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सं० ईएल/2.2.1

दिनांक 15.07.2011

मुख्य विद्युत अभियंता,

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- उत्तर रेलवे, बड़ौदा हाऊस, नई दिल्ली-110 001
- उत्तर मध्य रेलवे, सूबेदारगंज, ए-2, इलाहाबाद - 211 001
- पूर्व रेलवे, फेयर्ली प्लेस, कोलकाता-700 001
- पूर्व-मध्य रेलवे, हाजीपुर-844 101
- पूर्व तटीय रेलवे, चन्द्रशेखरपुर, भुवनेश्वर-751 023
- दक्षिण रेलवे, पार्क टाउन, चेन्नई-600 003
- दक्षिण मध्य रेलवे, रेल निलायम, सिकंदराबाद-500 371
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- पश्चिम रेलवे, चर्चगेट, मुम्बई - 400 020
- पश्चिम मध्य रेलवे, जबलपुर-482 001
- चित्तरंजन रेल इंजन कारखाना, चित्तरंजन -713 331 (पश्चिम बंगाल)

विषय: पेंटोग्राफ की जांच रिपोर्ट No. RDSO/2011/EL/IR/0147, Rev. '0' ।

संदर्भ: इस कार्यालय के दिनांक 15.07.2011 का समसंख्यक पत्र ।

उपरोक्त विषय पर इस कार्यालय के दिनांक 15.07.2011 का समसंख्यक पत्र आपके सूचना एवं आवश्यक कार्रवाई हेतु संलग्न है ।

संलग्नक : यथोक्त ।

प्रति : सचिव (विद्युत), रेलवे बोर्ड, रेल भवन, नई दिल्ली-110 001
(निदेशक विद्युत (चल स्टॉक) के ध्यानाकर्षण हेतु)

संलग्नक : यथोक्त ।

(ए के गोस्वामी)
कृते महा निदेशक / विद्युत

(ए के गोस्वामी)
कृते महा निदेशक / विद्युत

का/प्रति



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No. EL/2.2.1

Dated 15.07.2011

Chief Electrical Engineer,

- Central Railway, Mumbai CST-400 001.
- Northern Railway Baroda House, New Delhi - 110 001.
- North Central Railway, Block A-2, Subedar ganj, Allahabad- 211001
- Eastern Railway, Fairlie Place, Kolkata -700 001.
- East Central Railway, Hazipur-844101.
- East Coast Railway, Chandrashekharapur, Bhubaneshwar-751016.
- Southern Railway, Park Town, Chennai-600 003.
- South Central Railway, Secunderabad-500 371.
- South Eastern Railway, Garden Reach, Kolkata -700 043.
- South East Central Railway, Bilaspur-495004
- Western Railway, Churchgate, Mumbai-400 020.
- West Central Railway, Jabalpur-482001.
- Chittaranjan Locomotives Works, Chittaranjan - 713 331 (W.B.)

Sub: Investigation report No: RDSO/2011/EL/IR/0147, Rev. '0',
July 15, 2011 of pantograph.

Recently numbers of cases of pantograph entanglement have been reported by Railways. RDSO has carried out detailed study of the maintenance practices being followed by Railways, condition of pantograph on line and audit of manufacturers.

Based on above, a report has been prepared summarizing observations, maintenance/ manufacturing practices with recommendations to avoid their recurrence.

Railways are advised to ensure compliance of recommendations indicated in report enclosed herewith and also ensure compliance of MS/SMI/TC issued from time to time in this regard as summarized in annexure of the report.

RDSO's investigation report of pantographs No: RDSO/2011/EL/IR/0147, Rev. '0', July 15, 2011 is enclosed for your kind information and necessary action please.

(A K Goswami)

Encl: As above.

for Director General/Elect.

Copy to: Secretary (Electrical), Railway Board, Rail Bhawan, New Delhi-01
- for kind information please.

(Kind Attention: Shri Sumit Bhatnagar, DEE/RS/RB)

(A K Goswami)

Encl: As above.

for Director General/Elect.

