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जयते

भारत सरकार–रेल मंत्रालय
अनुसंधान अभिकल्प और मानक संगठन
लखनऊ– 226011
Government of India - Ministry of Railways
Research, Designs & Standards Organization, Lucknow – 226011

EL/3.2.182 **Date: 09.8.2019**

1. M/s India Metal & Alloys Mfg.Co.Pvt.Ltd.3A,Hare street,Kolkata-700001.
2. M/s Selvoc Engineering Co.P.Ltd.P/69A,Block-D, New Alipur, Kolkata-700053..
3. M/s Radhika Industries/Kanpur.83/141,johi, Kanpur-208014.
4. M/s Applied Engg. Services.34/662,Santa nagar, Kandivali East, Mumbai-400101.

Sub: Minutes of Meeting held at RDSO on 17.07.2019 on issues related to Zr-Cu rotor bar.

Ref: RDSO letter No. EL/3.2.182 dated 17.06.2019.

1. Please find attached Minutes of Meeting held at RDSO on 17.07.2019 on issues related to Zr-Cu rotor bar for your information and necessary action please.

2. Minutes of Meeting can also be downloaded through following path:
www.rdso.indianrailways.gov.in → Directorates → Electric Loco →Reliability Meetings →others →Minutes of Meeting.

9.8.19

(P.K. Saraswat)
For Director General/Elect

Copy To:-

Principal Chief Electrical Engineer , Chittaranjan Locomotive works,Chittaranjan-713331- For kind information please.

9.8.19

(P.K. Saraswat)
For Director General/Elect

Minutes of Meeting held at RDSO on 17.7.2019 on issues related to Zr.Cu rotor bars used in TM type 6FRA6068

RDSO	Designation	Firm	Representatives
Shri O. P. Kesari	PEDSE	M/s Applied	Shri Gopal BH
Shri P.K. Saraswat	DSE/TM	M/s Radhika	Shri Nitin Vaid
Shri Ritzu Ranjan	JE/-I/TM	M/s India Metal	Shri Brij Raj Rathi
		M/s Selvoc	Shri S.Kundu
CLW	**Designation**		
Shri Ravi yadav	SEE/TM		
Sri M.D.Zaman	SSE		

1. RDSO vide letter no. EL/3.2.182 dated 7.6.2019 & 18.6.2019 had invited CLW and all approved sources of ZrCu rotor bar to attend the meeting to discuss the supply issues and other technical issues involved.
2. During the meeting PEDSE RDSO welcomed all the participants and informed them to gear up for increased requirement as production of 6FRA6068 TM is likely to go up to 5820 TMs per year to meet the production target of 970 locos.
3. **Background:**
   - 3.1 ZrCu rotor bar is governed by Specification no. RDSO/2008/EL/SPEC/0063(Rev'2') of January 2010.
   - 3.2 There are four CLW Approved sources for the subject item namely; M/s Applied Engg. Services Mumbai, M/s India Metal & Alloys Kolkata, M/s Selvoc Engineering Kolkata and M/s Radhika Industries, Kanpur.
   - 3.3 BHEL vide letter number TME/6FRA/RDSO/2017-18/152 dated 3.1.2018 had informed that M/s Applied is not quoting as per specification and quoting with deviation, "*We can't guarantee Tensile of 400 Mpa in H04 temper however it can be guaranteed in H06 temper*"
   - 3.4 BHEL vide letter number TME/6FRA6068/RDSO/2018-19/264 dated 3.11.2018 had requested RDSO to issue necessary amendments to the specification as M/s Applied is not quoting as per specification.
   - 3.5 CLW also vide letter no. CLW/TM/9661 dated 15.5.2019, had informed that M/s Applied is quoting with technical deviation of the spec., "*As per RDSO approved QAP*".
   - 3.6 As per approved QAP, there is no necessity of final testing if raw material meets the required parameters and chemical testing is also not required.

3.7 As per deviation quoted to BHEL, M/s Applied cannot guarantee Tensile strength of 400MPa in H04 Temper, However it can be guaranteed in H06 temper.

3.8 CLW informed that CLW & other approved sources of TM are facing problem in procurement of subject item. CLW requested RDSO to examine the deviation and carry out changes in the specification if required.

