process was incorporated in above manual. With time, improved electrodes with higher service life have been tried and approved for use. Some of the electrodes such as H3 & H3A Class electrodes used earlier have become obsolete. At present reconditioning of CMS crossing is done by using H3B / H3C Class electrodes or in-situ by Robotic Welder Method. For each method minimum service life is prescribed as 35 GMT for H3C Class electrodes, 50 GMT for H3B Class electrodes and 80 GMT through In-situ Robotic Reconditioning Method. Revised manual has been prepared incorporating new electrodes and technologies and deletion of obsolete electrodes and processes.

Railway Board, in Feb. 2010, approved adoption of technology of in-situ reconditioning of CMS crossing on Indian Railways. Accordingly, technology of in-situ reconditioning of CMS crossing is under development. At present, one technology using Translamic Robotic Welder has been approved by Railway Board vide letter dated 12.04.2012 for regular use on Indian Railways. The work is to be executed strictly as per the instructions / guidelines issued by Railway Board / RDSO and as per "Work procedure for in-situ reconditioning of CMS crossing using Robotic Welding Machine (Provisional-2017)". Four other technologies are under various stages of field trial.

Railway Board had instructed that decision regarding which type of electrode / technology is to be used under what circumstances / conditions is to be taken at CTE's level based upon techno-economic considerations. Further, Railway Board vide letter No. 2016/Track-I/4/1 dated 07.04.2017 issued instructions that based on techno-economic analysis and other factors it is decided, that -

- i) On mainlines on all routes having traffic density more than 30GMT, "In-situ" reconditioning of CMS crossings with Robotic Welding is to be done.
- ii) On routes having traffic density up to 30GMT and loop lines of all routes, decision regarding type of electrode / technology to be used for reconditioning is to be taken by CTE keeping in view local requirement and other relevant factors giving due consideration to the requirement that departmental workshops for reconditioning have to be kept functional with sufficient work load so that in-house capacity remains available and track maintenance does not suffer in case of failure / problems in contract awarding / execution.
- iii) Departmental reconditioning depots should be kept fully functional. If any such depots are in disuse, the same should be revived and made functional.
- iv) Suitable provisions should be kept in the contract to ensure requisite service life after reconditioning.

Revision of 'Manual for Reconditioning of Medium Manganese (MM) Steel Points & Crossings, SEJs and CMS Crossings' issued in 1996 with Corrigendum No. 1 of January'1999 was taken up by RDSO for deletion of old & obsolete techniques / practices and addition of new techniques / practices including those for 'In-situ reconditioning of CMS crossings' and to include updation in various IS Codes, Para of IRPWM and digitisation of drawings. The latest version / revision of documents referred in the manual were collected and the procedure and precautions for in-situ reconditioning of CMS crossing using various technologies have been compiled. The revised manual is now being issued as Document No. CT-57 for the first time. This manual is expected to familiarize field engineers with the present methods and precautions to be taken during preventive maintenance for achieving desired service life.

(A.M. Rizvi)
Executive Director/Track-III

Content

Subject	Page No.
1. Introduction	1
2. Chemical composition & mechanical properties	1
3. Selection of worn-out points & crossings for resurfacing	2
4. Various resurfacing techniques	2-3
5. Welding Electrodes	3-4
6. List of equipment for welding MM steel points & crossings, SEJs and CMS crossing	4
7. Process of welding for resurfacing MM steel Points Crossing, SEJs and CMS crossings	4-10
8. Testing & Inspection	10-11
9. Special conditions for inclusion in welding contracts	11-12
10. Miscellaneous	12

LIST OF APPENDICES

S.No.	Content	Page No.
I.	Magnetic Particle Test	13
II.	Liquid Penetrant Flaw Detection Test	14-15
III.	Check list for resurfacing of worn-out MMS Switches, Built-up crossings, SEJs and CMS Crossings	16
IV.	Faults in Metal Arc Welding	17-18
V.	Do's & Don'ts	19
VI.	Guidelines for use of Portable DC Electric Welding Generator	20-21
VII.	Performa for recording details of reconditioned Built-up & CMS Crossings, Switches and SEJs	22-24
VIII.	Sketch showing templates for finishing CMS Crossings, Switches, Built-up Crossings & SEJs after reconditioning by welding	25-28
IX.	In-situ reconditioning of CMS Crossing Using 'Robotic Welding Technique'	29-37

Manual for Reconditioning of Medium Manganese (MM) Steel Points & Crossings, Switch Expansion Joints (SEJs) and Cast Manganese Steel (CMS) Crossings.

1. Introduction:

Indian railways have a vast network of over around 70000 route Kms of railway Track, in which more than one lakh turnouts are in service. A turn-out is one of the weakest links in the permanent way system and requires continuous attention and maintenance for ensuring their proper geometry, service performance and above all safety. In certain high traffic density areas, the points & crossings wear out within a very short period. Wear, which is a damage to a solid surface, usually involves progressive loss of material due to relative motion between the two contacting surfaces (i.e. rail and wheels). Wear is attributed to either single or a combination of physico-electro-chemical phenomenon such as abrasion (metal to metal wear), corrosion, heat (temperature variation), impact, erosion and friction. The vast network of Indian Railways is spread over different areas of varying weather and seasonal conditions. Therefore, in certain high traffic density routes where the weather conditions are also adverse, the points and crossings wear out within a short period. The cost of these components is comparatively much higher than any other P. way material. Therefore, to enhance the service life of these components, reconditioning of worn-out locations by metal arc welding technique and consumables have been introduced.

Provisions of para 430, 431 & 432 of IRPWM shall be followed for reconditioning of points & crossings.

2. Chemical Composition and Mechanical Properties:

Conventionally, the points and crossings were being manufactured from rolled rails. However, of late manufacture of Cast Manganese Steels (CMS) Crossings has also started in the country and as they have exhibited satisfactory service performance, their procurement is in progress for large scale use on Indian Railways. The chemical composition and mechanical properties of the steels used are as under:

(A) Chemical Composition:			
Element	Medium Manganese (Gr-710 or 72 UTS)*	Wear resistant (Gr-880 or 90 UTS)	Cast Manganese Steel (CMS)
C%	0.50-0.60	0.60-0.80	1.0-1.4
Mn%	0.95-1.25	0.80-1.30	11.0-14.0
Si%	0.05-0.30	0.10-0.50	0.50 Max
S%	0.06- Max	0.05 Max	0.03 Max
P%	0.06-Max	0.05 Max	0.06 Max
Mn : C Ratio			10:1 (Min)
(B) Mechanical Properties:			
UTS	72Kg/sq mm Min:	90Kg/sq mm Min:	Not specified
Elongation	14% Min	10% Min	Not specified
Hardness	220BHN	260 BHN (Min)	@229 BHN (Max)

*Now generally not used in manufacture of Points & Crossings.

@ This is initial hardness value which increases to about 450 BHN generally with work hardening of the running surface under passage to traffic.

Heat-treated/welded crossings will have same Chemical composition as that of 90UTS rails. Their surface hardness will, however, be in the range of 330-340 BHN.

3. Selection of wornout Points and Crossings for reconditioning:

3.1 Condition :

- (a) Points and crossing to be reconditioned by welding should be in good condition and certified by the sectional JE/SSE (P.Way) for their suitability for re-conditioning and should normally not exceeded specified limit of wear.
- (b) Points and Crossings containing cracks on the worn out portion having depth more than 3 mm (as determined by gouging) beyond the condemning size shall not be selected for further reconditioning.
- (c) In case of CMS Crossings, number of reconditioning cycles to be restricted to a maximum of 3 nos., subject to condition that the crossing is otherwise satisfactory.

Ultrasonic testing should be carried out as per “Manual for ultrasonic testing of rails and welds” to decide the serviceability. Points & Crossings having internal defects should not be reconditioned. For RDSO approved sources of Ultrasonic rail tester, refer latest Vendor Directory of QA Mechanical on RDSO’s website www.rdso.indianrailways.gov.in. This directory is updated every year in January and July followed by monthly correction slips.

3.2 Wear limits:

As far as maximum vertical wear limit on wing rails and nose of crossing is concerned, the existing provision of 10 mm vide para 429 (3) (e) of IRPWM will continue. However, on Rajdhani/Shatabdi routes as a good maintenance practice, crossings and the wing rails should be planned for reconditioning before reaching the following wear limits:-

Built up/welded crossings	: 6mm
CMS crossings	: 8mm

Note:

In case of CMS crossings, following dimensions should be deducted (to account for slope in casting of wing rails to 1 in 20 cant) from the wear measurements to find out the actual wear of wing rails and nose of crossing.

- (a) for 52 kg section – 2.0 mm.
- (b) for 60 kg section – 2.5 mm.
- (c) for heat-treated welded crossing – 3.5 mm.

Reconditioning of the broken/worn/damaged tip of tongue rail by welding can be done as per provision in para 429 (2) (c) of IRPWM.

4. Various Resurfacing Techniques:

4.1 Single /Double electrode technique:

In Single electrode system of welding, only one type of electrode is used to make up for the entire worn out portion of the crossing. In Double electrode system of welding, two types of electrode are used to make up for the entire worn out portion of the crossing, one electrode for buffer layer and another for surface layer. The worn out points & crossings can be resurfaced by this method by gradually depositing number of layers as per requirement with 3.15mm/4mm diameter electrode.

4.2. Depot resurfacing:

Conventionally, the points and crossings are usually brought from site to the welding depot and then they are resurfaced following the conventional manual metal arc or continuous wire welding process using transformer or rectifier. The reconditioned

crossing is then ground, properly profiled and again transported back to the site for re-use in track.

4.3. In-situ resurfacing:

To avoid undue transportation as well as loss of manpower and time, in situ resurfacing can be done on track itself, after taking block or only on caution order following the conventional arc welding technique. For such in situ welding, generally, a portable DC welding generator is to be used, which can be carried easily to the welding site.

4.3.1 In-situ reconditioning of CMS crossing:

As approved by Railway Board, technology for in-situ reconditioning of CMS crossing has been adopted for regular use on Indian Railway. Reconditioned CMS crossings by this technology, has to give minimum service life of 80 GMT on each reconditioning. In-situ reconditioning of CMS crossing is to be done at site using one of the following techniques:

- i) Manually, using electrode
- ii) Robotic welding technology, using flux cored wire

4.4. Current Practice:

4.4.1. As per the extant instructions of the Railway Board, Single & double Electrode welding process and in-situ reconditioning of CMS Crossings with Robotic Welding technology will continue. No other process/system will be used without specific and prior approval of RDSO. The welding process may be undertaken either at depot or in-situ depending upon feasibility.

In-situ reconditioning of CMS Crossings with Robotic Welding is to be done on main lines of all routes having traffic density more than 30 GMT. Further, on main lines on all routes having traffic density of upto 30 GMT and loop lines of all routes, decision regarding type of electrode/technology to be used for reconditioning is to be taken by CTE keeping in view the local requirement/condition.