O/c

GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS

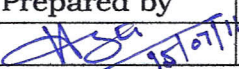
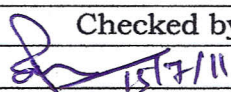
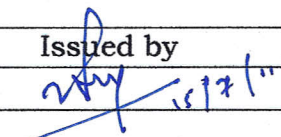


**INVESTIGATION REPORT OF
PANTOGRAPH
FOR
ELECTRIC LOCOMOTIVES**

Report No: RDSO/2011/EL/IR/0147, Rev. '0'

Issue Date /Year July 15, 2011

RESEARCH DESIGNS AND STANDARDS ORGANISATION
MANAK NAGAR, LUCKNOW-226011

Prepared by	Checked by	Issued by
 15/7/11	 15/7/11	 15/7/11

1.0 Introduction:

Recently numbers of cases of pantograph entanglement have been reported by Railways. RDSO has carried out detailed study of the maintenance practices being followed by Railways, condition of pantograph on line and audit of manufacturers. Based on above, remedial majors to avoid their recurrence have been suggested.

2.0 EQUIPMENT

- 2.1** The majority of pantographs presently in use on 25 KV AC Electric Locomotives, EMUs are of Faiveley type AM12 or similar design (85%) and AM92/IR-03H (12%).
- 2.2** The pantograph is subjected to shock and vibration transferred to it due to movement of the vehicle on which it is mounted. The factors which contribute to these shocks and vibrations on these pantographs are:
 - a) Interaction between the rail and the wheel
 - b) Interaction between loco body and bogie.
 - c) Interaction between OHE and pantograph
- 2.3** Further, the pantograph is also subjected to air drag on the bow assembly. The design of the pantograph is such as to cater to the above.

3.0 Analysis of pantograph entanglement cases:

Failure investigation of pantograph of loco 27035 of ELS/MGS, 27392 of ELS/ED & 31062 of ELS/AQ involved in entanglement with OHE on 02.06.2011 between Etawah – Kanpur section was carried out at ELS/CNB on 02/03.06.2011. Observations are as under:

- 3.1** The pantograph components which were found damaged/broken during entanglements are:
 - Plunger sticking/split pin broken.
 - Longitudinal tube breakage/crake. It came out from center swing ling.
 - Top mounting assembly breakage.
- 3.2** There was no old flaw on any component and fresh breakages were noticed on the various components of pantographs involved in entanglement.
- 3.3** Though the pantographs were completely damaged yet thorough investigation revealed that:
 - Pantograph horn of panto type AM-12 bearing sl.no 6164 fitted in 27392 of ELS/ED was not modified and its swivel angle was more than the specified angle as $7\pm 1^\circ$. RDSO vide Modification sheet No. ELRS/MS/0333, Rev. '0' dated 28.12.2004 restricted the swivel angle as $7\pm 1^\circ$.

- There was excessive play in plunger box assembly of panto bearing serial no 6164 of ELS/ED & serial no1708H of ELS/AQ which indicates that bushes have worn out & was not replaced during IOH and plunger box spring have not been replaced during AOH as recommended vide technical circular No. RDSO/2007/EL/TC/0094 (Rev.'0'), Dated 08.06.2007.
- However above factors cannot lead to panto entanglement.

4.0 Condition of pantographs on line:

Few pantographs were checked at ELS/CNB, Trip shed/CNB, ELS/MGS and ELS/JHS and observations are as under:

4.1 Loco no 22507 of ELS/HWH :

PT-1 of M/s SIL make bearing serial no 1772, manufacturing date 02/05 & PT-2 of M/s Contransis make bearing serial no. 0900, manufacturing date 04/00 were checked and following deviations are noticed.

- There was excessive play in lateral and longitudinal direction in plunger box of PT-1.
- Main spring was unevenly loaded as balancing beam is not perpendicular with central pedestal.
- Though additional spring catcher has been fitted but the welding portion was not cleaned and painted. Additional plates welded in lower arm have not been removed. Flexible shunt was in damaged condition in PT-2.

4.2 Loco no 23413 of ELS/TKD :

PT-1 of M/s SIL make bearing serial no 7000, 3/94 & PT-2 of M/s SIL make bearing serial no. 206 were checked and following deviations are noticed.

- Mounting insulator of Pantograph -2 was not properly seated.
- Visually observed the alignment of Panto Pan Assembly with longitude tube, Centre Swing Ling and base frame. It appeared that the pantograph is slightly mis- aligned.
- Excessive play in lateral and longitudinal direction in plunger box was noticed in PT-1.
- Swivel angle of Pantograph -2 was more than the specified limit.
- Additional spring catcher was not provided as per RDSO MS 0389 dated 31.08.2010.
- It was observed that grease is applied on plunger box instead of lubricating oil as recommended by RDSO vide MS no 198. Grease may cause jamming of plunger box.
- Top mounting fitting was not supported properly on the rubber stopper. It was shifted on one side.