3.9 Accordingly, the meeting was held at RDSO on 17.7.2019 to discuss all technical issues related to ZrCu rotor bars.

4. **Technical Specification:**

4.1 Technical Specification no. RDSO/2008/EL/SPEC/0063(Rev'2') of January 2010 specifies the following requirements for the subject item.

a. Material : UNS no. C15000 – H04 Temper (Hard).

b. Composition: Cu + Ag : 99.80% min
Zr : 0.05–0.2 %

c. Electrical Conductivity : 93% IACS min at 20^0C

d. Resistivity : 0.16481 Ω-g/m2 (Maximum)

e. Tensile Strength : 400 MPa (Minimum)

f. Yield Strength : 380 MPa (Minimum)

g. Elongation in 50 mm gauge length : 11 % minimum

h. Hardness : 90 HRF (minimum)

i. Specific gravity : 8.89

5. **Source of Raw material**

During the meeting, all the approved sources confirmed that they are procuring required raw material from M/s Mitsubishi Japan. During the meeting M/s Applied, Channel Partner / Local Representatives of Mitsubishi Shindoh Co. Ltd., clarified as under :

i. Mitsubishi Materials Corp. is the manufacturer of Primary form of Raw Material – Billet. All Vendors , including Mitsubishi Shindoh Co. Ltd., source Billet from Mitsubishi Materials Corp.

ii. All Vendors confirmed that there are no issues related with supply of Billets.

iii. M/s Applied Supplies Rotor Bars manufactured by Mitsubishi Shindoh Co. Ltd., with minimal value addition locally , as was done at the time of development / Proto type approval by RDSO and for which CLW has given special permission / exemption in STR in 2011.

iv. Two other Vendors – M/s IMA & M/s Radhika – manufacture Rotor Bars from Billet, as per original approved QAP /Prototype Test. Fourth Vendor – M/s SELVOC , fabricate Rotor Bars from strips supplied by M/s Applied by cutting and machining process only as per original approved QAP/ Prototype Test.

6. **Tests specified in the specification**

6.1 Type tests, routine tests and acceptance tests are specified in the specification.

6.2 Followings tests had been prescribed for each category of tests (Type tests, routine tests and acceptance tests)

6.3 Visual Examination
Measurement of dimensions
Electrical Conductivity
Tensile & yield strength/elongation test
Hardness
Chemical composition
Ultrasonic/eddy current testing

6.4 It was informed by firms during the meeting that routine tests are conducted internally by firms and acceptance tests are witnessed by customer.

7. **Issues discussed related to chemical testing**

7.1 As per clause 14.3 of the specification, "*The manufacturer shall test every lot of rotor bars for chemical composition, if extrusion has been done by another agency*".

7.2 ASTM B747-15 is the governing specification.

7.3 For chemical analysis, ASTM B747-15 specifies that:

14.2.1 The sample for chemical analysis shall be taken in accordance with Practice E255 for product in its final form from the pieces selected in 14.1.2 and combined into one composite sample. The minimum weight of the composite sample shall be 150 g.

14.2.2 Instead of sampling as directed in 14.2.1, the manufacturer shall have the option of sampling at the time castings are poured or from the semifinished product. ***When samples are taken during the course of manufacture, sampling of the finished product by the manufacturer is not required.***

17.1.3 Since no recognized test method is known to be published, the determination of zirconium shall be subject to the agreement between the manufacturer and purchaser.

7.4 M/s Applied requested for removing the requirement of chemical testing of Zr from the specification since there is no protocol for testing Zr in ASTM.

7.5 For chemical analysis, M&C Dte. Of RDSO had observed that:

Method for chemical analysis of Zirconium in ferro-silicon zirconium alloys is available in IS: 15396:2003. However, method for chemical analysis of Zirconium in copper base material is not found available.

Spectrographic Analysis of Zirconium in copper base material is available in NABL accredited 'Spectro Analytical Laboratory, New Delhi.

Spectrometer available in M&C Dte. Has channel for determination of Copper base alloys with Certified Reference Material (CRM satandard), but no CRM standard is available for copper base material with zirconium. Hence, Spectrographic analysis of Zirconium in copper base material is not possible

7.6 All the firms were requested during meeting to explore whether any NABL laboratory carry out testing of Zr in Cu and it is part of its accredition, before taking final decision.