4.4.2. Similarly, from the convenience point of view, it is preferable to resort to in-situ resurfacing techniques, especially for built-up crossings and CMS crossings, since transportation of crossings from site to depot and back is avoided saving considerable time and effort. Moreover, it is also beneficial in case of turnouts where heel/toe joints of switches & crossings have been welded with lead/main line rails. In case of CMS crossings, the temperature is to be particularly controlled during the welding process either by water sprinkle/resorting to air quenching or by any other suitable process. Therefore, in-situ reconditioning of CMS crossings needs additional precaution. During in-situ reconditioning of CMS crossings using Flux cored wire or electrode, temperature of base metal should be maintained below 250 °C with the help of water sprinkle, air quenching or any other suitable method.

5. Welding Electrodes:

5.1. Approved brands of electrodes:

H3B and H3C series of electrodes of the brands, duly approved by RDSO are to be used for reconditioning of worn out points & crossings by welding. For approved brands of hard facing electrodes, refer latest Vendor Directory of QA/Civil on RDSO's website www.rdso.indianrailways.gov.in. This directory is updated every year in January and July followed by monthly correction slips.

5.2. Class of electrodes used in respect of traffic density:

Electrodes now used for welding purposes are classified into H3B & H3C class based upon their traffic carrying capacity as detailed below:

- (a) H3B class to achieve minimum service life of 35GMT
- (b) H3C class to achieve minimum service life of 50GMT

6. List of equipment required for reconditioning:

6.1 For Crossing and switches fabricated from 72 UTS or 90 UTS rails:

- i) A portable welding generator DC set or AC set with 80 OCV or more (see APPENDIX –VI)
- ii) Welding cables
- iii) Electrode holder
- iv) Ground clamp
- v) Welding electrodes
- vi) Pre heating oven for electrodes
- vii) Pre heating arrangement for crossing body (torch)
- viii) Gouging equipment
- ix) Chipping hammer, wire brush etc.
- x) Protective cloth including hand gloves, apron shoes etc.
- xi) welding and shield
- xii) Magnetic Particle Test kit (See APPENDIX-I)
- xiii) Liquid Penetrant Flaw Detection Testing kit (See APPENDIX-II)
- xiv) Tong tester
- xv) Thermo chalks
- xvi) Grinders/Hand grinding Machine.(Preferably electric angle grinder or straight grinder)
- xvii) Templates for finishing switches, crossing and SEJs after resurfacing by welding
- xviii) Hammer ball peen 1/2kg weight

6.2 For Switch Expansion joints:

All equipment mentioned at para 6.1

6.3 For CMS Crossings:

- (i) All equipments mentioned at para 6.1 above except pre-heating arrangement for crossing body at SL. No. (vii).
- (ii) For depot reconditioning, a water tank made of either masonry or steel plate walls of suitable size which can accommodate a crossing, however, for in-situ reconditioning of CMS crossing temperature should be maintained below 250⁰ C with the help of water sprinkle, air quenching or any other suitable method.
- (iii) While using flux cored wire for in-situ reconditioning of CMS crossing, robotic welding machine is also required.

7. Process of welding:

7.1 Medium Manganese steel or 90 UTS Points & Crossings (In depot):

7.1.1 Surface preparation:

The locations to be reconditioned shall be ground by pneumatic or electrical grinder to remove adherent scales, deformed and work hardened metal and surface cracks. Complete removal of the surface cracks is necessary as any left-over crack on the surface may extend due to contraction of the weld deposit during cooling and cause premature failure of the crossings in service. After grinding, the locations to be welded

shall be tested by Magnetic Particle Test or liquid -penetrate methods as applicable to ensure freedom from cracks. (See APPENDIX-I & II)

7.1.2 Electrodes to be used and precautions taken:

Electrodes approved under H3B & H3C Class (as per IRSM-28) of the approved list issued by RDSO shall only be used. Low hydrogen type of electrodes shall be dried at 130⁰ C to 170⁰ C for at least one hour immediately before use. In case, the packing of electrodes is absolutely intact and all the electrodes are consumed within 06 (six) hours after opening of the packing, then pre-heating of electrodes may be dispensed with. During use of this type of electrodes, care is to be taken to use shortest possible arc and minimum weaving. Current polarity, angle of electrode and welding technique as recommended by the manufacturer of the electrode shall be used. Welding shall be done using 3.15mm/4mm diameter electrodes only to avoid high heat input. Electrodes having cracked and damaged flux covering shall be discarded. The electrodes shall be stored in accordance with the directions laid down in para 11.2 of IS: 814-2011, the extract of which is appended below:

“11.2. Electrodes shall be suitably packed to guard against damage during transportation. The packing shall be suitable to ensure that under normal store room conditions the electrodes shall for period of at least 6 months after the dispatch from the manufacturer's stores, be capable of giving results in accordance with the provisions of the specification. If the flux covering is of a type requiring special protection during storage, the details and reference to this should be included in the marking of bundle or box of electrodes. The electrodes shall be stored in a dry Store room.”

7.1.3. Welding sequence:

7.1.3.1 To avoid distortion, weld metal shall be deposited following a proper sequence so as to achieve uniform welding as well as low heat input. The runs shall be deposited in turn on the right wing rail, nose and left wing rail as shown in figure-1. In case of switches, stock rail should be reconditioned before the tongue rail.

Example of welding sequence:

In case skip welding is started from right wing rail, sequence will be in the order as under:

Set A-Right wing-Rail (RWR)-I, Nose-II and left wing Rail (LWR)-III.

Set-B-RWR-I,Nose-II and LWR-III

Set-C-RWR-I, Nose-II and LWR-III and so on

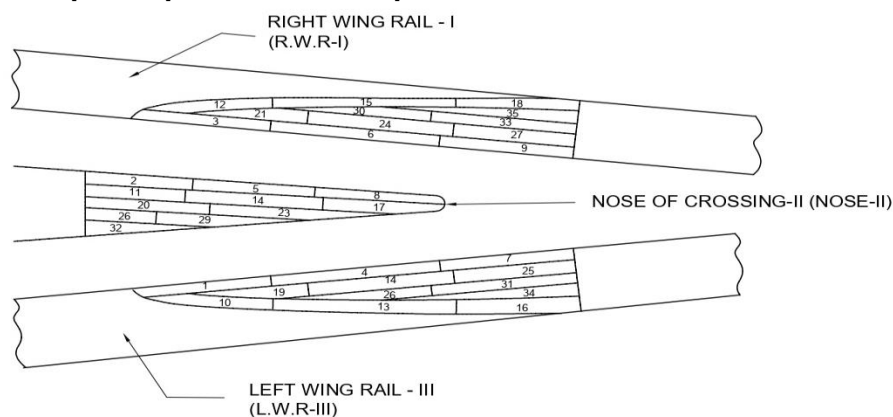
Similarly, if skip welding is started from left wing rail, the sequence will be as follows:

Set A-Left wing-Rail -III, Nose-II & Right wing Rail -I

Set-B- LWR-III, Nose-II and RWR-I

Set-C-LWR-III, Nose-II and RWR-I and so on

Fig 1: A sample sequence of above process:



7.1.3.2. Reconditioning of tongue rail inside the track leads to unsafe condition. Due to pressure of clearing traffic block, it may not be always possible to complete all activities in the available block time leading to unsafe conditions. Therefore, the reconditioning of wornout tongue rail shall be done by taking it outside the track and can be done on cess or in depot.

7.1.4. Welding Plant and Accessories:

7.1.4.1. DC or AC arc welding plant shall be used. Instruments, cables and the accessories shall conform to the requirements of the relevant Indian Standards wherever available. Their capacity shall be adequate for the welding procedure laid down. All welding plants shall be maintained in good working order.

7.1.4.2. All electrical appliances required with the welding plant shall be properly earthed.

7.1.4.3. Means for measuring the current (tong tester) shall be available in addition to the current setting panel integrated with the welding plant as the actual output of welding current may not be equal to the current as set on the control panel in many cases, especially when the plant becomes old.

7.1.5. Pre-heating:

The points & crossings shall be pre-heated by oxyacetylene flame to a temperature 250 to 300⁰C before welding. This temperature shall be maintained throughout the welding operation. If welding is to be interrupted for some reason, then the portions to be reclaimed subsequently shall be preheated again to the above temperature range before welding is continued. The pre-heating and interpass temperature shall be measured either by contact type pyrometer or tempil stick. No post heat-treatment is required after welding.

7.1.6. Current condition:

The current range as recommended by the manufacturer for the particular brand of electrode selected for welding shall be used.

7.1.7. Welding operation:

Welding shall be carried out in the flat position following the welding sequence as in mentioned para 7.1.3.1. The arc shall be struck on the points/crossings and then the electrode shall be progressively advanced by maintaining the arc using uniform movement. Care shall be taken to fill the crater to the full weld size before breaking the arc to avoid formation of crater cracks. During re-start of the welding operation, the arc shall be struck ahead of the crater and then drawn back. Slag shall be removed thoroughly in between runs. Depending on the depth of wear, the number of layers to be deposited shall be assessed and sufficient weld metal shall be deposited to provide an excess of weld metal by about 3 mm which shall finally be finished by grinding. An interpass temperature of 250⁰ C to 300⁰ C shall be maintained throughout during the welding operation.

7.1.8. Grinding operation:

After completion of welding, reconditioned area shall be ground off in accordance with the original contour of the rail. A straight edge along with a proper template may be used to check the profile after finish grinding (See APPENDIX-VIII). During grinding, the grinding wheel shall be moved back and forth over the area and not stopped at one stop to avoid high localized heating and cooling which may result into formation of grinding cracks. The grinding wheel shall be kept properly dressed to have a clean cutting surface as a smoothened and loaded face will increase frictional heat and proneness to grinding cracks.

7.2. Medium Manganese Steel or 90 UTS Points and Crossings (In-situ):

7.2.1. History of the crossing:

Before start of welding, the history of the crossing shall be collected and recorded on a card or register. The details to be recorded shall be as indicated in para 7.2.10.

7.2.2. Wear pattern:

The wear pattern shall be recorded along with depth of wear measured at ten different locations marked in Fig:2 at Para 8.4.

7.2.3. Grinding:

The work hardened, fatigued and loose metal if any, shall be removed by minimum grinding. Cracks if any, shall be completely removed by grinding and then the surface shall be tested by magnetic particles or by liquid-penetrant test. In case, deep cracks are present, the same may be removed first by special cutting electrode followed by grinding.

7.2.4. Electrodes:

Only RDSO approved H3B & H3C Class of electrodes conforming to IRS: M-28 specification of single/double electrode system shall be used.

7.2.5. Preheating:

The tongue rail or nose and wing rails of MM/90UTS steel shall be preheated on the surface by to and fro play of oxy-acetylene torch so that a rail temperature of 250° C (approx) is maintained when depositing the weld metal. Once welding continues, blowpipe can be withdrawn and the welding process will itself sustain the interpass temperature of 250° C.