4.3 Loco no 22722 of ELS/GZB:

PT-1 of M/s Contransys type IR-03 H bearing serial no 1546 H, manufacturing date 01/2004 & PT-2 of M/s Contransys type IR-03 H bearing serial no. 2426 H, manufacturing date 08/2007 were checked and following deviations are noticed.

- Plunger of panto-2 was not moving freely as it was slightly jammed. It was also observed that grease is applied on plunger box instead of lubricating oil and grease was also dried out, which might have obstructed free movement of plunger.
- Top mounting fitting was not supported properly on the rubber stopper.
- There was no gap between jaws of plunger box assembly of panto-2.
- Flexible shunt between upper arm and lower arm of panto-2 was in damaged condition.
- Heavy flash mark noticed at metalized carbon strip bracket of panto-2.
- It was also noticed that though the panto-1 & 2 was of M/s Contransys make type IR-03 H (high speed) but bow assembly and upper articulation of M/s SIL type AM-12 (freight loco) was fitted in above pantograph. RDSO vide Technical circular no. RDSO/2007/EL/TC/0094 has recommended only interchangeability of components of pantograph AM-12 or similar (AM12/IR 01/PAN01).

4.4 Loco no 27047 of ELS/MGS:

PT-1 of M/s SIL type AM-12 bearing serial no 521, & PT-2 of M/s SIL type AM-12 bearing serial no. 6724, manufacturing date 07/1993 were checked and following deviations are noticed.

- There was excessive play in lateral and longitudinal direction in plunger box of PT-1.
- Swivel angle of PT-1 was more than specified angle.
- Additional spring catcher was not provided as per RDSO MS 0389 dated 31.08.2010.

4.5 Loco no 27569 of ELS / JHS:

PT-1 of M/s Contransys bearing serial no 1607/04/04, & PT-2 of M/s SIL type AM-12 bearing serial no. SIL 9638, manufacturing date 08/2001 were checked and following deviations are noticed.

- Excessive play in laterally and longitudinal direction was observed in panto -2 . .

- Swivel angle in panto-2 was more than the specified value.

5.0 Summary :

Investigation of pantographs involved in entanglement and checking of condition of pantographs on line revealed few common maintenance lapses as given below:

- *There was excessive play in plunger box assembly which indicates that bushes have worn out & was not replaced during IOH as recommended vide technical circular No. RDSO/2007/EL/TC/0094 (Rev.'0'), Dated 08.06.2007.*
- *Regular replacement of plunger box spring in every AOH is not being ensured.*
- *With the induction of Metalized Carbon Strip, total weight of pan assembly has increased by 2.5 kg. To compensate additional weight of Metalized Carbon Strip, RDSO vide Modification sheet No. ELRS/MS/0333, Rev. '0' dated 28.12.2004 has advised to increase the stiffness from 0.35 kg/mm to $0.5 \pm 5\%$ kg/mm of spring to take care the additional weight of metalized carbon strip of AM-12 or similar design of Pantograph. The same is not being ensured.*
- *Panto horns were not modified as per RDSO MS/0333 as excessive swivel angle of panto pan are being observed.*

6.0 Maintenance practices of sheds:

Maintenance practices being followed by two sheds have been checked and observations are as under:

- i. Cleaning of inner surface of centre swing link and top mounting fittings has not been done by one shed. These are required to be done as during surface painting, paint may get stick inside the inner hollow portion which may result into poor contact between tinned surface of longitudinal tube and centre swing link /top mounting fitting.
- ii. Similarly prior to fixing of metalized Carbon strip proper cleaning on bow strap and inner surface of metalized carbon strip was not carried out for removal of paint .
- iii. It has also been observed that deflection of plunger support rod with 10 Kg weight is not checked by sheds.
- iv. Transverse rigidity test at a height of 1500 mm with a weight of 50 Kgs was conducted in one direction only in one shed. It is also observed in one of the shed that transverse rigidity test was not carried out. This test should be conducted on both the directions and deflection should not be more than 36 mm in each side.
- v. Split pins are not being procured from RDSO approved sources by few sheds.

- vi. Housing force (force to lift the Pan off the rubber stop) is not measured by the sheds.

