

NO. WD-73-BD (SDB)-20



INDIAN RAILWAYS
SCHEDULE OF TECHNICAL REQUIREMENTS
FOR
DEVELOPMENT OF
SLACKLESS DRAW BAR DEVICES FOR CONTAINER FLAT
WAGONS AND ITS VARIANTS

ISSUED BY
WAGON DIRECTORATE
RESEARCH DESIGNS & STANDARDS ORGANISATION
MINISTRY OF RAILWAYS LUCKNOW- 226011

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Price:

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1. SCOPE

- 1.1 This STR covers the vendor approval, supply and acceptance requirements of Slackless Draw Bar (SDB) to be used in new age container wagons of IR and similar type of other stocks for connecting two freight cars/wagons.
- 1.2 This draw bar shall be used in the existing Slackless Draw Bar (SDB) assemblies used at lower ends of existing container flat wagons and its variants in wagons with axle load 20.32 T and 22T (or higher variants).
- 1.3 This STR is intended to specify the technical provisions relating to material, process, manufacture, tests, infrastructure for indigenous design and manufacture of Slackless Draw Bars and does not include all the necessary provisions of the contract. Scope of supply as per this STR shall include slackless draw bars only.
- 1.4 All the provisions contained in RDSO's ISO procedures (and subsequent version/ amendments thereof) regarding vendor – Changes in approved status, shall be binding and applicable on the successful vendor/ vendors for supply against contracts floated for procurement of these devices for fitment in wagons operated on IR network (in order to maintain quality of products supplied).
- 1.5 This STR intends to provide opportunity to all indigenous firms (having long experience of manufacturing of coupling devices) to offer their in-house designs to RDSO for scrutiny and approval. This STR shall enable development of indigenous manufacturing and testing capability for Slackless Draw Bars matching international standards. Development of indigenous manufacturing (including proven design from overseas sources) is in line with Government of India's 'Make in India' initiative. It would be prudent to progress in a graduated manner, meeting the imperatives of up gradation of indigenous manufacturing capabilities. It is also emphasised that the product developed through this STR shall be capable to qualifying the requirement of IR wagons and perform satisfactorily in service life.

2. GENERAL

2.1 FUNCTIONAL REQUIREMENTS

- 2.1.1 Since the location of these devices and dimensional aspects are controlled by various other factors (i.e. low travel raised capacity draft gears, centre sill, yokes, followers, etc.), it is equally important that product interchangeability is ensured (in a rake/unit of wagons), to avoid duplication of resources & inventory costs.
- 2.1.2 Also, the SDB (sub-assembly) to be utilized on the new age Container Flat Wagons should be such that they can be fitted on the Wagons without involving any modification in the existing Wagons – which will again enhance the cost.
- 2.1.3 SDBs developed through this STR shall be interchangeable across wagons having standard pockets and components (as per assembly drawing of SDB).

2.2 TECHNICAL REQUIREMNT

- 2.2.1 SDBs will be a casted component. The grade of casted material shall be as per AAR M-201, 'Grade E'.
- 2.2.2 Draw Bar Arrangement on Container Flat Wagons BLC/BLCM and its variant wagons shall be as per Drg. No. – RITES/TP-9405-S/001. The Drawbars should generically conform to the envelope (and other components of sub-assembly) and exhibit unassisted angular vertical and lateral movement capability as also shown in the drawings.
- 2.2.3 The manufacture of SDBs shall be taken as per guidelines of **Annexure-1**. The firm shall strictly adhere to the prescribed input raw material, infrastructural requirements (furnace, heat treatment set up etc.). To ensure that the SDBs casting are at par with couplers manufactured through str WD-70-BD it is required that firm shall abide by the requirements for methoding process laid under said STR.
- 2.2.4 The SDBs manufactured through the STR shall exhibit satisfactory test results when subjected to the test regime (As given under Annexure-II) to ascertain various physical, metallurgical characteristic etc. through destructive/non-destructive tests.

3. PARTICULAR REQUIREMNT

3.1 ELIGIBILITY CRITERIA

- 3.1.1 The SDB manufacturer shall hold a valid Quality Assurance Certification as per ISO 9001 for manufacture and testing of coupling devices of railway freight stock.
- 3.1.2 SDB manufacturer offering their product shall have to possess the infrastructure for testing as per **clause no 3.2**.
- 3.1.3 Indigenous coupler manufacturer, if offering a proven SDB design, shall have the certificate of approval/agreement/ TOT documents from the principle manufacturer and the same shall be submitted to RDSO. Proven design means SDB to that design being used in wagons 20.32T, 22t & 25 T axle load or above in an established rail road system.
- 3.1.4 Indigenous coupler manufacturer, offering a non-proven SDB design but having experience in manufacturing of similar type of coupling component and should be a developmental/developed source of CBC couplers as per STR WD-70-BD.
- 3.1.5 This STR is meant for development of indigenous sources/design as well as import substitution of SDB without compromising on quality aspect.

Wagon Directorate of RDSO had already issued the final "Guidelines for Multisourcing of Slackless Draw Bars used on wagons of IR" (as Wagon Directorate Document No. CONTR-02-SDB-MSG-2012 of May 2012), for development of proven designs for IR.

The said multisourcing guidelines will remain in force to enable sources possessing the laid pre-requisites to submit their proposal to this office. Such firms (with AAR certification) can qualify as 'Developed Source for SDB' through a (min. of) field assessment of eighteen months (subjected to completion of documentary stage).

Previously Approved/Developed sources of these SDBs (whose name already exists in the list of RDSO Vendors through MSG/RITES) shall continue to be a source of these SDBs for supply to IR without any ceiling on the numbers of SDBs supplied. Proposal of such firms if opts for indigenous manufacturing (by themselves or in collaboration) of the proven design (on IR) shall be processed through guidelines of MSG.

- 3.1.6 However other overseas firms/proposer (having proven/new design of such type of SDBs) are required to set-up their facility in India or can enter in an agreement with Indian firm/partner to submit their proposal (having manufacturing & testing facility detailed as mentioned earlier) in line with Government of India's 'Make in India' initiative.