7.2.6. Welding:

The crossing shall be welded following proper weld sequence for ensuring uniform and minimum heat input. For this purpose; weld metal shall be deposited alternatively on left wing rail nose then right wing rail. Lower side of the recommended current range shall be used with shortest possible arc. Weaving may be carried out, but it should be minimum. Slag inclusion shall be removed by suitable hardwire brush having three rows of bristles on 25 mm width and suitably hardened chipping hammer having pointed and flat ends. In case, DC welding is recommended by the supplier of electrodes, the electrode should be connected to the recommended polarity. After completion of welding, reclaimed area shall be carefully checked for presence of sufficient metal at each point and presence of any weld defects. Undercut, groove or any other defect, if noticed, shall be removed immediately by electrode cutting followed by re-welding when the crossing still remains hot. Only 3.15mm/4.0 mm dia. Electrode shall be used. In rainy season, such electrode shall be preheated at 130-170° C for at least one hour immediately before use. In case, the electrode is absolutely intact and all the electrodes are consumed within 06 (six) hours after opening of the packing, preheating of the electrodes may be dispensed with.

7.2.7. Welding generator:

Diesel/petrol-driven portable welding generator shall be used for in-situ welding. It should be capable of supplying 200 amperes at 60% duty cycles as mentioned in APPENDIX-VI.

7.2.8. Passage of train:

Trains can be passed at normal speed over the weld-metal on crossing even before completion of the hard facing operation. After passage of the train, welding can be started again. However, the weld metal should be allowed to cool for a period of 2 to 3 minutes before allowing the passage of train.

7.2.9. Welders:

Only skilled or highly skilled welders, who have been trained and certified by the competent authority in resurfacing of the crossings by welding in accordance with para 7.5 shall be engaged.

7.2.10. Records:

For each crossing, records shall be maintained at SSE (P.WAY)'s office showing station, point no., up/down line, facing/trailing direction, traffic density, angle, UTS(72/90), date of last resurfacing, traffic carried since then, date of present resurfacing, wear readings(depth in mm) at locations as shown in Fig :2 of para 8.4 on left wing rail, nose, right wing rail, brand and size of electrode used, quantity of electrode consumed(in Nos. or Kg.), grinding time, welding time, total time taken, no. of trains passed during welding and name of welders (Proforma given at APPENDIX-VII may be used for this purpose). These records shall be diligently maintained so that these can be used to monitor/improve the productivity/quality of work of the welder.

7.3. Switch Expansion joints:

The wornout tongue and stock rail of SEJs may be reconditioned by welding as per requirements of field officials. It will be preferable to do reconditioning of SEJs in-situ to avoid de-stressing of LWR panel. The process as recommended for reconditioning of MM steel/ 90 UTS points & crossings at para 7.1 or 7.2 above shall be followed.

7.4. Austenitic Manganese Steel Crossing (CMS Crossing):

7.4.1. Surface preparation:

The portion to be reclaimed shall be ground by pneumatic or electrical grinder to remove all work hardened metal, spilled edges, cracks, adherent scales etc. It shall be ensured that before welding, all surface cracks have been removed, as any leftover cracks on the surface may extend due to contraction of the weld deposit during cooling and may cause premature failure of the crossing in service. After grinding, the locations to be welded shall be tested by liquid- penetration method to ensure freedom from cracks (See APPENDIX-II). The consumables should comply with RDSO specifications. Being non-magnetic steel, Magnet particle testing is not applicable.

7.4.2. Electrodes to be used and precautions taken:

The electrodes approved under H3B & H3C Class (as per IRS-M-28) of the approved list issued by RDSO shall be used. The electrodes shall be dried at the specified temperature as recommended by the manufacturer. Welding shall generally be done using 3.15mm/4.0mm dia. electrodes to avoid high heat input. The electrodes having cracked and damaged flux covering shall be discarded. The electrodes shall be stored in accordance with the directions laid down in IS: 814-2011, as explained in para 7.1.2.

7.4.3. Welding sequence:

Rectification of defects by welding of Austenitic Manganese Steel Crossings requires great care in reducing the heat input. The cycle shall be short i.e. not more than two minutes at a time and on no occasion more than one run shall be deposited. It is advisable to follow skip welding sequence or to weld different portions of the crossings by rotation keeping the intervals adequate to ensure that the temperature of the adjoining areas remain below 150°C. The runs may preferably be deposited in turn on the right wing rail, nose and left wing rail in case of crossings following a skip sequence as explained in para 7.1.3.

7.4.4. Welding plant and accessories:

The welding plant, accessories and precautions during their use shall be same as mentioned in para 7.1.4. However, DC Generator with reversed polarity will be preferable.

7.4.5. Pre-heating:

Due to its low thermal conductivity and possibility of brittle structure formation, it is not advisable to pre-heat the crossings before welding as done in case of medium manganese steel or 90UTS points & crossings. Interpass temperature shall always be maintained below 150 °C by keeping adequate intervals in between the runs and cooling the weld deposit and heat affected zone by means of compressed air jet or water quenching immediately after welding. Alternatively, the crossings may be kept submerged in a water bath (water tank made of either masonry or steel plate wall) so that only top 1 cm of the crossing remains above the water surface level. The interpass temperature shall be measured either by contact type pyrometer or tempil stick. No post heat treatment is required after welding.

7.4.6. Current conditions:

Welding shall normally be carried out with the reversed polarity to minimize vibration and heating of the coating or as recommended by the electrode/wire manufacturers. Current on the lower side of the recommended range and short arc length shall be used to reduce the heat input in the base metal, thereby reducing the dilution of the weld metal with the base metal, which would otherwise cause embrittlement in the weld.

7.4.7. Welding operation:

Welding shall be carried out in the flat position following the sequence as recommended in para 7.1.7, except that at no stage the temperature of crossing shall be allowed to go beyond 150 °C. The arc shall be struck on the crossing and then the electrode shall be progressively advanced by maintaining the arc with uniform movement. At a time, a run of about 7 to 8 cm length only shall be deposited by using weaving technique with the electrode held at 45 degree angle to the direction of welding. The width of the bead shall be twice the diameter of the electrodes and the arc length approximately equal to the electrode diameter. Care shall be taken to fill the crater and then drawn back. Slag shall be removed thoroughly in between the runs. Depending on the depth of wear, the number of layers to be deposited shall be assessed and sufficient weld metal shall be deposited to provide an excess of the weld metal deposit of about 3.0mm which shall finally be finished by grinding.

7.4.8. Grinding Operation:

After completion of welding, the reconditioned areas shall be finished by grinding to obtain a smooth surface. The sharp edges along the flange way shall be ground to proper radius and profile with the help of templates as per Appendix-VIII, so as to match with the original contour of the rail. A straight-edge along with a proper gauge may be used to check the profile after finish grinding. During grinding, water shall be sprayed frequently and the grinding wheel shall be moved back and forth over the whole area and not stopped at one spot so as to avoid high localized heating and cooling which may form grinding cracks. The grinding wheel shall be kept properly dressed to have a clean cutting surface, as a smoothened and loaded face will increase frictional heat and proneness to grinding cracks.

7.4.9. Welding site:

Austenitic manganese steel contains higher percentage of alloy elements (manganese 11-14%, Carbon 1-1.4%) and also has lower thermal conductivity. As such, it requires special welding procedure and precautions for obtaining crack free weld deposit on them. The process needs cooling of the deposit intermittently by water or compressed air or any other suitable method to maintain the temperature below 150 °C thereby requiring longer time for welding.

Note: The process of in-situ reconditioning of CMS crossing manually using MMAW electrode is same as above. In addition, extra precautions are needed to maintain the temperature at weld area by not more than 150°C. For in-situ reconditioning of CMS crossing by Robotic welding technology using flux cored wire “Work Procedure for In-

situ Reconditioning of CMS Crossing Using 'Robotic Welding Machine' (Provisional-2017)" at APPENDIX - IX shall be followed.

7.5. Welder:

(i) Departmental Welders:

The welder should be qualified and certified by the competent authority. Competency of the welder should be checked and certified by Chemical and Metallurgist (CMT) of the Railway or by any other officer(s) nominated by CTE or CE/Con. of concerned railway in case of departmental welder. The competency certificate issued once will be valid for a period of five years from the date of issue. Therefore, the concerned welder will have to get it renewed again from CMT of the railway or RDSO or any other nominated officer as the case may be.

(ii) Outsiders/Private Welders:

RDSO shall checkup the training facilities available with RDSO approved manufacturers of hard facing welding electrodes. If adequate training facilities are available with the approved manufacturers of hard facing welding electrodes, then RDSO shall issue an authorization letter to such manufacturers who in turn will impart training to outsiders or private welders and issue a competency certificate to them for using their products manufactured by the authorized firms which will be valid for a period of five years from the date of issue. The concerned welder will have to get it renewed again from the approved manufacturers of electrodes before expiry of validity period. Any outside welders carrying out the job of reconditioning should possess the certificate all the time at site bearing their photographs and other relevant details duly stamped by such authorized training centers of the approved manufacturers of electrodes.

7.6. Precautions in Metal Arc Welding:

The welding arc is a point of intense heat. It emits harmful Ultraviolet and Infra red rays and fumes which may cause inconvenience to the welder. Hot metal, slag and spatter can often be hazardous to the operators. Adequate precautions are, therefore, required to safeguard from:

- (i) Electric Shock
- (ii) Radiations from the arc
- (iii) Scattering hot particles and globules of metal and slag
- (iv) Flying pieces of sharp slag when being chipped
- (v) Heat and fumes

8. Testing and Inspection:

8.1. The resurfaced points and crossings after cooling and finish grinding shall be subjected to a visual inspection, dimensional measurement and freedom from the presence of any surface defects during welding i.e. undercut, slag inclusion, porosity, cracks etc.

8.2. The points and crossings found to be free from any defect during visual examination shall be subjected to Magnetic Particle Test or Liquid Penetrant Flaw Detection Test, to ensure freedom from the presence of any surface crack, which may not be detected during visual examination. The details of Magnetic Particle Test and Liquid Penetrant Flaw Detection Test, are given in APPENDIX-I & II.