7.7 CLW is requested to confirm whether *CRM satandard is available for copper base material with zirconium.*

8. Issues related to Ultrasonic testing

8.1 It was informed by M/s Applied that though the ultrasonic testing had been specified, its acceptance norms are not defined in the specification. Further, ultrasonic testing to be carried out on 10% quantity as per specification, which is very high and time consuming and needs review.

8.2 M/s Applied also requested to remove the Eddy current testing, which is defined as an alternate to the ultrasonic testing. All the firms confirmed that they are doing only ultrasonic testing and no firm is carrying out the Eddy current testing.

8.3 All the firms were requested during meeting to suggest acceptance norms for ultrasonic testing and sample quantity for testing.

9. Issues related to marking

9.1 It was informed that presently as per specification, there is no requirement of marking on the rotor bars. It was suggested to incorporate marking requirement in the specification as marking will help in identification in case of failures.

9.2 It was suggested by M/s Applied that Laser Engraving may be adopted instead of punching for marking on rotor bar.

9.3 All the firms were requested during meeting to examine the suggestion and give their views on adopting laser engraving system for marking.

10. Issues related to sampling

10.1 M/s Radhika informed that as per specification, samples has to be taken per lot. The lot needs to be defined. It is suggested to do sampling as per IS613 based on offered quantity irrespective of the heat lot.

10.2 All the firms were requested to examine the suggestion and give their views on sampling practice and definition of lot.

11. Issues related to supply

11.1 All the firms were informed that current production target is about 970 locomotives for WAG9/WAP7. Total requirements for TMs is approximately 5820. All the firms were requested to gear for the requirement of ZrCu for about 6000 motors.

11.2 All the firm informed that lead time from M/s Mitsubishi for raw material is from 6 to 8 months. All the firms were requested to initiate advance action for procurement of raw material considering anticipated requirements and lead time for procurement of raw material.

11.3 CLW was also requested to allow for sufficient lead time in its procurement cycle and should place POs well in advance.

11.4 M/s Applied informed that there is no supply constraint for billet from M/s Mitsubishi Material Corporation, however there is supply constraint from M/s Mitsubishi Shindoh for supply of extruded strip/rod/bar which at present is limited to around 2000 TMs.

11.5 M/s Applied informed that two of the Vendors have changed from the originally approved form of Raw material - Billet [from Mitsubishi Material Corp.] to intermediate form of strip [from Mitsubishi Shindoh Co. Ltd.,] with a reduced local content / value addition and technically whole requirement is currently met by Mitsubishi Shindoh Co. Ltd., instead of earlier 3 Vendors and this has caused some capacity issues with Mitsubishi Shindoh Co. Ltd. and causing delays.

11.6 RDSO suggested to M/s IMA and M/s Radhika to manufacture Rotor Bars from Billets, instead of strips, if they have capacity to manufacture Bars from Billets and revise the QAP suitably.

11.7 RDSO also asked M/s Mitsubishi Shindoh Co. Ltd. thru their Local Representative – M/s Applied to gear up for the enhanced production.

12. Issues related to Tensile Strength

12.1 Tensile Strength of 400 MPa (Minimum) is specified in the specification. Temper of H04 is specified in the specification.

12.2 ASTM B747-15 is the governing specification. It specifies Tensile strength of 365 – 425 MPa for H04 (Hard) temper and 405 – 450 MPa for H06 (extra hard) temper.

12.3 M/s Applied informed that initially, rotor bars of oxygen free copper as per Specification No. 4TMS. 096.060 were used, which prescribes Tensile Strength of 260 to 345 MPa. In case of Oxygen Free Copper Bars , physical properties tend to soften above 150 degree C. However in case of Zirconium Copper bars retain the physical properties even at elevated temperature of 300 degree C.

12.4 M/s Applied informed that at the time of development & trials of ZrCu rotor bar in 2009, Mitsubishi Shindoh had supplied bars with Tensile Strength more than 420 MPa and Temper H06 and these were subjected to several testing at IIT Kanpur. After these trials decision was taken to revise the Specification as per governing ASTM Standard ASTM B-747 and Temper revised to H04

12.5 M/s Applied informed that, Mitsubishi Shindoh is putting more efforts to improve the conductivity of the bar and has currently achieved higher conductivity of 99 % for intermediate shape as compared to 96 % at the time of Proto type testing in 2009.