3.2 INFRASTRUCTURAL/TESTING FACILITIES

3.2.1 MINIMUM FOUNDRY INFRASTRUCTURE REQUIREMENTS

Firms possessing the foundry setup in line with Wagon Directorate STR WD-70-BD-10(or as per latest), mentioned below:

- 3.2.1.1 A foundry producing SDBs/coupler castings should have the capacity to produce 2000 of SDBs/year.
- 3.2.1.2 To ensure dimensional and feature control, the castings shall be produced by one of the following moulding processes mentioned in Clause 1.3.3 of Annexure-II of this STR for which the necessary infrastructure should be available.
- 3.2.1.3 The foundry must have the ability to conduct all the tests mentioned in this STR.
- 3.2.1.4 Chemically bonded no bake sands out of a articulated continuous mixer with PLC control shall be used to produce casting cores for which necessary infrastructure should be available.
- 3.2.1.5 Melting furnace capacity should be a minimum of 5 MT utilizing electric arc.
- 3.2.1.6 Heat treating furnaces should be capable of holding at least 3 MT of castings and reaching and maintaining temperatures of 950 deg C. Furnaces should have automatic temperature control and be capable of operating as low as 500 deg C and fitted with an automatic digital recorder.
- 3.2.1.7 Other equipment to meet the requirements of this STR should be available.
- 3.2.1.8 The foundry shall hold a valid Quality Assurance Certification as per AAR M1003 or ISO 9001.

3.2.2 Methoding, Moulding and Foundry

Firm shall have melting and ladle analysis set up as per point no 1.2 of Annexure-I of the STR. Similarly firm shall have an in-house set up for carrying out methoding as per point no 1.3.2 of the Annexure-I. Moulding set up as per details mentioned in para 1.3.3 of Annexure-I, shall be arranged.

3.2.3 Machinery & Plant set up for destructive/non-destructive test

Firm shall have necessary machinery and testing set-up for carrying out various test as per Annexure-II of the STR. Digital hydraulic load testing machines having a capacity for carrying out the Static compression testing/Proof testing (as per point no. – 1.2.5 of Annexure-II). The machine shall be capable of applying loading of in varying increments.

4. APPROVAL REQUIREMENT

The firms/proposers who offer their proposal for such type of SDBs shall be required to comply the following:

4.1 Documents to be submitted with the proposal

- 4.1.1 The Product description in terms of the Model Number and the General Diagram Drawing. (Copy of the Drawing to be annexed). In case the proposer is a licensee/holding design under TOT etc., the product identification details i.e. the Original Model Number of the OEM and the General Diagram Drawing of the OEM shall also be submitted.
- 4.1.2 The SDB manufacturer shall submit the gauging procedure including the gauge drawings for approval to RDSO at the time of registration. No change shall thereafter be carried out without the prior approval of RDSO. SDBs manufacturer shall supply full/partial set of gauges to zonal railways on their request against payment.
- 4.1.3 The SDB manufacturer shall submit one set of drawings detailing important controlling dimensions and tolerances of SDB along with surfaces and dimensions necessary to be gauged at the time of registration. Manufacturer shall also submit the detailed technical parameters of the proposed SDB design along with internal test records for establishing intended performance. Maintenance manual is also required to be provided to RDSO at the time of registration. Maintenance manual shall contain following information:-
- i) Principle of operation and important design features
 - ii) Illustration explaining the working and maintenance practices
 - iii) Details of attention during overhauling
 - iv) Special tools, capacity & STR of press etc.
 - v) Details of welding equipment & method of welding
- 4.1.4 Any pragmatic change to SDB (or its sections) which can take place during service life (which will not adversely affect the normal working of SDB and the envelope in which it is fitted) shall be clearly indicated in the initial proposal. It shall be clearly indicated the reasons for same and preventive action if any.

4.2 Processing of Proposal - For Indigenous supplier or foreign proposer through Indian licensee/associate(With owned Proven technology)

- 4.2.1 Indigenous SDB manufacturer has to submit RDSO the test results and certificate from collaborator principal manufacturer that the indigenously manufactured SDB has already been tested by the collaborator principal manufacturer in their premises. It has to be clearly specified that the during testing (at indigenous manufacturing site) and its

manufacturing parameters, performance is at par with the product manufactured by principal manufacturer and satisfies all testing requirements mentioned in Annexure –I & II, as applicable. They have to also get their quality Assurance plan (QAP) certified from their collaborator principal manufacturer.

4.3 Processing of Proposal - For Indigenous supplier(Without Proven technology)

4.3.1 Indigenous coupler manufacturer, if offering a new SDB design (i.e. design not proven), shall have to submit the complete design details of proposed draft gear to RDSO. They have to also submit the internal (or at a reputed agency as approved by RDSO) test results for test as detailed in Annexure-I & II.

4.4 Inspection of Manufacturing facility and Processes:

In scenario as described in Clause 4.2.1 or 4.3.1, RDSO team of two nominated officials shall carry out an audit of the manufacturing facilities and the quality assurance system to verify if the indigenous manufacturer is capable of manufacturing and testing SDBs to this STR (along with verification of QAP submitted).. The inspection procedure shall also include a review of the following items:

- Plant operation and procedures, including confirmation of certification tests, production and quality equipment inspection, employee interviews and finished product defect levels
- Process control plans, including critical inputs, outputs and STR limits, sample size and frequency, control method and reaction plan.
- Critical processes, including practices for pattern and core boxes, core making, molding, melting, pouring, cleaning, heat treating and casting quality.
- Organization, verifying separation between production and quality control responsibility, resolution mechanism for non-conforming product and controlled disposition of non-conforming product.
- Personnel, verifying procedures for qualifying employees, training of new employees, and existence of competent expertise.

4.5 TYPE TEST:

Based on the successful compliance of foregoing point, if the SDB manufacturer is seeking the approval for new design (complying test regime mentioned in Annexure – I & II), the following shall be the procedure:

- 25 SDBs will be manufactured by the manufacturer seeking approval.
- First article inspection of the two (randomly selected) SDBs for dimensional control as per gauging scheme will be carried out. Similarly two of the SDBs shall be subjected to dimensional check of key parameters (through measuring gauges).

- Test lugs/coupons shall be integral casted on min. of 3 SDBs out of which samples for carrying out various mechanical; & metallurgical testing(as per table under point 1.2.6 of Annexure-II) and other parameters shall be undertaken.
- Destructive and Non-destructive testing on relevant no of SDBs shall be carried out as per relevant para's of the STR.

4.6 **Status of 'Developmental Source' of SDB for supply to IR for field assessment of the product:**

In case the audit of manufacturing facility and processes by RDSO/RDSO nominated third party as per Clause 4.4 and type test as per Clause 4.5 are satisfactory, RDSO will grant an approval for supply as a developmental source. The developmental source will be placed in the List of RDSO Vendors for Developmental Orders available on RDSO website with the following addendum

Maximum permitted quantity – 4000(with proven technology)/3000(new/non-proven technology) no's of SDB can be supplied by a Developmental Source. The firm shall keep record of all such supplies made by them during this stage.