8.3. Rectification of defects after testing and inspection:

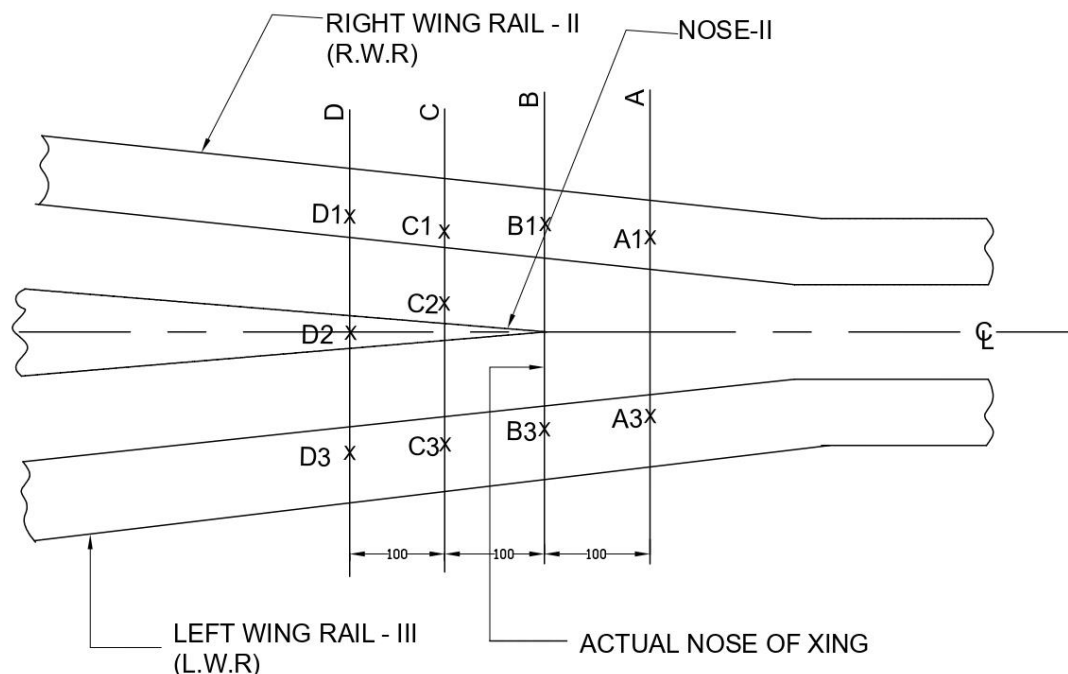
If during visual inspection and Magnetic Particle Test and /or Liquid Penetrant Flaw Detection Test, cracks or other weld defects are found, the portion containing the defects shall be gouged either by pneumatic gouging or grinding and the remaining portion shall be re-examined by Liquid Penetrant Flaw Detection Test for ascertaining freedom from

any cracks or defect before undertaking further repairs. In the absence of any crack, the portion shall be rewelded, ground and inspected by following the recommendations as mentioned above.

8.4. Periodical inspection:

After laying in track, the resurfaced points and crossings shall be inspected quarterly in order to record the amount of wear on the nose, left wing rail and right wing rail as well as stock and tongue rail and also for the structural soundness, presence of disintegration or any other defects. Wear shall be recorded in crossing at ten different locations marked (A1, A3, B1, B3, C1, C2, C3, D1, D2 & D3) as shown in fig:2 and in tongue rail at seven different locations starting from one at toe to places each 100mm away towards heel side and upto 600 mm from the toe.

FIG: 2 Location for Recording wear of Crossing:



9. Special conditions for inclusion in the welding contract:

9.1. Any welding contract will be subject to General Conditions of Contract as prevalent on the Railway and as amended from time to time. However, some of the special conditions are given in clause 9.2., which may be considered for inclusion in the contract depending upon the prevailing site conditions.

9.2. Special Conditions:

9.2.1. The responsibility for obtaining all materials required against the contract shall rest entirely with the contractor.

9.2.2. Welding electrodes of 3.15mm/4mm diameter having valid & current approval as issued by RDSO under H3B or H3C series as the case may be, shall be arranged by the contractor. The contractor will have to submit documentary proof for having procured the approved brand of electrodes from authorized stockist duly supported by necessary test certificates issued by the manufacturer of electrodes.

9.2.3. The rate for the reconditioning work shall be inclusive of all costs of contractor's labors, materials, consumables, tools & plants, templates for finishing and machinery etc. (including reassembling of the crossings in case of built-up) complete for the above. The accepted rate is deemed to be inclusive of all incidental works.

9.2.4. The payment shall be as per Schedule of Rates (SOR) for Track Works on contracts or as decided by concerned contracting authority.

9.2.5. The work shall be carried out as per the Rly's standard drawings, provisions in Indian Railway's Permanent Way Manual and Standard Technical Requirement (STR) as explained in the "Process of Welding", at para 7 by qualified and certified welders.

9.2.6. The contractor shall complete the reconditioning work as per schedule mentioned in the contract. In the event of default, penalty shall be imposed depending upon the expenditure that will be incurred for getting the incomplete work done by the alternative agency or departmentally.

9.2.7. In case there is a failure of welding reported within a period of one year from the date of laying the reconditioned points/crossings/SEJ or before passage of required GMT of traffic prescribed for the class of electrodes used, the contractor shall have to resurface the damaged points/crossings/SEJ again free of cost. If the contractor fails to comply with this requirement, the work may be got done through some other agency and the cost thereof, may be recovered from the security deposit of the contractor.

9.2.8. No adverse site condition reported by the contractor during or after resurfacing work shall be taken into consideration on any account until and unless already mentioned in the contract beforehand.

9.3. Inspection:

Inspection of the reconditioned points, crossings & SEJs will be done by Assistant Divisional Engineer of the sub division concerned or by his authorized subordinate not below the rank of Sectional JE /SSE (P.WAY).

10. Miscellaneous:

10.1. The reconditioning work should be carried out in accordance with this manual. In case any deviation is needed to suit the local condition, it should have prior personal approval of CE/CTE of the concerned Railways.

10.2. Clarifications on any clause of the manual may be sought from Director General (Track), RDSO, LUCKNOW.

10.3. Suggestion, if any, on the improvement of the manual shall be submitted to Director General (Track), RDSO, LUCKNOW through CE/CTE for consideration.

APPENDIX-I

Magnetic Particle Test:

1. Procedure:

This testing procedure shall be adopted in case of medium manganese steel points and crossings only, as the same are magnetic. The areas to be reconditioned shall be magnetised by means of permanent magnets or electro magnets as detailed in the IS specification IS: 5334:69. Equipments and consumables used should conform to RDSO specification M&C/NDT/109 (Rev.1) March 2007). As the surface cracks lying at right angle to the direction of magnetic flux are more prominently revealed, the test shall be done once with the field oriented along the length of the rail and again at right angles to it. After completion of the tests, the surface is to be examined by a magnifying glass. No crack is to be permitted.

2. Testing Kit:

Magnetic Particle testing kit consists of:-

- i) Permanent Magnet(Yoke type)*
- ii) Magnetic powder for dry testing. **
- iii) Magnetic paste for wet testing. **
(To be dissolved in kerosene oil before use)
- iv) Kerosene oil.
- v) Polythene bottle fitted with Swan neck extension pipe for applying suspension.

*(Ref: RDSO's specification No. M&C/NDT/109 (Rev.1) March 2007)

** (RDSO's specification No. M&C/NDT/109/III/2001 (Rev 1) -2011)

- 3. Precautions: The particles used shall be finely divided ferromagnetic materials suitably treated to facilitate visibility. These shall be designed to have a high magnetic permeability and a low retentivity. It shall be free from rust, grease, paint, dirt and other deleterious materials.
- 4. This method of testing is applicable from MM steel points & Crossings only for checking locations to be reconditioned after surface preparation by grinding i.e. before welding operation. Post welding checking cannot be done by this method, because of electrodes being of austenitic type.

APPENDIX-II

Liquid penetrant Flaw Detection test:

1. Procedure:-

This test can be adopted in case of medium manganese, 90 UTS as well as austenitic manganese steel points & crossings. Consumables used should conform to IS: 12889-89. The method of application is as described in detail in IS: 3658. It is briefly described hereunder:

- (i) **Cleaning:**
The test surface shall be cleaned of all rust, scale, welding flux, spatter grease, oil film, water, dirt, etc. Wire brushing, solvents, detergents, descaling solution etc. can be used for this purpose depending upon the condition.
- (ii) **Drying after cleaning:**
The surface shall be thoroughly examined after cleaning so that no water or solvent remains in the area under examination, as this may prevent penetrants from entering the discontinuities, if present.
- (iii) **Application of penetrant:**
The surface to be tested shall be thoroughly and uniformly wetted with the penetrant liquid. This can be applied with a brush, a spray-gun or by flooding and the surface shall remain wet for a period as recommended by the manufacturer of the penetrant.
- (iv) **Application of emulsifier:**
After application of the penetrant, a proper emulsifier shall be applied, if required for the penetrant used. The emulsifying time is critical and depends on prevailing conditions, surface roughness and type of flaws. It may vary from 10 seconds to 5 minutes (average 2 minutes).
- (v) **Excess penetrant removal:**
After adequate penetration time or emulsifying time, the surface film of penetrant and emulsifier shall be removed by rinsing or swabbing or spraying with water. The solvent removable penetrants can be removed in the following way:

As much penetrant as possible may be removed by wiping with a clean, dry, absorbent lint free cloth. Then the remaining surface film of the penetrant may be removed by spraying or washing with a suitable solvent and wiping it promptly with a clean cloth.
- (vi) **Drying :**
After excess penetrant removal and before applying the developer, the surface shall be dried by means of clean dry cloth or normal evaporation at ambient temperature or by blowing compressed air over it.
- (vii) **Application of the developer:**
A developer, either liquid or dry as recommended by the manufacturer of the penetrant, shall then be applied by spraying or by brushing etc. uniformly on the test surface immediately after the surface has been dried. The surface shall then be allowed to stand for sufficient time (developing time) for any indications of defects to develop. This time will depend on the testing media being used, the material examined and the nature of the defect.

(viii) Observations of indications:

The area under testing shall be adequately illuminated by daylight or artificial ultraviolet light (in case of fluorescent dye penetrant) to enable a proper evaluation to be made of the indications revealed on the test surface. In any case, the viewing conditions shall be such that glare is avoided.

(ix) Interpretation of results:

Laminations and cracks appear as broadening lines, the deeper the flaw the wider the lines. Narrow fissures may appear as broken lines or as a row of small dots. Porosity can appear as either scattered small dots or just a haze of colour.

(x) Instructions :

While handling cleaner, penetrant & developer for application, the following points should be looked into to achieve desired level of accuracy of DPI.

(i) Shake well before use.

(ii) Press the actuator from a distance of 15 to 20 cms for even spray.

(iii) In case of clogging, place the can upside down and press the actuator to clear it.

(iv) Use in temperature range of 10 to 50°C.

(v) Do not make attempt to puncture the can.

(vi) Keep away from direct sunlight or hot objects.

2. Testing Kit:

D.P. Testing kit consists:

i) Cleaner

ii) Dye liquid red*

iii) Developers*

iv) Solvent Removers*

*(Ref. IS: 12889-89)

3. Precautions:

(i) Liquid penetrant materials used on Ni base alloys and austenitic stainless steels shall not have more than 1% when tested and fluorine (exceeding 1% of the residue by weight.) when tested as per ASTM D 129/ASTM D-808 respectively.

(ii) Penetrant system i.e. the cleaner, the penetrant, and the developer may be procured from the same source as a system to ensure compatibility.

(iii) All the chemicals viz. cleaner, penetrant, emulsifier and the developer shall be biologically non toxic, chemically non-active to all metals and shall not react with the skin.

(iv) The products used for dye penetrant examination including the aerosol contained products shall have a shelf life of at least 2 years from the date of manufacture under the normal working condition. It can be ascertained from the batch number with month & year of manufacture printed/stamped on the product

APPENDIX-III

CHECK LIST FOR RESURFACING OF WORNOUT MMS/90 UTS SWITCHES, CROSSINGS, SEJs AND CMS CROSSINGS:

The following checks will have to be carried out during resurfacing:

1. Crossing condition:

The crossing shall be inspected and it shall be ensured that it is repairable. In case crack is through and through across the complete section either through nose or through wing rails it should not be taken up for repairs. Bolt holes, if elongated, shall be re-deposited by welding followed by drilling.