7.0 Audit of manufacturers:

RDSO has also carried out technical audit of manufacturing process of AM-92 and IR-03 H pantograph of M/s SIL and M/s CCPL respectively. Deficiencies noticed and action plan is appended below:

7.1 Audit of M/s SIL for manufacturing process of AM-92 pantographs:

S N	RDSO Observation	Firm's Reply	Action Plan
1	Panto pan profile: Pan assembly is made up of CRCS 1.5mm thick sheet. In the straight portion of bow assembly the 'U' shaped end portion of the sheet has been folded to increase the strength whereas in the horn portion edge portions has not been folded. Hence horn portion is flimsy which may lead to variation of horn profile in service.	Firm accepted RDSO advice to review the horn/ bow design to make it more rigid and suitable for Metallized carbon strip. After reviewing the various types of requirement of the collector head/ bow, firm vide letter dated 12.07.2011 informed that horn design will be changed by making separate horn for each panto pan instead of existing one horn joining both the panto pan. Firm will submit the revised drawing during 3 rd week of July'11.	Firm to submit revised drawing for scrutiny & implementation. Firm to arrange wind tunnel test to validate the design changes.
2	Panto pan Horn radius: Gauge for checking of Panto pan profile was not available. Radius profile checking was shown by firm by making a profile on card board of radius 140mm instead of radius 138mm as specified.	Firm agreed to maintain the radius as 138mm and stated that it is being incorporated in the revised drawing.	Firm to submit revised drawing for scrutiny & implementation.
3	Plunger spring : The original pan design of the Pantograph type AM-92 was with steel strip. Subsequently with implementation of Metalized Carbon Strips, steel Strip has been replaced with Metalized Carbon Strips. With the induction of Metalized Carbon Strips the total weight of the pan assembly has increased approximate 2.5 kg. It is observed that the same suspension springs is being provided in	Firm agreed with RDSO observation that due to metalized carbon strips for collector head, weight has been increased . Firm stated that plunger spring of higher stiffness as $0.5 \pm 5\%$ kg/mm will be provided in AM-92 panto.	Firm to submit cut-in number along with action plan for replacement in existing panto.

	<p>metalized carbon strip as provided earlier with steel Strip. To compensate the additional weight on Bow assembly, the spring stiffness of bow suspension spring has not been revised by firm. This may be one of the factors responsible for poor current collection on higher speed.</p> <p>Sharp edges were also noticed on the end wearing strips of Bow assembly horn, which may cause the Panto entanglement.</p>	<p>Regarding the sharp edges on the end wearing strips of bow assembly, firm stated that it is taking more care in manufacturing and finishing stage so that there will be no sharp edges.</p>	
4	<p>Welding quality : Welding of Pan Assembly at different locations were not continuously welded, it appears as tag welded & the welded surfaces were not dressed properly.</p>	<p>Firm stated that it is taking more care such that the pan assembly is being continuously welded and the welded surfaces are being dressed properly.</p>	<p>Firm to offer one panto after implementing modification for RDSO's verification.</p>
5	<p>Painting : The surface finish after painting was found uneven and chipped. Thickness of painting could not be shown as the depth gauge was not available. CLW has also reported the poor quality of painting.</p>	<p>Firm stated that it has already introduced Polyurethane painting since April 2011 having pantograph Sl. No. 704 and there is no unevenness and no possibility of chipping off the paint. Firm has also arranged the instrument for checking thickness of painting.</p>	<p>Firm to arrange wind tunnel test to validate the design changes.</p>

7.2 Audit of manufacturing process of IR-03 H pantographs of M/s CCPL:

S N	RDSO Observation	Firm's Reply	Action Plan
1	<p>Panto Pan: Panto Pan Profile has been verified as per RDSO's drawing no. SKEL 3871. It is noticed that the panto horns being supplied to Railways are as per firms drawing No.C03H103 Rev. '1' dated 20.05.2005, which is neither approved by RDSO nor the horn profile mentioned in above drawing is in-conformity with the RDSO's drawing no. SKEL 3871 of bow profile of panto pan.</p>	<p>Firm stated that panto will henceforth be fitted with modified horn Aluminium die casting material LM-9 to BS1490/1988 as per their drawing No. C03H103 Rev. 2 which is in conformity with RDSO drawing No. SKEL 3871.</p> <p>Firm has confirmed that in their IR-03H Pantograph Spring</p>	<p>Firm confirmed that revised drawing of panto horn will be cut-in on regular basis from serial no B777H to be manufactured in Aug,2011.</p> <p>Firm stated that firm will carry out retro fitment from Nov,2011 in</p>