4.7 **Qualifying parameters for withdrawing ceiling limit-** The ceiling of 4000/3000 Nos. mentioned in Para 4.6 shall be withdrawn when the following is met:

- Nos. of SDBs equivalent to 6 rakes (i.e.216 Nos.) of Container wagons have completed one year of satisfactory service.
- Satisfactory type tests on two SDBs which have completed one ROH cycle of service. Samples picked up from the field must meet the physical and chemical properties of the STR (proposer firm shall accord necessary assistance for the same).
- No unresolved non-conformances or **not more than** one line failures per year on manufacturing account.
- An audit of the manufacturing facility by RDSO/ RDSO nominated third party to ensure compliance of prescribed manufacturing facilities and adherence to approved quality assurance plan as per requirements of Clause 4.4 are being met.

4.8 Non-conformances shall be reported to RDSO and the manufacturer, identifying the failed material or service provided by the manufacturer. The initiator of non-conformance reports may include the wagon builder or owner or Indian Railways. The non-conformance report shall identify the product, a description of the non-conformance and disposition of the product. The manufacturer shall respond to the report within 30 days, identifying the root cause and corrective action plan to address the non-conformance. A follow up plan shall also be included to ensure that the corrective action is effective and permanent. Inadequate or ineffective response to non-conformance will initiate a process of decertification at the discretion of RDSO.

5. DRAWINGS, STR & SPECIFICATIONS FOR REFERENCE

- a. Draw Bar Arrangement drawing No.-RITES/TP-9405-S/001(Latest)
- b. M-201, M-205, M-211, M-215.
- c. WD-70-BD-10, WD-71-BD-15 & WD-72-BD (SDB)-19(and relevant referred STR & specifications).
- d. ASTM A 255, A 370, B 208, E 446 and E 604.
- e. IRS R-6.

6. Annual Type Testing

Indigenous manufacturer shall carry out annual type testing (as specified under Annexure-II) in-house(verified by inspection wing of RDSO) or in the premises of principal collaborator/SDB manufacturer or at any AAR approved facility through third party or at independent third party testing house or in-house witnessed by a member of classification societies (IACS) as specified by RDSO. The parameters as specified under various para's shall be measure and recorded on two SDBs. The samples for annual type test shall be picked up by RDSO. These annual type testing reports shall be submitted to Wagon Dte/RDSO by the manufacturer. Failure in either carrying out the annual type testing or failure in annual type testing shall lead to withdrawal of vendor approval.

7. Production/purchase inspection

- 7.1 The Inspecting Authority shall first check the records of the manufacturer to ensure that the item offered for inspection have been manufactured strictly to the requirement of this STR and QAP of the manufacturer in the manufacturer's premises. **A lot is defined as the total no. of castings offered for inspection and this may include several heats/batches. A heat is defined as the total quantity of the castings produced in one melt and heat treated together i.e castings having same chemical composition. One batch consists of castings having same chemical composition and undergoing same heat treatment in the heat treatment furnace.**

Inspecting Authority should also do at least one in PROCESS inspection during manufacture of casting for the followings:-

1. Chemical composition
2. Mechanical properties
3. Impact test.
4. Hardness test
5. General requirement of casting acceptance.
6. Requirements of components manufactured other than steel castings (if applicable).

Records of these inspection shall be verified at the time of inspection.

After having been satisfied about offered inspection lot that the components are strictly manufactured to all the requirement of this STR, the Inspecting Authority shall carry out the inspection as per procedure given bellow:-

The manufacturer shall submit test results of SDB component offered for inspection with Heat No., Batch No. marking details and internal test details to Inspecting Authority. From a lot of 100 SDBs or a part there-of (as per order), following inspection shall be done.

- a) Five percent of SDBs ordered or 10 in 100 (whichever is higher) shall be checked for the following:-
- (1) Gauging of all components with calibrated gauges.
 - (2) General requirement of casting acceptance.
 - (3) Marking.
 - (4) Weight variations.

On identification of a single defect on any of the components, the whole lot shall be rejected. However the manufacturer can re-offer the lot after carrying out internal inspection for identification of all defective components. Such defective component can be repaired or replaced by the manufacturer. In the re-offered lot ten (10) percent draw bar shall be checked for the above requirement and whole lot shall be rejected if a single defect is identified in the re-offered lot.

7.2 In addition to the tests mentioned in para 7.1 the inspecting official will conduct tests as tabulated under:

S.N.	Parameters	Test to be done on	Sampling plan	Reference	Test specification
1	Mechanical Properties • Tensile strength • YS • Elongation • RA	Test Coupon /SDB	1 per lot	Para:1.2.2.1 of Annexure-II	ASTM A370
2	Proof Static tension test	SDB	As per Table-8 of Annexure-II	Para:1.2.5 of Annexure-II	-
3	Chemical composition	Lug/test coupon	3 per lot	Table-1	IS-228
4	Microstructure	Lug/test coupon	3 per lot	Para:1.2.4 of Annexure-II	IS-7739
5	Hardness	SDB	5% of the lot	Para:1.2.2.3 of Annexure-II	IS-1500

6	Destructive test	SDB	1 per lot or 1 per 100 (whichever is higher)	Para:1.2.2.5 of Annexure- II	Para:7.2.5
7	Impact	SDB/ Test Coupon	1 per lot	Para:1.2.2.2 of Annexure- II	ASTM A370
8	Nil ductility	SDB/ Test Coupon	1 per lot	Para:1.2.4.4 of Annexure- II	ASTM E604 or E208
9	Weight variation	SDB	10%	Para:1.3.3 of Annexure-II	-
10	Radiographic test	SDB	5 % of the offered lot or one in 10(whichever is higher)	Para:1.2.3.1 of Annexure- II	Annexure-III

On failure of sample in any of the above tests, the whole lot shall be rejected. However the manufacturer can re-offer the lot after removing all the defective components manufactured in that particular heat in which failed component was cast.

In the re-offered lot double the sample shall be tested provided re-offered lot meets the requirements of Para 7.1. There should not be any failure in re-offered lot.

The SDBs with illegible marking shall be identified and rejected from the lot. On completion of inspection and acceptance by inspection authority, the SDBs shall be painted as per point no. 9 of this STR, before inspector's approval stamping & dispatch to consignee. The components used for tests etc. from the lot during purchase inspection shall be replaced free of cost by manufacturer.

8. Upgradation to Developed/Approved Vendors

A manufacturer will obtain status of Approved Vendor when following is met:

- Manufacturer should have manufactured nos. of SDBs equivalent to 12 rakes (i.e. 432 Nos.) of container wagons.
- Nos. of SDBs equivalent to 6 rakes (i.e.216 Nos.) have completed one POH of satisfactory service.
- No unresolved non-conformances or not more than **one line failures** per year on manufacturing account.
- An audit of the manufacturing facility by RDSO/ RDSO nominated third party to ensure that requirements of **Clause 4.4** are being met.
- The Developed/Approved Status granted to a firm/vendor shall remain valid of 5 years. Firm shall have to re-apply (at least three month in advance) to enable quality audit by RDSO/ RDSO nominated third party for validation of its status and capability. The team will carry out assessment of capacity/capability, QAP verification and carrying out chemical, mechanical testing etc. of two samples of SDBs (randomly picked from a lot of 25 draw bars) to ensure that the status quo of

quality system and infrastructural setup is in desired condition. The parameters as specified under various para's shall be measure and recorded on two SDBs.