2. Grinding:

In case of single electrode system, it shall be ensured that after grinding, the depth of worn-out area shall be less than 3mm at any location.

3. Only those electrodes which are approved by RDSO shall be used.

4. Electrodes should be connected to correct polarity using recommended current. Tong testers will have to be used to determine actual current flow.

5. During welding, straight-edge should be employed continuously for correct build-up. After completion of welding, built-up area should be carefully examined and any under welded spot shall be deposited again while the crossing still remains hot.

6. Pre-heating of MMS/90UTS switches, crossings and SEJs before welding to a temperature of about 250⁰ C to 300⁰ C shall be done by to and from movement of the oxyacetylene torch. The blowpipe shall not be held at one spot. No pre-heating is required for CMS crossings.

7. Welding shall be commenced immediately after pre-heating discontinued.

8. Pre-heating of electrodes shall be done at 130⁰C to 170⁰C for at least one hour immediately before use. In case, the packing of electrodes is absolutely intact and all the electrodes are consumed within six hours after opening of the packing, then pre-heating of electrodes may be dispensed with.

9. Complete removal of slag shall be ensured during welding with the help of hardened chipping hammer having flat and pointed ends and hardened wire brush having three rows of bristles on a width of 25mm.

10. Electrodes with damaged and cracked coating shall not be used.

11. In case the crack in switch, crossing or SEJ is deep, instead of grinding, suitable cutting or gouging electrodes shall be utilized to remove such cracks easily.

12. Temperature of the switches, crossings and SEJs shall be checked during welding. It shall not exceed 300⁰C for MMS/90UTS switches, crossings & SEJs and 150⁰C for CMS crossings.

13. In case of CMS crossings, it shall be ensured that the crossing is submerged in a water tank with only the head portion projecting out of water by 1 cm. Lower current of the recommended range shall be employed with stringer bead of shorter length say 7cm, deposited at a time. In case of CMS crossings, electrodes should be connected to positive polarity to reduce heat input.

14. It shall be ensured that all records regarding history of the switches, crossings and SEJs like no. of times reconditioned, worn-out area reclaimed, electrode used, laying particulars, service life in terms of GMT etc. are recorded in a card or register. Preferable, card shall be maintained separately for each switch, crossing and SEJ.

APPENDIX-IV

COMMON FAULTS IN METAL ARC WELDING:

Faults	Description	Reasons	Effects
(i) Lack of fusion	Discontinuity in a weld between weld metal and parent metal or between two adjacent layers of metal	<ol style="list-style-type: none"> 1. Dirt surface. 2. Improper joint preparation. 3. Current too low. 4. Excessive welding speed. 5. Wrong electrode angle. 6. Too large electrode dia. 	<p>Considerable reduction in static strength.</p> <p>Stress raiser under fatigue loading.</p>
(ii) Incomplete penetration	A gap left by failure of the weld metal to fill the root of joint or incomplete fusion with the root faces of the parent plates/surface.	<ol style="list-style-type: none"> 1. Improper joint design/preparation. 2. High welding speed. 3. Current too low. 4. Too large electrode dia. 5. Excessively long arc length. 6. Incorrect electrode angle 7. Incorrect polarity when welding with DC 	Cracks may develop from root due to slag.
(iii) Overlap	An imperfection at the toe of weld caused by overflow of weld metal on to the parent surface without proper fusion	<ol style="list-style-type: none"> 1. Lower arc current. 2. Too low welding speed. 3. Incorrect electrode dia. 4. Incorrect electrode angle. 	Stress concentration under fatigue loading in fillet areas.
(iv) Undercut	A groove or channel in the parent metal along the sides of weld bead.	<ol style="list-style-type: none"> 1. Too fast welding speed. 2. Too large electrode dia. 3. Too high welding current. 4. Wrong electrode manipulation. 5. Too long an arc length. 6. Rusty and scaly job surface. 	Serious stress concentration under fatigue loading.
(v) Slag inclusion	Slag or any other foreign matter entrapped in weld.	<ol style="list-style-type: none"> 1. Incomplete slag removal between run/passes. 2. Faulty welding speed. 3. Too large electrode dia. 4. Longer arc. 5. Too high or too low arc. 6. Improper joint design. 7. Damp or cracked electrode coating. 	Reduction in static strength and development of cracks at weld junction alongside inclusions.

(vi) Porosity	A group of gas pores in the weld causing elongated or tubular cavity due to entrapped gas called piping or a large isolated cavity called Blowhole.	<ol style="list-style-type: none"> 1. Welding speed too high. 2. Too low or too high welding current. 3. Dirty surface. 4. Damp or damaged coating of electrode. 5. Higher sulphur content in parent metal. 6. Arc length too short or long. 	Reduction in static strength and stress raiser under fatigue loading.
(vii) Cracks	A discontinuity produced either by tearing of metal in plastic condition (hot crack) or by fracture when cold (cold crack). Cracks may be confined at the surface only or may be internal both in longitudinal or transverse direction.	<ol style="list-style-type: none"> 1. Welding speed too high. 2. Poor ductility of base metal. 3. High S% and C% in base metal. 4. Rapid cooling or high restraint. 5. Improper joint design/preparation. 6. Electrodes with high Hydrogen content. 7. Base metal having oil, grease, rust or moisture. 	Serious reduction in strength & complete failure.
(viii) Spatter	Spatters are the small metal particles which are thrown out of arc during welding and get deposited on the base metal round the weld bead along its length.	<ol style="list-style-type: none"> 1. Arc current too high. 2. Longer arc. 3. Damp electrode. 4. Electrodes coated with improper ingredients. 5. Arc blow marking the arc uncontrollable. 	Creates burnt structure on parent metal which acts as stress raiser and reduces fatigue strength.

APPENDIX-V

Do's and Don'ts of welding process:

Do's:

1. Clean wornout area thoroughly to ensure freedom from dust, rust, grease or any foreign material.
2. Ensure freedom from cracks or any other defect by visual inspection followed by Magnetic particle or Dye-penetrant test.
3. Use DC generator/rectifier with rating of 65-80 OCV (open circuit voltage). It should preferably be with reversed polarity in case of CMS crossings
4. The cables should be free from any damage.
5. The cables should not be too long to avoid current loss.
6. The power source and job to be welded should be properly earthed.
7. Use only RDSO approved electrode H3B or H3C.
8. Use 3.15mm /4mm dia electrode.
9. Current to be as specified by manufacturer.
10. Use short arc length.
11. Employ short stringer beads.
12. Weld with job in flat position.
13. Adopt skip welding sequence in the order LWR, NOSE & RWR or vice-versa.
14. Pre-heating MMS or 90UTS switch/crossing/SEJ to 250°C, but no preheating of CMS crossing to be done.
15. Maintain inter-pass temperature at about 150 °C for CMS crossings and at about 250°C for MMS or 90 UTS crossings/case switches/SEJs.
16. Welding cycle to be of not more than 2 minutes.
17. Maintain electrode angle at 45 degree with the direction of welding.
18. Deposit run of short length i.e. 7 to 8 cm at a time for CMS crossings
19. Remove the slag completely before restart of welding.
20. Grinding for surface preparation/finishing to be done avoiding localized heating.
21. Dry electrodes for about one hour in the oven at a temperature of 130 to 170°C before use.
22. During the process of welding, entire CMS crossing to be kept submerged in a water trough except for its head. Portion projecting out of water by 10mm to ensure that its temperature does not increase. (It is not applicable to MM Steel points crossings).

Don'ts:

1. Welding of rusted, greased or cracked surface/location.
2. Test with magnetic particle tester in case of CMS crossing.
3. Welding with lower OCV than specified 65-80 OCV.
4. Use damaged cables for welding.
5. Use too long cables for welding.
6. Do welding without proper earthing.
7. Make use of electrode brand not having RDSO approval.
8. Use higher dia. of electrode unless specified.
9. Use very high current. (Higher current can be used in case of continuous wire welding process).
10. Use larger arc lengths.
11. Have higher non stringer beads.
12. Do welding in vertical down position.
13. Do welding continuously.
14. Pre-heat the CMS crossings.
15. Have welding cycle of more than 2 minutes for welding CMS crossings.
16. Have electrode angle more than or less than 45 degree with the direction of welding.
17. Do welding without completely cleaning the slag.
18. Do welding on CMS crossings without quenching facilities.
19. Grind for longer period at the same location.

APPENDIX-VI

GUIDELINES FOR USE OF PORTABLE DC ELECTIC WELDING GENERATOR:

1. Range of welding current : 60 to 200 Amp.
 2. Minimum hand welding current : 60 Amp at 100% duty cycle.
 3. Maximum hand welding current : 200 Amp at 60% duty cycle.
 4. Open circuit Voltage : 65V-85V.
 5. Welding load Voltage : 20V- 30V.
 6. Insulation glass : F
 7. Auxiliary Voltage : 200V AC
 8. AC output : 4.KVA at 50Hz
 9. 4 Stroke Twin Cylinder : 15 HP
 10. Rated Speed : 3000 R.P.M.
 11. Fuel Consumption : 3 Liters/Hour(Approx.)
 12. Running Hours (Welding) : 4 Hours(Approx.)
 13. Weight : 135 Kg (Approx.)
2. Proposed use:
- 2.1. The equipment capable of giving 200 Amp. current at 60% duty cycle is ideally suited for reconditioning of points & crossing by using 4.00mm electrode size of H3B, H3C class. It can also be adopted for hand welding with 5.00mm electrode dia, requiring 160-180Amp.current.
 - 2.2. This equipment can also be used for general lighting purpose and for working of small track tools, as it capable of giving an AC output of 2500 watts (min.) at 220V, single phase.
 - 2.3. The equipment is not suitable for continuous wire feeding equipment, automatic welding process and semi automatic welding process requiring higher current or higher duty cycle.
 - 2.4. For welding process where lower current is required i.e. where electrode size used is 3.0mm (approx.) or below. The purchaser may use generator of lower capacity, specifications of which may be drawn in same way as enclosed herewith taking necessary guidance from IS:2635-1975.
3. Specifications :
- The generator shall be in conformity with IS: 2635-1975.
4. Accessories:
- The Various accessories used in welding process shall conform to relevant standards.
- 4.1. Cable:
- Welding cable used with generator shall be of copper conductor having cross sectional area of conductor as 95 sq.mm and shall conform of IS: 9857-1990 (Welding cable).

4.2. Electric holders earthing clamp and accessories for personal protection:

Electric holders earthing clamp and accessories for personal protection, filter, filter cover, goggles, hand shield, helmet etc. shall conform to IS: 2641-1964 and IS: 1179-1967.

4.3. Safety precautions:

Necessary safety precautions & fire protection shall be taken as laid down in IS: 3016-1982 and other various manuals, codes for welding process, handling & operation instructions for generators.

5. Operating and maintenance practices:

Instructions contained in the manual given by machine supplier should be strictly followed. The Manual considering of system of operation, repair, maintenance, periodical over hauling, trouble shooting and remedies etc. and list of spares to be carried along with the machine.