12.6 M/s Applied requested to revise the specification and specify the tensile strength as per ASTM for H04 class. It was informed that Min 400 MPa tensile strength cannot be guaranteed in H04 temper. It can be guaranteed in H06 temper. M/s Applied requested to correct the discrepancies in the specifications as per ASTM B 747.

12.7 However, other firms informed that they are not facing any issues related to tensile strength and they are able to achieve required tensile strength of 400 MPa with required minimum conductivity of 93% as per testing carried out by the customer as per IS 613 sampling plan.

12.8 CLW is requested to give details of supplies of M/s Applied where Tensile strength of 400 MPa is not complied with and also provide of performance of those traction motors.

12.9 It is required to examine the effect of Tensile strength of rotor bar through FEA, if it is changed as per ASTM.

12.10 CLW is requested to provide 3D model for carrying out the FEA, and carry out the FEA if possible with Minimum Tensile strength as 365 as per ASTM.

13. **Issues related to QAP:**

13.1 **QAP of M/s Applied**:

i. QAP of M/s Applied approved provisionally by RDSO on 24.2.2011.

ii. Raw material : 16 to 22 mm dia Rod, hot extruded from billet sourced from M/s Mitsubishi.

iii. After extrusion, the rod undergoes Thermo Mechanical Treatment (TMT) either at Japan or at India to improve conductivity from 60 to between 93 – 98%

iv. Tensile & conductivity of Rod is tested before processing.

v. Processing :

Rolling process – repeated several times
Cold Drawing – initial & final

vi. Dimensional checking

vii. Conductivity & Tensile Checking

viii. Cutting to required length

ix. In the QAP, it is mentioned that:
"*Normally, the conductivity, drops between 2 to 3 % [and tensile strength increases] during the rolling and cold drawing process*".

"*If the conductivity of first & last length meets the specification requirements, whole lot is accepted, if not subjected to 100% checking.*

13.2 **QAP of M/s India Metals & Alloys Mfg. Co. (M/s IMA)**

i. QAP of M/s India Metals dated 23.3.2010 is available.

ii. Raw material : ZrCU billet.

iii. Processing: Forging

iv. Hot & Cold Rolling

v. Die Drawing

vi. Mechanical Testing of Cu. Bar

vii. Machining Testing

viii. Inspection Plan of Finished Product:
Visual – 100% - Dimension
Elec. Properties - 100% - Conductivity
Final Inspection – 100% - Complete TCs documentation & Identification
Packing – 100% - Protection Verification

ix. Chemical testing of final product is not specified in QAP.

13.3 **QAP of M/s Selvoc**

i. QAP was approved by RDSO on 7.3.2011.

ii. Raw material : procured from M/s Mitsubishi Japan, through M/s Applied.

iii. Processing: Cutting, Machining & Slot Cutting

iv. Inspection Plan of Final Product:
Mechanical Properties – One Sample - Tensile, Elongation, Hardness, Yield – NABL Lab
Chemical Properties - One Sample – Chemical Analysis - NABL Lab
Ultrasonic Testing – Ten Samples – Ultrasonic - - NABL Lab
Dimensions – at random
Surface finish – visual

v. It is observed that M/s Selvoc is now procuring material directly from M/s Mitsubishi.

13.4 QAP of M/s Radhika

i. QAP of M/s Radhika was approved by RDSO on 18.1.2013.

ii. Raw material : Extruded section from M/s Mitsubishi.

iii. Processing: pickling & washing, drawing, annealing, pickling & washing, cutting, milling and finishing

iv. Final Internal Inspection:
Mechanical Properties – per lot- Tensile, Elongation, Hardness, Yield
Ultrasonic Testing – 100%
Electrical properties – 5 per lot
Final Inspection – Verification of complete TCs

v. Chemical testing of final product is not specified in QAP.

vi. However, it was informed by the firm that chemical testing is routinely tested at the time of inspection by customer as per IS613 sampling policy.

13.5 It is observed that there are some issues in the QAPs of all the firms.

14. All the firms are requested to give their suggestions on the changes required in the specification if any, and also review their QAP for compliance with the specification. There should not be any deviation in QAP from specification. If required, revised QAPs may be submitted to RDSO for approval.

15. CLW is also requested to give their suggestions on the changes required in the specification if any.

16. In the end of the meeting, DSE/TM thanked all the participants and requested them to take necessary steps to expedite the supply.

9.8.19

(P.K. Saraswat)
For Director General/Elect