9. Painting

Only exposed surfaces of SDBs shall be painted with Black quick drying paint in accordance with IRS R 6. Paint must not be applied to the inside of the SDBs or its internal sections. Painting shall be done after the completion of inspection on SDBs of acceptable casting lot.

10. Marking

- 1.1 The manufacturer shall get the marking scheme for manufacturer's code, batch no., serial no. etc. approved from RDSO. SDBs should have clear and legible manufacturer's code, batch no, month and year of manufacture etc., in cast condition, which shall remain legible throughout the entire service period. The word 'TOP' and 'BOTTOM' shall be marked accordingly on faces (required) for ensuring correct fitment on wagons. The SDB found having illegible marking at the time of fitment in Railway Workshops, Maintenance depot or on Wagon Builders premises shall be treated as rejected and shall be replaced by the manufacturer free of cost. The cost of transportation shall be borne by the manufacturer.
- 1.2 The marking shall be made at the casting/forging stage itself so that the marking shall remain legible during entire service life of the components. Metallic markings (made from engraving process in CNC Machine) shall be used. Cores prepared from Shell core making process to be used for marking of serial numbers only during casting process. The manufacturer will not be permitted to provide manufacturer's code batch no., serial no. etc. by electric arc welding in case these are not visible at casting / forging stage.

11. Guarantee

The SDB supplied shall be accompanied by a guarantee for a period of 84 months from the date of supply or 72 months from the date of fitment, whichever is earlier.

The Contractor shall at his expense, replace the SDB failing or proving unsatisfactory in service attributed to defective/faulty design, defective material or poor workmanship within a period specified above. This guarantee shall survive notwithstanding the fact that the equipment may have been inspected, accepted and payment thereof made by the purchaser for the replaced equipment and period of 72 months would commence when the replaced component is commissioned in service. The sole judge in this case would be the purchaser whose decision shall be final and binding.

12. Record of Internal Acceptance Tests

The manufacturer will maintain a list of all internal acceptance tests being carried out by him at various stages of manufacturing of the product. Proper record of such internal acceptance tests shall be maintained by him and also included in the QAP. At the time of inspection of

the product, these records shall be put up to the Inspecting Authority for scrutiny and countersign.

The manufacturer shall maintain records for a minimum period of six years of all weights, mechanical test reports, chemical test reports and heat treatment records as applicable to the purchased SDBs. These records shall be made available to the purchaser upon request. The manufacturer shall also maintain records for a minimum of six years that provide traceability from the serial number of individual draft gear, where applicable to the records stated above.

13. Reconditioning

The manufacturer shall also undertake reconditioning of SDBs against Zonal Railways request. The reconditioned draw bar shall perform satisfactory in service and shall meet the requirements laid down in clause 11 above.

FINAL STR

Annexure-I

1. MANUFACTURE PROCESS FOR SDBs**1.1 Material**

The material of SDBs shall be as indicated in para 2.2.1 of this STR.

1.2 Process of Steel Making

1.2.1 All steel melting and refinement must be performed with the use of an Electric Arc Furnace. Any other process of steel melting may also be employed provided it's capability of consistently attaining the required chemisrty of castings is established to the satisfaction of RDSO.

1.2.2 Ladle Analysis

The ladle analysis of steel when carried out by spectrometer to determine the percentage of carbon, manganese, phosphorous, sulphur, silicon chromium, nickel & molybdenum shall conform to requirements in Table 1.

Table -1

Element (%)	Grade E
Carbon	0.28 - 0.33
Manganese	0.60 – 0.90
Phosphorus max.	0.03
Sulphur max.	0.03
Silicon	0.40 –0.60
Chromium	0.50 – 0.80
Aluminum	0.020 – 0.050
Nickel	0.50 – 0.60
Molybdenum	0.15 – 0.25

1.3 Manufacturing Process**1.3.1 Raw Material**

Raw material, scrap and ferro-alloys used for the manufacture of steel castings shall be analysed in advance and only those conforming to the QAP shall be used. Care should be taken to ensure that the scrap selected is free from rust, grease, oil and other prohibited contaminants.

1.3.2 Methoding

- i Casting solidification software must be utilized to evaluate castings for potential defects and to qualify the casting for production.

- ii Standardized running, gating and risering system including use of chills and chaplets shall be developed with the help of casting solidification software and only such system be employed for regular production of castings.
- iii Casting solidity must be verified with the aid of casting solidification software to achieve proper internal solidity standards. These standards are measured by means of porosity percentage values. These porosity percentage values must not exceed the maximum severity levels of a particular sectional area as given in Para 1.2.2.5 of Annexure-II.

1.3.3 Moulding

Moulding shall be carried out by employing either of the following process given below:

- (a) High Pressure Moulding Line with Intensive Mixture for Green sand mould with Automatic Moisture Control and addition of Binder in fixed rates
or
- (b) Articulated Mixer (continuous type) with fume extraction facility & Compaction Table for No-Bake System.

Mould hardness shall range from 80 to 100 and the same should be uniform at all the surfaces so as to get good dimensional accuracy in castings.

1.3.4 Core making

All cores shall be produced by No-bake process for which continuous mixer with compaction table/ batch mixer shall be available.

1.3.5 Melting

A sufficient carbon boil must be accomplished with a 20 point carbon reduction. Double slag process for proper removal of sulphur and phosphorus shall be followed. Argon purging may be carried out to ensure freedom from harmful gases. Ladle pre-heating at 600 to 700°C shall be carried out. Temperature checking in Furnace and in Ladle by Immersion Pyrometer shall be done before pouring in Mould.

1.3.6 Pouring

During pouring in mould, temperature checking by Laser Beam Type Optical Pyrometer shall be done. After pouring castings shall be allowed to cool to a temperature below 300°C, at a rate that will not be injurious to the castings. Moulding boxes shall be opened to extract the castings after they have cooled down sufficiently to room temperature.

1.3.7 Fettling

Risers, runners and ingates shall be removed from the castings. Use of knock-off risers

shall be preferred for improving the surface condition of the castings. All castings shall thereafter be properly cleaned, dressed and shot blasted to ensure freedom from surface imperfections, loosely adherent sand, scale etc.