APPENDIX-VII/1

PROFORMA FOR RECORDING DETAILS REGARDING RECONDITIONING OF BUILT-UP/ CMS CROSSINGS

Railway _____ Division _____ SSE (P.WAY) Section _____

1. Station :
2. S. No. of Crossing :
3. Make :
4. Angle/Gauge/Section/Sleeper type :
5. Laying and traffic carried particulars (GMT):

	New Crossing	After 1 st recond	After 2 nd recond	After 3 rd recond	After 4 th recond
a) Point No.					
b) Line(up/down)					
c) Direction of traffic (Facing/Trailing)					
d) Location (Curve/Straight)					
e) Date of laying					
f) Date for removal					
g) Reasons for removal					
h) Traffic density of section (GMT)					
i) Traffic carried since last reconditioned (GMT)					
ii) Cumulative traffic carried (GMT)					

6. Wear and welding particulars	For 1 st recond	For 2 nd recond	For 3 rd recond	For 4 th recond
a) Wear on nose when released from track (100 mm away from arc)				
b) Wear on nose after surface preparation (100mm away from arc)				
c) Date of reconditioning				
d) Technique of welding				
i) Whether depot or in-situ				
ii) Whether single/double electrode or flux cored wire with welding machine				
e) Brands of electrodes used				
f) Qty. of electrodes/ Wires consumed (nos./Kg)				

7. Remarks

Signature of SSE/P.Way Concerned

NOTE: In case of reconditioning being done in-situ, the col.5 (e) and 5(f) will be replaced by date of reconditioning.

APPENDIX-VII/2

PROFORMA FOR RECORDING DETAILS REGARDING RECONDITIONING OF SWITCHES

Railway _____ Division _____ SSE (P.Way) Section _____

1. Station :
2. Angle/Gauge/Section/Sleeper type :
3. Description of turn-out (Straight or curved switch:
4. Laying and traffic carried particulars (GMT) :

	New Crossing	After 1 st recond	After 2 nd recond	After 3 rd recond	After 4 th recond
a) Point No.					
b) Line(up/down)					
c) Direction of traffic (Facing/ Trailing)					
d) Location(Curve/ Straight)					
e) Date of laying					
f) Date for removal					
g) Reasons for removal					
h) Traffic density of section (GMT)					
i) Traffic carried since last reconditioned (GMT)					
ii) Cumulative traffic carried (GMT)					

5. Wear and welding particulars	For 1 st recond	For 2 nd recond	For 3 rd recond	For 4 th recond
a) Condition of tongue rail				
b) Wear at tongue rail tip				
c) Wear at location where head width 18 mm				
d) Technique of welding				
i) Whether depot or in-situ				
ii) Whether single/double electrode				
e) Brands of electrodes used				
f) Qty. of electrodes consumed (nos./Kg)				

6. Remarks

Signature of SSE/P.Way Concerned

APPENDIX-VII/3

PROFORMA FOR RECORDING DETAILS REGARDING RECONDITIONING OF SEJ

Railway _____ Division _____ SSE (P.WAY) Section _____

1. Location :
2. Between Station :
3. LWR details :
 - a) Length of LWR :
 - b) Type of Sleepers :
 - c) Type of fastening Provided :
 - d) Behavior of breathing Length :
4. Laying and traffic carried particulars :

	New SEJ	After 1 st recond	After 2 nd recond	After 3 rd recond	After 4 th recond
a) Line(up/down)					
b) Sectional speed					
c) Traffic Density					
d) Date of laying					
e) Date for removal					
f) Reasons for removal					
g) Traffic carried since last reconditioned (GMT)					
h) Cumulative traffic carried (GMT)					

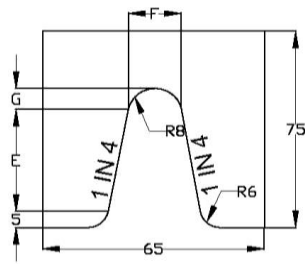
5. Wear and welding particulars	For 1 st recond	For 2 nd recond	For 3 rd recond	For 4 th recond
a) Wear at tongue rail tip				
b) Wear at rear of tongue rail				
c) Horizontal side wear of tongue rail				
d) Chipping off, if any				
e) Condition of stock rail				
f) Date of reconditioning				
g) Technique of welding <ol style="list-style-type: none"> i) Whether depot or in-situ ii) Whether single electrode or double electrodes 				
g) Brands of electrodes used				
h) Qty.of electrodes consumed (nos./Kg)				

6. Remarks:

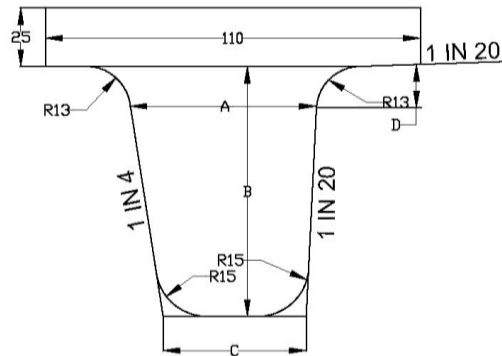
Signature of SSE/P.Way Concerned

NOTE: In case of reconditioning being done in-situ, the col.4 (d) and 4(e) will be replaced by date of reconditioning.

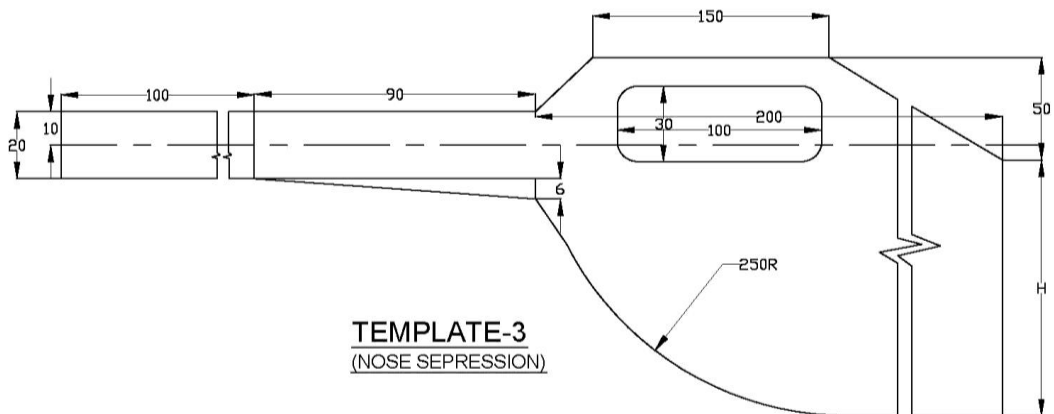
APPENDIX-VIII/1



TEMPLATE-1
(FOR NOSE THICKNESS)



TEMPLATE-2
(FOR FLANGE WAY CLEARANCE)



TEMPLATE-3
(NOSE SEPRESSION)

SKETCH SHOWING TEMPLATES FOR FINISHING
CMS XING AFTER RECONDITIONING BY WELDING

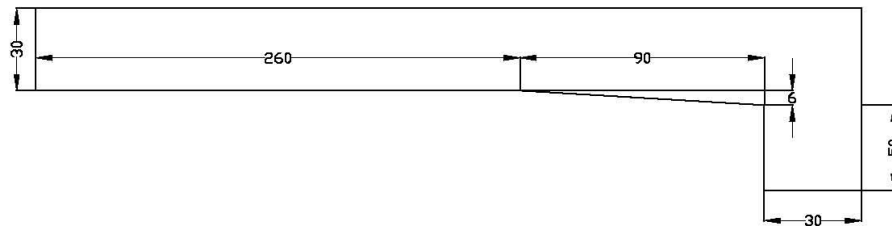
NOTE: TEMPLATES ARE TO BE MADE FROM A 6MM THICK PLATE

ALL DIMENSIONS ARE IN MILLIMETRES

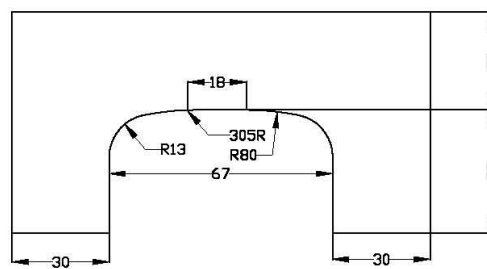
TABLE OF TEMPLATE-1, 2 & 3

DRG. NO.	SECTI ON	ANGLE	DIMENSIONS IN MM							
			A	B	C	D	E	F	G	H
RDSO/T-287/1	52 KG	1:8.5	44	78	33.5	12.5	23	16.5	6.5	58
RDSO/T-33/1	52 KG	1:12	44	48	33.5	12.5	23	16.5	6.5	58
RDSO/T-2678/1	60 KG	1:12	41	52	29.69	14.3	23	17.5	6.5	62
RDSO/T-136/1	52 KG	1:16	44	48	33.5	12.5	23	16.5	6.5	58
RDSO/T-4867/1	52 KG	1:8.5	41	48	37.45	12.5	23	16.5	6.5	58
RDSO/T-4967/1	60 KG	1:8.5	41	52	29.69	14.3	27	17.5	6.5	62
RDSO/T-4739/1	52 KG	1:12	41	48	30.35	12.5	23	16.5	6.5	58
RDSO/T-3941/1	60 KG	1:12	41	52	29.69	14.3	27	17.5	6.5	62