1.4 Heat-treatment

All castings shall be heat treated after fettling. Grade E steel castings shall be furnished normalised, quenched and tempered. State-of-the-art heat treatment furnaces shall be employed and must be capable of maintaining an even heat distribution within $\pm 10^{\circ}\text{C}$ throughout. Verification must be established by performing a minimum of eight zone survey on monthly basis.

1.4.1 Normalised, Quenched and tempered steel castings shall be processed in the following manner:

Heating shall be done in the Furnace with Automatic Charging Arrangement and facility to quench within 60 seconds. Castings shall be heated to the proper uniform temperature above the transformation range (890°C - 920°C) and held for the proper time (1Hr + 1Hr for each 25mm section thickness) to achieve complete austenization and to refine the grain structure.

Withdraw from the furnace and cool in still air until casting in their entirety are below 500°C .

Castings shall be reheated to proper uniform temperature above the transformation range (880°C - 900°C) and held for the proper time (1Hr + 1Hr for each 25 mm section thickness) to achieve complete austenization and to obtain the finer grain structure.

Withdraw from furnace while castings are above the transformation range, subject to rapid cooling (quenching) in suitable liquid medium in a quench tank to a temperature substantially below the transformation range. Quenching Tank should have capacity of more than 10 times of charge with Cooling Tower system along with highly agitated liquid medium mechanical arrangement from bottom of the tank. Rise in the temperature of the quench tank after quenching shall not be more than 10°C .

Tempering should be done within one hour of quenching. Tempering is to be done in the Furnace equipped with Hot Air Circulation System at the top for better heat transfer from Hot Air to casting.

Temper by reheating to proper uniform temperature above the transformation range (590°C - 620°C) and held for the proper time (1Hr + 1Hr for each 25 mm section thickness). Hold for the required time, remove from the furnace and allow to cool to room temperature at any desired rate.

1.4.2 All the stages of heat treatment with various temperature ranges of processes shall be

clearly brought out in QAP. Inspecting Authority shall examine it with actual heat treatment process being followed during quality audit.

1.4.3 Heat-Treatment Documentation

The manufacturer is required to develop and document heat-treating standards that describe the processes, process control procedures, and record keeping requirements. These documents are to be presented and reviewed as part of the Foundry Approval Process and are intended to ensure that products are properly heat treated. Furnace temperatures for heat treatment shall be controlled by pyrometers having associated recording equipment that produce time-temperature record charts that are identified by date and furnace number. A log sheet for each load of castings heat treated (batch) should show all information pertinent to each heat-treat load including the following:

- Type of casting.
- Prescribed heat treatment.
- Serial numbers and the heat numbers of the castings.
- Actual time of heat treatment.

Pyrometers shall be calibrated every 3 months. Records of time-temperature charts, furnace log sheets, and pyrometer calibrations will be maintained for 3 years and available to the purchaser upon request.

1. PREPARATION OF TEST LUGS/SAMPLES AND TESTING REGIME

1.1 TEST SAMPLES

Test samples shall be prepared from the castings (SDBs). For all castings two lugs shall be integrally cast. The location of test lugs shall be such that when removed, they shall indicate that the steel castings have been subjected to heat treatment. The standard test lug shall be 25mm in height by 25 mm in width and 13 mm or 16 mm in thickness where it joins with castings. The samples from the test lugs must meet the properties of this STR. However when samples are taken from casting there will be variation from the test coupon depending on the location of casting. Manufacturer will submit drawings to RDSO regarding location of test piece on castings, where correspondence with test piece integrally cast will be determined and finalized to have minimum variation. If test piece is taken from any other location at random from the test coupon, the properties will be at least 80% of stipulated properties.

1.1.1 Test coupons

The coupons shall either be cast attached to the castings or the gating system and prepared in accordance with ASTM Standard A 370, latest revision. All the SDBs to be cast integral with coupon and the same shall be removed only after the inspecting authority has inspected and passed the lot.

1.2 TESTING

1.2.1 Chemical Composition

The product analysis shall be carried out on the finished casting by spectrometre. Permissible variation in the case of such analysis from the limit specified in Table-2 (ladle analysis) shall be as follows:

Table-2

Element	Variation percent
Carbon	±0.03
Manganese	±0.04
Silicon	±0.05
Phosphorus	±0.005
Sulphur	±0.005
Chromium	± 0.04
Nickel	±0.03
Molybdenum	±0.03
Aluminum	±0.003

1.2.2 Mechanical Properties and Tests

Each heat shall be tested for mechanical properties after heat treatment. The coupons from each melt shall be heat treated with castings of the same grade, in the same manner

as the casting they represent.

1.2.2.1 Tension Test

Test shall be conducted in accordance with standard Methods and Definition for mechanical testing of steel products, ASTM standard A 370, latest revision, using 13mm round, 51mm gauge length specimens prepared from the test coupons / casting as illustrated in that specification. Specimens shall meet the following requirements:

Table-3

Mechanical Property	Grade E
Tensile strength N/sq. mm. (Minimum)	825
Yield strength N/sq. mm. (Minimum)	690
Elongation on 51mm gauge length (minimum %)	14
Reduction in area % (minimum)	30

One specimen per heat of steel grade shall be tested. If test specimen shows a defect during machining or exhibits flaws before or after testing, it should be discarded and another specimen substituted.

1.2.2.2 Impact Test

This test consists of determining the average energy absorbed from three-impact specimen from the same heat. The manufacturer shall carry out test to determine impact properties by using Standard Charpy-V-Notch type "A" specimen prepared in accordance with ASTM Standard A 370. Test Specimens shall be prepared from castings. The test results should meet the following minimum requirements at the temperatures indicated against them.

Table-4

Cast steel	Temp. Deg.C	Energy Kg.m.
Grade E	- 40	3.50

1.2.2.3 Hardness

The heat treated cast steel components must meet the following Brinell hardness range as specified in Table-5(i):

Table-5(i)

Grade	Hardness(BHN)
Grade E steel castings	241-311

As Quenched Hardness

The cast steel components after quenching must meet the following Brinell hardness range as specified in Table-5(ii):

Table-5(ii)

Grade	Hardness(BHN)
Grade E steel castings	Minimum 429

Testing shall be done on a surface (that has been ground to remove decarburization) as well as in the core on the sectioned castings in accordance with ASTM A 370. The hardness shall be checked on both shank and near centre (on top and bottom faces, in line with CBC couplers).

1.2.2.4 Nil Ductility Test

Fracture Toughness/**Nil Ductility Test** test shall be conducted on specimens from castings in accordance with either ASTM E604 or E208 except that Nil –Ductility Transition Temperature (NDTT) shall be -57° C or lower for grade E. The test specimen shall withstand the test without showing any sign of distress.