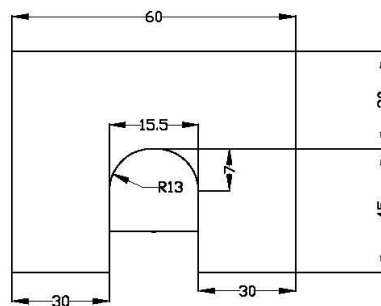
APPENDIX-VIII/2



1. TOP LONGITUDINAL CONTOUR OF NOSE



2. TOP CONTOUR OF WING OPPOSITE TO ANC



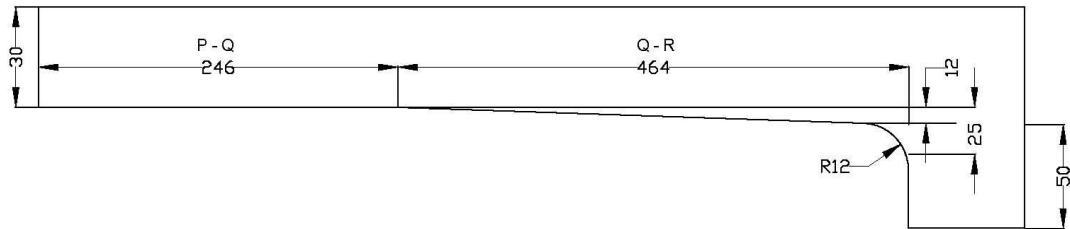
3. NOSE THICKNESS AT ANC

SKETCH SHOWING TEMPLATES FOR FINISHING
FABRICATED XING: AFTER RECONDITIONING BY WELDING

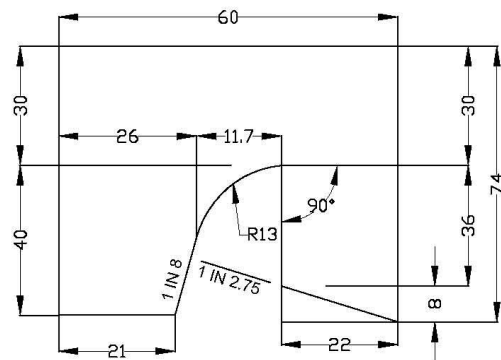
NOTE: TEMPLATES ARE TO BE MADE FROM A 6MM THICK PLATE

ALL DIMENSIONS ARE IN MILLIMETRES

APPENDIX-VIII/3



1. TOP LONGITUDINAL CONTOUR OF TONGUE RAIL



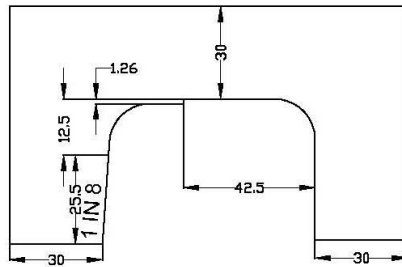
2. HEAD CONTOUR OF TONGUE RAIL AT 464 FROM ATS

SKETCH SHOWING TEMPLATES FOR FINISHING TONGUE RAILS AFTER RECONDITIONING BY WELDING

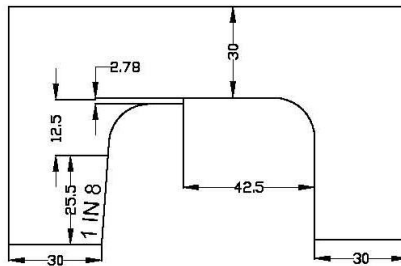
NOTE: TEMPLATES ARE TO BE MADE FROM A 6MM THICK PLATE

ALL DIMENSIONS ARE IN MILLIMETRES

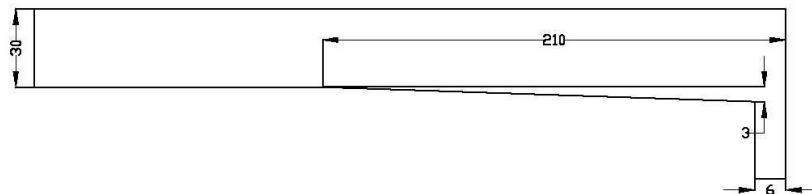
APPENDIX-VIII/4



1. TOP CONTOUR OF A SEJ AT A DISTANCE OF 26mm FROM ATT



2. TOP CONTOUR OF A SEJ AT A DISTANCE OF 210mm FROM ATT



3. TOP LONGITUDINAL CONTOUR OF TONGUE RAILS

SKETCH SHOWING TEMPLATES FOR FINISHING SWITCH
EXPANSION JOINT AFTER RECONDITIONING BY WELDING

NOTE: TEMPLATES ARE TO BE MADE FROM A 6MM THICK PLATE

ALL DIMENSIONS ARE IN MILLIMETRES

APPENDIX- IX

In-situ reconditioning of CMS Crossing Using 'Robotic Welding Machine'

0. Foreword

This work procedure has been framed to adopt uniform procedure for in-situ reconditioning of CMS Crossing using Robotic Welding Machine.

1. Work procedure:

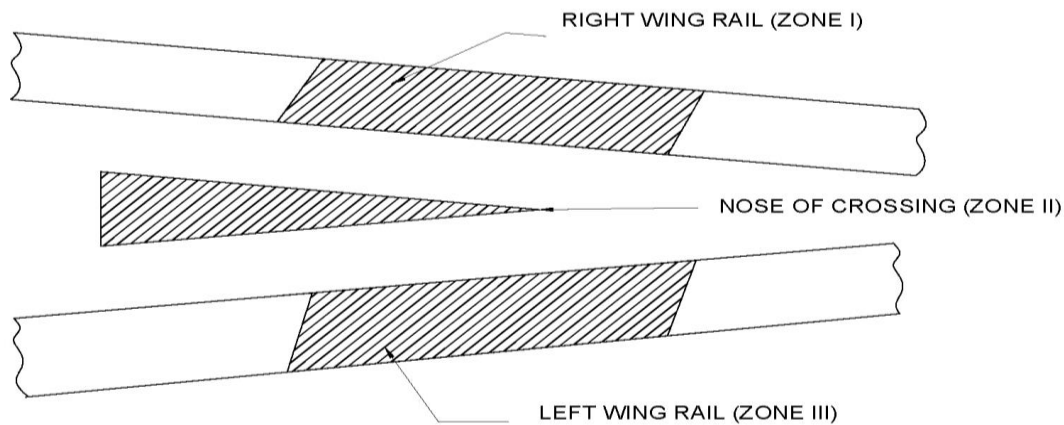
RDSO "Manual for Reconditioning of MM steel Points & Crossings, Switch Expansion Joints (SEJs) and Cast Manganese Steel (CMS) Crossings- 1996" or latest revision shall be followed. One complete sets of gauges (i.e. 52kg & 60kg 1 in 12 & 1 in 8.5 crossing) as specified in this manual shall be kept at site for checking of reconditioned crossing. Further, provision of para 432 of IRPWM shall be followed for reconditioning of Robotic Welding technique.

- 1.1 Visual Examination:** The CMS crossing, to be reconditioned, shall be inspected carefully and thoroughly to ensure that it is in good condition and free from surface defects. Wear of the crossing should not be more than as prescribed in IRPWM para 429 (3) (e).
- 1.2 Table grinding for surface preparation:** The wear area shall be subjected to grinding by the suitable hydraulic/ electric grinders to remove hard metal, cracks, micro cracks, cavities and other heterogeneous materials on the surface of CMS crossing to be reconditioned. If any crack or cavity present in the crossing cannot be removed by grinding, that crossing shall not be reconditioned.
- 1.3 Liquid-Penetrant Test:** To ensure that the prepared surface is free from cracks and any other defects, the area of CMS crossing to be reconditioned shall be checked by the approved quality Liquid-Penetrant.
- 1.4 Fixing of Robotic Welding Machine on crossing:** The robotic welding machine shall be fixed on the CMS crossing to correct line and level. It should be ensured that the welding arm of Robotic Welding Machine can cover the whole area to be reconditioned, by dummy movement. The electric generator shall be used to supply the electrical power. The Wire Feeder, Robotic Welding machine and Remote Control shall be connected through the leads and wires. The area to be reconditioned shall be delimited (i.e. demarked) in shape of polygons and/or triangles at right wing rail, nose and left wing rail.
- 1.5 Mapping of weld areas:** The delimited areas - polygons and/or triangles at right wing rail, nose and left wing rail shall be mapped by locating the corners of the polygons and triangles and registered in controller of the machine.

The sequence of registration of the individual areas for reconditioning is:-

a) right wing rail (Zone I) b) nose (Zone II) c) left wing rail (Zone III) then again to Zone-I

A sample sequence of mapping is given in figure below:



1.6 Setting of Voltage and Current: The setting of Voltage and Current shall be done as per specification of welding technology. The requisite values of Voltage and Current should be maintained throughout the welding.

1.7 Stick-out of welding wire (Distance between electric contact point of wire and arc): The Specified flux-cored welding wire is inserted in the welding arm of the machine through the lead and pull-out mechanism. The wire should be in good condition before use. The movement (feeding) of the wire shall be checked. The height of the nozzle shall be kept as specified in the particular welding technique.

1.8 Welding: Weld metal shall be deposited following a proper sequence so as to achieve uniform welding as well as low heat input. The welding of three zones (i.e. right wing rail, nose and left wing rail) is performed one by one, putting single bead at a time in a zone. The welding arm should come from third zone to the first, automatically. Before starting of bead, it should be ensured that the temperature at weld area is not more than 150 °C and it shall be measured by thermo chalk or any other suitable equipment. The welding parameters such as voltage current etc. shall be as recommended for particular welding technology. The slag of weld shall be removed after each run continuously by applying a peening hammer and hard wire brush. The entire area of each zone shall be covered by a complete layer of weld metal. The height of deposits shall be checked with the special gauges. Additional layer/layers on deficient areas shall be deposited till the requisite height plus grinding allowance is achieved. After ensuring that the sufficient metal has been deposited on all three zones, the Robotic Welding Machine should be removed from crossing and kept away from track.

Temperature of the base metal of crossing in the vicinity of weld deposit (within ½ inch from weld) shall be checked during welding and it shall not exceed 250 °C at any time.

1.10 Grinding: The grinding of welded area is to be done by the hydraulic/ electrical grinders to remove the excess metal and to achieve the requisite contour and profiles as per dimensions given in the drawing of the crossing. The grinding shall be carried out by to and fro motion of grinder and grinder should not be kept steady at any location for long time to avoid over heating of the weld metal. The height of built-up surface shall be kept 0.5 mm high from original table. Smooth ramps shall be provided between welded table and original table of the crossing.

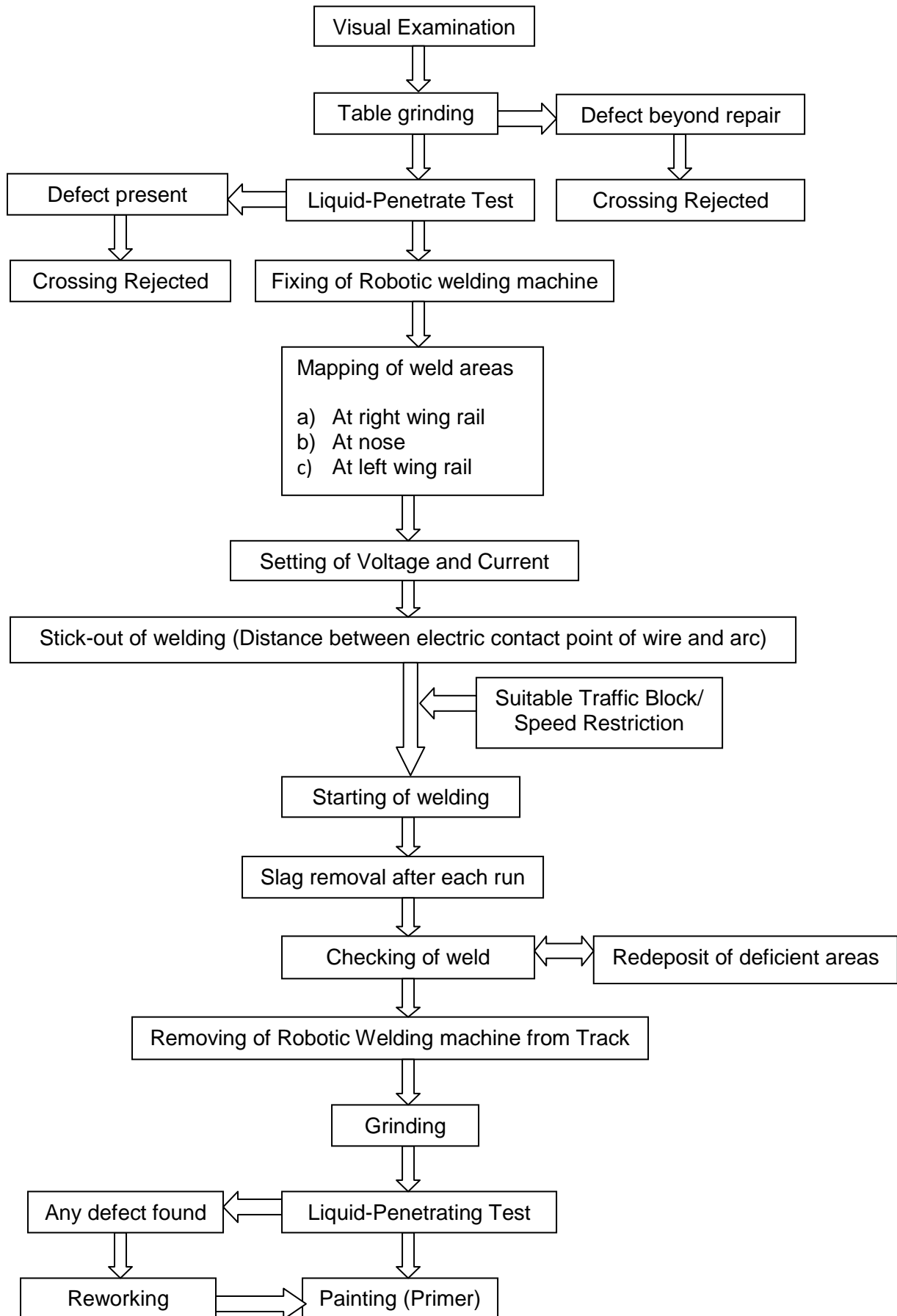
1.11 Liquid-Penetrant Test: To ensure that the welded surface is free from cracks and defects, the reconditioned area shall be checked by the approved quality Liquid-Penetrant. If any crack or cavity is observed then the area shall be cleaned and