1.2.2.5 Destructive Testing

Destructive test shall be carried out on the actual casting during prototype inspection as well as during acceptance inspection.

One casting per 100 casting shall be subjected to destruction to examine the presence of casting defects. Defects such as blow holes, slag inclusions, shrinkage, etc. are not acceptable. Porosity to a level of 2% of the cross section may be considered acceptable.

Castings are to be sectioned in accordance with Fig-1. Areas to be rated for discontinuity severity level are as illustrated in Fig-1. Casting areas for evaluation shall be rated as to level of severity by comparing them with "Standard Reference Photographs for Casting Solidity" included as per AAR M-211 (latest) and results shall be recorded. The rated level of severity for each section must not exceed those listed in the following table-6:

Table-6

Component Type	Sectional area Maximum severity Levels					
	A	B	C	D	E	F
SDB Body	3	5	4	4	4	2
SDB Shank(both ends)	3	4	4	4	-	-

1.2.3 Non-Destructive Testing

1.2.3.1 Acceptance standard for Radiographic Examination

Radiographic examination shall be conducted on SDB to the extent of 5% of the casting produced or one in ten (whichever is higher) and level of acceptance shall be as per ASTM E 446 Level-II. The location for Radiographic test shall be as per **Fig-2**. Radiographic testing facility to be available with the manufacturer i.e. testing to be in-house. The procedure of radiography is given in **Annexure-III**.

1.2.4 Metallographic Test

With a view to ensure the homogeneity of the steel and the quality of heat treatment, it is essential to examine the microstructure of the SDBs at the time of acceptance inspection. The samples should be taken from the lugs attached to actual castings produced and not from the separately cast test bars. Microstructure achieved shall be uniform fine tempered martensite.

1.2.5 Static Test

Manufacturers must maintain Internal Process Specification and Quality Assurance Programme control casting integrity. As a periodic check, a laboratory static test will be conducted on one (1) specimen of every 500 SDBs, being produced or once every three (3) or six months according to the following tabulation, whichever occurs first. If production is less than 200 in the frequency period, no test is required for that period. However, in any case, at least one (1) test is required per year. The specimen shall represent current production practices.

Table-7

Component	Frequency Period
SDB	6 months

Proof Test

SDBs must meet permanent set and ultimate strength requirements shown in **Table-8**. The dimensions shown in **Fig-3** shall be used for determining permanent set and result shall be recorded. Special test dummies for testing SDB bodies shall have a load capacity in excess of 408 tonnes. When testing SDBs, if test dummy breaks before required loading is attained, the test shall be terminated and the load recorded as the “maximum applied load. “Test machines shall have a minimum capacity to meet specified loads and be calibrated to ASTM standards

Static Tension Test Requirements:**Table-8**

	Maximum Permanent Set – mm Grade E Steel		
	At 181.5 t	At 317.5 t	Minimum Ultimate
SDB (Shank and body)	-	0.76	408 t.

*Based on testing with dummy fixture.

After application of ultimate load (i.e. 408t) there shall not be any crack, breakage, permanent set, failure in any section of SDB (to be ascertained with dye penetrant test/MPI).

1.2.6 Type and Number of Tests

The quality control organization of the manufacturer should carry out tests as given below. Records must be maintained for the tests carried out.

S.No.	Parameters	Test to be done on	Sampling plan	Reference	Test specification
1.	Visual & Operational Check	SDB	10% of the offered lot	Para:7.1 & 1.3 of Annexure-II	RDSO approved Drgs & SCRATA Comparators
2.	Dimensional	SDB	10% of the offered lot	Para: 2.2.2 & 4.1.1	RDSO approved Drgs
3.	Mechanical Properties i) Tensile strength ii) YS iii) Elongation iv) RA	Test coupon	1 per heat	Para:1.2.2.1 of Annexure-II	ASTM A370
4.	Proof Static tension test	SDB	As per Table-8	Para:1.2.5 of Annexure-II	-
5.	Chemical composition	Lug/Test coupon	1 per heat	Table-1	IS-228
6.	Microstructure of SDBs	Lug/Test coupon	1 per heat	Para:1.2.4 of Annexure-II	IS-7739
7.	Hardness	Castings	5% of the castings	Para:1.2.2.3 of Annexure-II (Table 5(i))	IS-1500

8.	Destructive test	SDB	1 per 100 or part thereof	Para:1.2.2.5 of Annexure-II	-
9.	As Quench hardness	E Grade Casting	5% of the castings	Para:1.2.2.3 of Annexure-II Table 5(ii)	IS-1500
10.	Impact	SDB	Three per heat	Para:1.2.2.2 of Annexure-II	ASTM A370
11.	Nil ductility	"	1 per heat	Para:1.2.4.4 of Annexure-II	ASTM E604 or E208
12.	Weight variation	"	10%	Para:1.3.3 of Annexure-II	-
13.	Radiographic test	SDB	5 % of the offered lot or 1 in 10 (whichever is higher)	Para:1.2.3.1 of Annexure-II	Annexure-III

1.3 Surface Finish of SDB castings

Riser pads and gate stubs shall not project more than 6 mm above the surrounding surface at any location. Where interference would exist in the operation or application or where serviceability would be affected, the riser pads and gate stubs shall be contoured to surrounding areas.

Castings shall be blasted sufficiently clean to permit thorough, visual Inspection. Prior to shipment, castings shall be free of dirt, rust, or loose material that would affect operation. Couplers must not be sand or shot blasted when completely assembled.

The castings shall not be painted or covered with any substance that will hide defects. However, manufacturer's and/or purchaser's paint identification marks are acceptable.

1.3.1 Surface Finish Acceptance Level

The minimum acceptable surface conditions for the defects described below shall govern. Acceptable surfaces shall be defined utilizing Steel Castings Research and Trade Association (SCRATA) Comparators for the Definition of Surface Quality of Steel Castings (1981). The listed defect classification does not apply to inaccessible areas. Surface defects described herein do not preclude the requirements of proper gauge application as defined elsewhere in this STR.

Surface conditions evaluated with SCRATA comparators:

		Critical Area (Fig-8)	Non Critical Area (Fig-8)
A	Surface Roughness	A3	A3
B	Surface Inclusion	B2	B4
C	Gas Porosity	C2	C3
D	Laps	D1	D4
E	Scabs	E2	E2
F	Chaplets	F2	F4
G	Thermal Dressing	G2	G3
H	Mechanical Dressing	H3	H4
J	Welds	J2	J3

Surface conditions B and C are acceptable if the depth of the defect does not exceed ten (10) percent of the section thickness at critical areas and twenty- five (25) percent of the section thickness in non-critical areas.

Surface conditions not evaluated with SCRATA comparators

Offsets greater than ten (10) percent of the casting wall thickness are not permitted. (Offsets: An offset is an abrupt, unintentional change in the casting surface.)

Cracks, hot tears, cold shuts, and weld cracks , which are visually apparent, are not permitted Zone 1 areas must be prepared in accordance with **Fig 4**.

1.3.2 Wall Thickness

Wall thickness tolerances shall be generally as tabulated below:

6 mm up to, not including 11mm wall,	+ 3 mm	- 0.8 mm
11 mm up to, not including 19mm wall,	+ 3 mm	- 2.4 mm
19 mm up to, not including 32mm wall,	+ 3 mm	- 3 mm
32 mm and over,	+ 4.8 mm	- 4 mm

1.3.3 Weight Variation:

Variation in weight of SDBS, shall not vary more than FIVE percent above or THREE percent below what has been determined as the average weight, ascertained from the actual weight of 20 nos. of each of the SDBs verified for each dimensional accuracy in presence of Inspecting Authority at the time of approval and thereafter as given in the approved drawing of the proposer. Those SDBs components, which do not fall within the prescribed limits of weight variation, shall be rejected by manufacturer.

Annexure- III

Procedure for Radiography

Procedure:

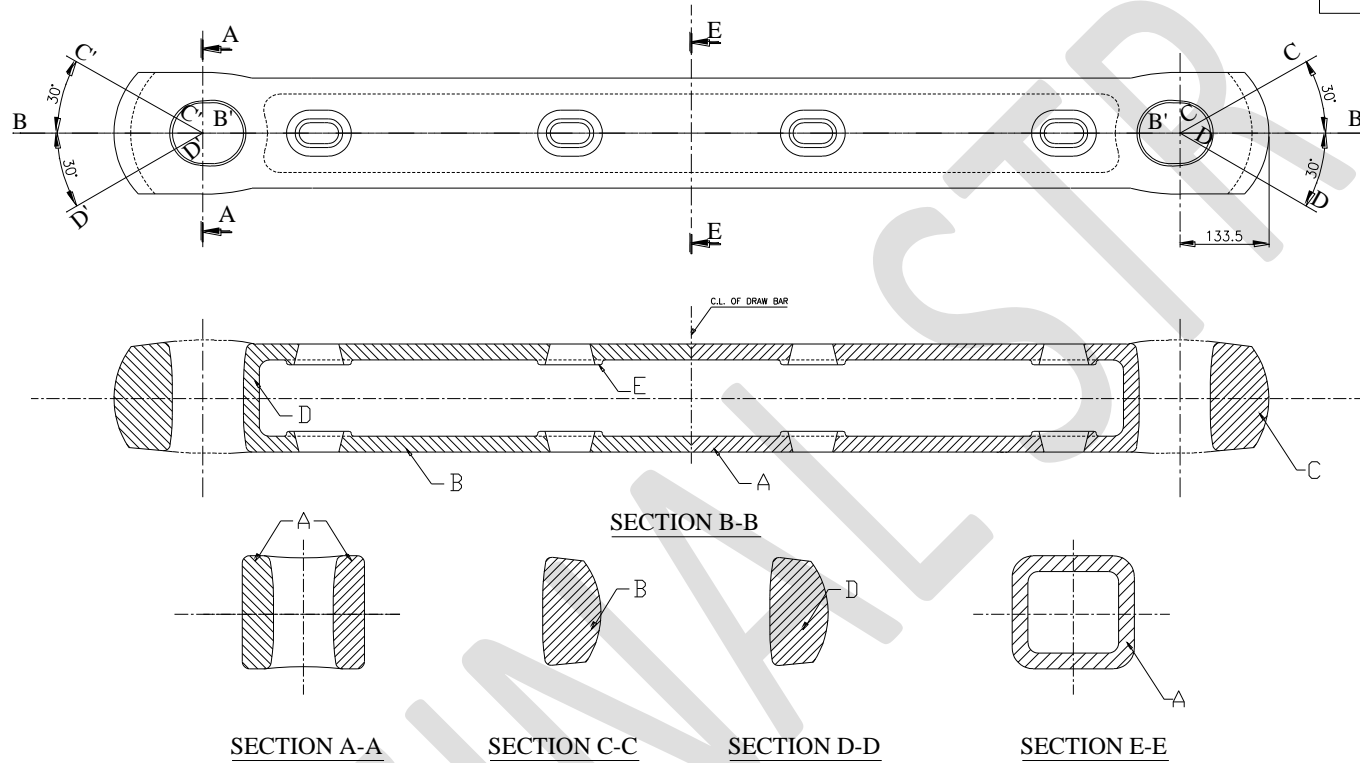
1. Radiograph shall be taken in open space.
2. Gamma Radiography shall be used for radiography.
3. Source of radiography shall be put at specified locations.
4. Put the Radiography film outside the pin Holes as shown in photograph.
5. Appropriate penetrameter shall be keep over the radiography film.
6. Sensitivity of radiography shall be set 2% of the thickness of the castings.
7. Radiography shall be taken for area of SDBs shown in FIG.-2.

Acceptance Standard:

Acceptance Standard shall be ASTM 446 (Reference Radiographs for steel casting upto 2 in. (51 mm) in thickness), Volume-II.

- (i) Sensivity of radiography shall be 2% of the thickness of casting.
- (ii) Defects like Gas Porosity, Sand & Slag inclusion and Shrinkage upto Level-II shall be accepted.
- (iii) Defects like Hot Tear, Crack, Insert, and Mottling shall not be permitted.