ground again. After ensuring complete removal of defect, re-welding, grinding and testing etc. shall be done as detailed above.

1.12 Records: The wear of crossing and other parameters shall be recorded in the enclosed proforma as per Annexures- I & II.

1.13 Painting (Primer):- Two coats of primer (Red Oxide) shall be applied on the rebuilt areas.

Process Flow Chart:



2. Results from the various processes:

Process Schedule	
Description	Result to be obtained
Visual Inspection of CMS Crossing	Should be free from cracks
Grinding for surface preparation (Precaution: No localized grinding permitted)	Removal of hardened metal, surface cracks and micro cracks from the areas to be reclaimed.
Liquid-Penetrant Test	The surfaces to be reclaimed should be free from cracks otherwise grinding up to clear surface.
Parameter for welding depth on different locations recording	On prescribed format attached
Programming in the Software <ul style="list-style-type: none"> • Right hand wing Rail • Nose • Left hand wing rail 	Horizontal polygons and/or triangles on all three areas one by one.
Welding Each layers Start & Stop controlled by Remote Control	Precaution: Temperature of the locations from where the welding is to be started should not be more than 150 °C at the start of each bead.
Checking of reconditioned portion of the crossing as per original contour of the crossing by the standard Gauges	Refilling of defect areas
Welding Subsequent layers & finally free welds	Precaution: Temperature should not be more than the 150 °C start of each bead.
Checking of deposited metal	Refilling of defect areas
Grinding for finishing	Correct profiles & contour 0.5 mm above rail table
Liquid-Penetrating Test	The surfaces reclaimed should be free from cracks
Gauging & measurement	As per "Manual for Reconditioning of MM steel, Points & Crossings, SEJ, and CMS Crossings" and shall be ensured by the gauges, templates and measuring Instruments.
Filling for smoothness	To achieve more surface smoothness, correct profiles & Geometry
Painting of new surface	Appearance & Protection

3. Sequential Working Procedure:

Sr. No.	Item/Activity	Characteristics to be checked	Method of Test	Acceptance Criteria
1	Visual Examination	Damage to crossing, crack	Visual, Magnifying Glass	No physical damage, crack
2	Table Grinding	Table free from cracks	Visual, Liquid-Penetrant Test	Free from surface, sub surface cracks
3	Fixing of Robotic Welding Machine on crossing	Proper positioning & fixing of the equipment	By dry run	Proper alignment retention
4	Mapping of weld areas (a) At right wing rail (b) At nose (c) At left wing rail	The entire ground area mapping	By Remote control	Entire area to be welded to be mapped
5	Setting of Voltage and Current	Voltage and Current	Checking by Voltmeter & Ammeter	----
6	Height of welding nozzle	Height	By Depth Gauge	25 to 35 mm
7	Start of welding	Voltage, Current and Speed of Travel	Visual	Smooth and uninterrupted welding in specified sequence
8	Checking of Weld Bead	Overlapping of Beads	Visual	Proper overlapping
9	Slag	Removal of Slag	Visual	Complete removal of slag before next run
10	Removing of robotic Welder from crossing	Completion of Weld Metal deposit	By rough measurement	----
11	Grinding	Dimensions as per drawing	By Gauging	Crossing profile. Alignment as per drawing
12	Painting (Primer)	Smoothness	Visual	No bare deposited weld metal
13	Details of Dimensions	Dimensions before and after welding	Recording in Annexure-I	As per Welding Manual

5. List of Machinery, Tools & spares with one Team/Machine for Robotic Welding:

- i. Power generator
- ii. Wire feeder
- iii. Robotic welding machine
- iv. Remote control
- v. Grinders
- vi. Peening hammer
- vii. Wire brush
- viii. Arrangement for cooling for welded area
- ix. First Aid Box
- x. Adjustable Spanner
- xi. Spare Bolt-Nut, Screw
- xii. Primer Paint
- xiii. Screw Driver set
- xiv. Nose Plier
- xv. Goggles
- xvi. Any other tools & plants required for particular welding technology

6. List of Testing &Measuring Equipment with one Team/Machine for Robotic Welding:

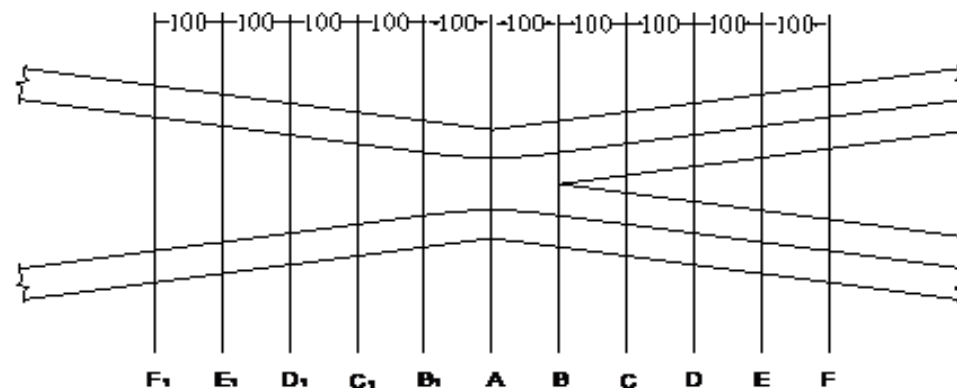
- i. RDSO Specified Gauges & Templates
- ii. Steel Scales (150mm & 300mm)
- iii. Step/ filler Gauge
- iv. Steel Flat 500mm (min.) Long
- v. Stop Watch
- vi. Liquid-Penetrant Test Kit
- vii. Magnifying Glass
- viii. Thermo chalk (150 °C, 200 °C & 250 °C) or any other suitable arrangement for measuring temperature during welding

7. Safety and Protection:

A suitable traffic block and speed restriction is required to perform the In-Situ reconditioning for each CMS Crossing by Robotic Welding Machine. The work shall be/conducted under the supervision of representative of the railway not below than JE (P. Way). The necessary train lookouts shall be arranged by the railway. Helmets, Welding goggles and Protective Aprons should be used while working on or near the track. A first-aid box must be present at site. Relevant paras of IRPWM shall be followed for site protection during traffic block/speed restriction.

Particulars for In-Situ Reconditioning of CMS Crossings at the time of Reconditioning

1. Name of Welding techniques
2. Name of the firm
3. Brand Name of welding consumables
4. Types of welding consumables
5. Railway
6. Division
7. Section
8. Route GMT
 - a) UP
 - b) DN



SN	Angle, Rail Section & other details of crossing	Date of Reconditioning	Line (Up/ Down)	Station	Point No.	Facing/ Trailing	Time of Reconditioning			Wear Measurement (mm) before reconditioning			Length of Weld			Remarks
							Grinding time before welding	Welding time	Grinding time after welding	RWR	Nose	LWR	LWR	Nose	RWR	
										A B C D E F B1 C1 D1 E1 F1	B C D E F	A B C D E F B1 C1 D1 E1 F1				

Note: The firm will also provide a copy of technical literature of the welding consumable used. This must include chemical composition of weld metal (percentage range of each element with minimum & maximum value), hardness range of weld metal and other relevant information regarding welding

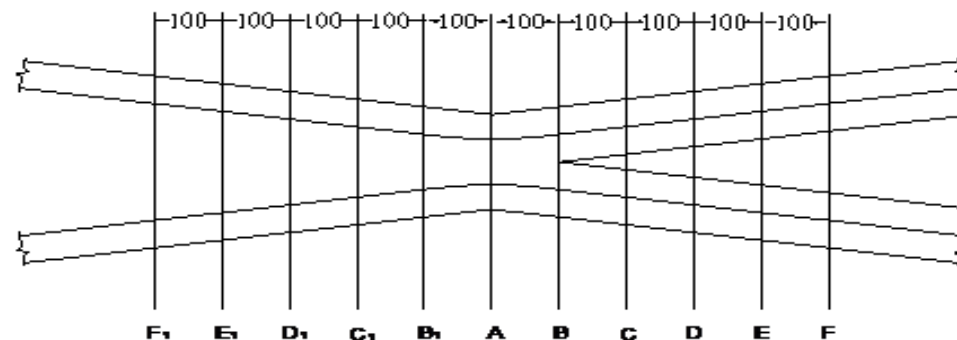
Firm's Representative's Signature

Rly's Representative's Signature

Countersigned by Rly. Officer

Particulars for Service Behaviour of In-Situ Reconditioned CMS Crossings

1. Name of welding techniques
2. Name of the firms
3. Brand Name of welding
4. consumables
5. Types of welding consumables
6. Railway
7. Division
8. Section



SN	Angle, Rail Section & other details of crossing	Date of Reconditioning	Line (Up/Down)	Station	Point No.	Facing/Trailing	Date of Inspection	GMT earned	GMT of Point	Wear Measurement (mm)			Surface Condition Visual /DP	Remarks
										RWR	Nose	LWR		
										A B C D E F B1 C1 D1 E1 F1	B C D E F	A B C D E F B1 C1 D1 E1 F1		

Note: Acceptance criteria shall be same as given in case of MMAW electrodes as per relevant Clause of TDG-026 latest version for the service life of minimum 80 GMT.

Firm's Representative's Signature

Rly's Representative's Signature

Countersigned by Rly. Officer