FIGURE-1



SOLIDITY TEST RESULT		
S.No.	LOCATION	OBSERVATION

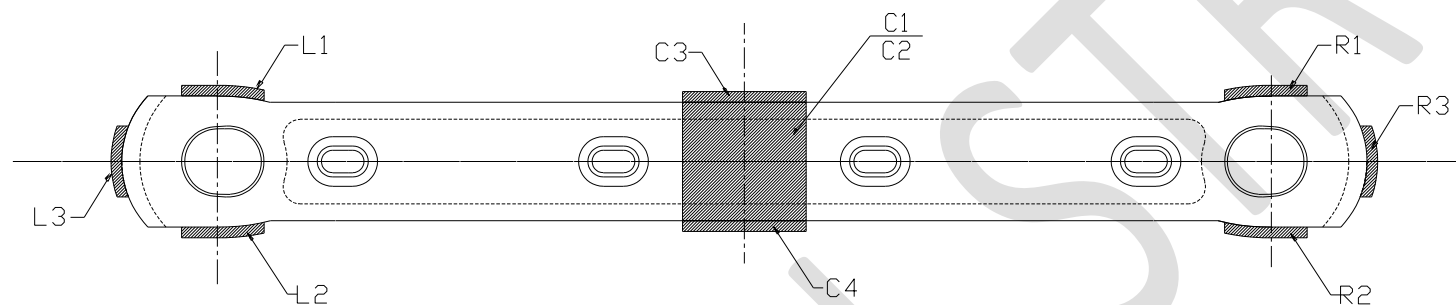
FORMAT FOR MEASUREMENT OF OBSERVED PARAMETERS

DRAW BAR SECTION INSPECTION

FIGURE-2

LH SIDE

RH SIDE



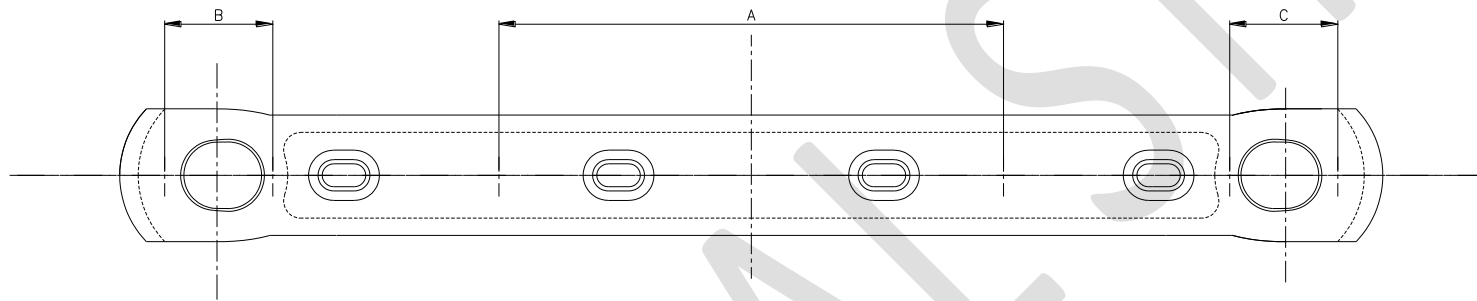
RADIOGRAPHY LOCATIONS DEFINED		
S.No.	LOCATION	OBSERVATION
1	L1,L2	SHANK SIDES LEFT END
2	L3	SHANK END LEFT SIDE
3	R1,R2	SHANK SIDES RIGHT END
4	R3	SHANK END RIGHT SIDE
5	C1,C2	TOP & BOTTOM FACES AT CENTRE
6	C3,C4	SIDE FACES AT CENTRE

LOCATION TO BE RADIOGRAPHED

FIGURE-3

LH SIDE

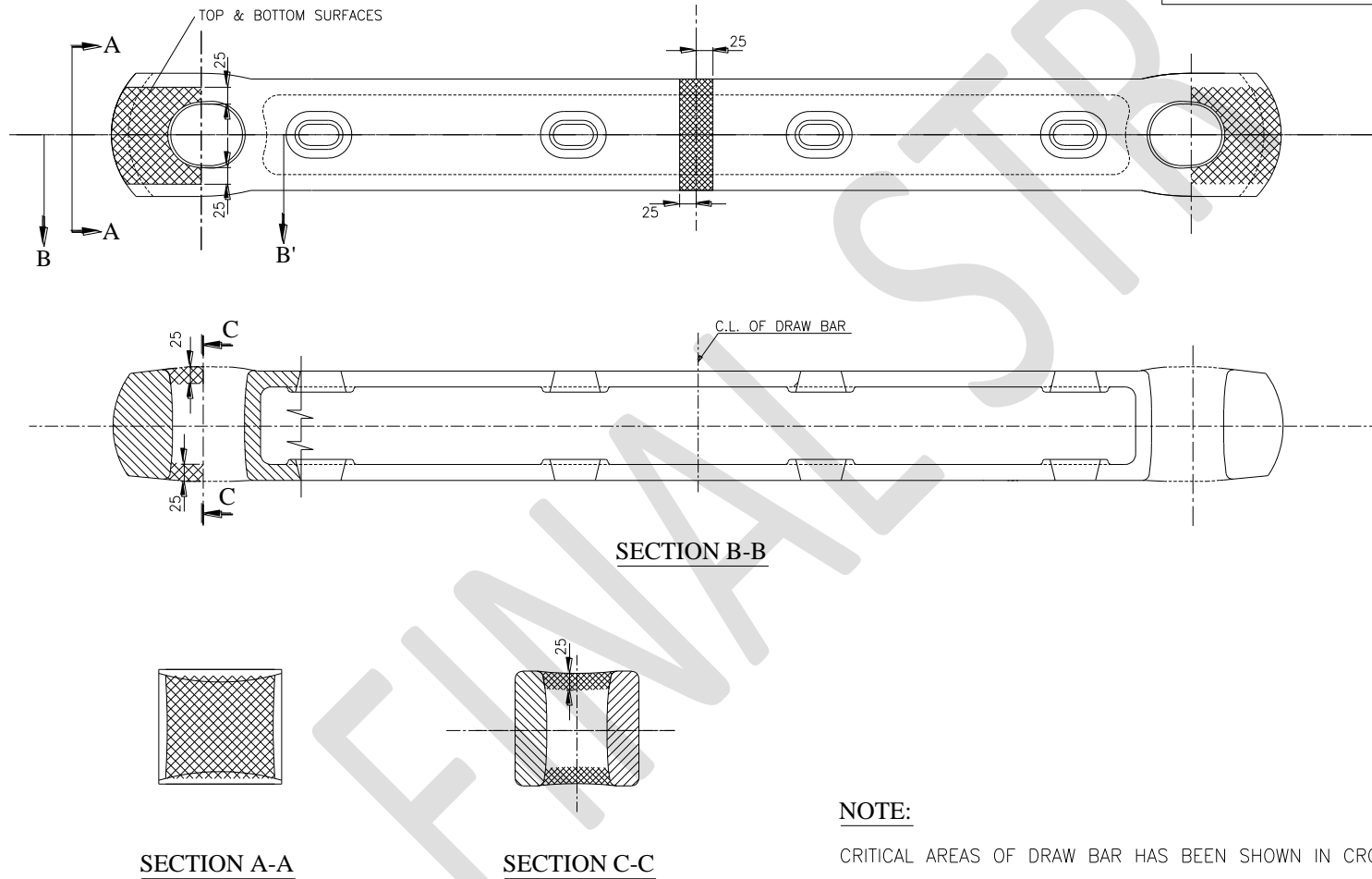
RH SIDE



PROOF LOAD DEFINED		
S.No.	LOCATION	DESCRIPTION
1	A	700MM
2	B & C	150MM

LOCATION FOR PERMANENT SET MEASUREMENT

FIGURE-4



INSPECTION ZONES FOR CRITICAL AREAS