<p>instruction/ procedure available at working location.</p> <p>Bearing fitting: During fitment of bearing on lower arm bracket, it is observed that bearing is fitted by using hammer which is undesirable as it may damage the bearing and also cause its miss- alignment. It is advised to use Hydraulic Push & Pull device.</p> <p>Main spring anchoring hook fitment: It was observed that main raising anchoring hook was assembled by heating the end portion of spring by flame and there is no temperature control process, which may change mechanical property of the spring. Fitment may be carried out in controlled condition. There was no procedure/WI available at working location for fitment of anchoring hook.</p> <p>Calibration of jigs & fixtures: During verification of calibration and records of jigs and fixture, procedure for carrying out calibration for jigs and fixtures and records was not available with quality control department. In view of above, it is advised to incorporate the above procedure in QAP and submit revised QAP mentioning details of manufacturing process along with quality control points. Format for submission of QAP is enclosed.</p> <p>Facility of testing of springs: During verification of technical data, the facility of testing of springs, servo motor springs, bow suspension spring etc. was not available.</p>	<p>finish of Tinning.</p> <p>Appropriate tools for bearing fitment will be used as per RDSO advice.</p> <p>The firm has also confirmed that firm is importing Main Spring of proven design of M/s Hagens Fjedres A/S, Hagensvej, Den mark since decades being proven source on the basis of their guarantee and other test reports.</p> <p>Testing facility of spring is at their Kalyani unit. Firm has confirmed that firm will set up testing facility of spring at Baddi unit.</p>	
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8.0 Recommendations:

On the basis of failure analysis of entangled pantographs and shortcoming noticed in maintenance practices, it is recommended that following measures are to be taken to improve the reliability of pantographs:

- i. Plunger box spring is to be replaced by new one with stiffness of $0.5 \pm 5\%$ kg/mm, if not replaced earlier (RDSO MS/0333).
- ii. To ensure regular replacement of Plunger box spring during every AOH (RDSO /TC/0094).
- iii. To ensure that deflection of plunger support rod should less than 25 mm with 10 Kg weight (RDSO MS/0333).
- iv. All the split pins and fasteners may be procured from RDSO approved sources (RDSO /TC/0094) & Split pins should not be re-used.
- v. Centre swing link and bushes of plunger box are to be replaced in every IOH.
- vi. Swivel angle of panto pan is to be restricted as $7 \pm 1^\circ$ (RDSO MS/0333).
- vii. To conduct transverse rigidity test at a height of 1500 mm with a weight of 50 Kgs in both the directions and deflection should not be more than 36mm in each side.
- viii. To develop proper fixture to carry out transverse rigidity test.
- ix. While fixing longitudinal tube on centre swing link it is necessary that after full tightening of bolts, gap of around 2 mm is to be ensured between jaws of centre swing link. It will ensure proper fitment & tightness of longitudinal tube with swing link. Similarly gap of around 2 mm is required to be maintained between longitudinal tube and top mounting fitting jaws.
- x. Railways reported that existing spring catcher was not able to prevent the spring to come in contact with loco roof in case of breakage. RDSO vide Modification sheet No. 0398 recommended for provision of additional spring catcher which will not allow the broken portion of spring to fly off. The same may be implemented and MS plate welded on lower arm if any (local modification done by few sheds) may be removed as it may affect total up thrust force on panto pan.
- xi. Proper cleaning of inner surface of Centre swing link, top mounting fittings and bow strap for removal of paint to be done.
- xii. To ensure alignment of middle articulation assembly, longitudinal tube and centre of panto pan bow assembly.
- xiii. The force to lift the Pan off the rubber stop should be 15 kg (minimum). If housing force is less than specified value, it may

lead to vibration of pantograph which is in locked down condition (non-working pantograph).

- xiv. To ensure lubrication schedule as recommended in RDSO SMI No. RDSO/ELRS/SMI/198.
- xv. Proper fitment of Bi metal plate at flexible shunt location is to be ensured so that aluminum surface touches with aluminum alloy part and copper side come in contact with the shunt.
- xvi. Proper dressing of strip is to be done for any sharp edge / groove on pantograph.
- xvii. As a preventive measure against insulator flashover during foggy/misty atmospheric conditions, silicone grease application on the external faces of the insulators is to be adopted. Thickness of coat 1.6mm approximately, to be applied by hand / brush or by air spray.
- xviii. To ensure implementation of various modifications sheets, SMIs & TCs issued by RDSO from time to time as summarized in annexure.

Annexure to Report RDSO/2011/EL/IR/0147, Rev. '0'

List of MS/SMI/TC circulated by RDSO

- Modification Sheet No. ELRS/MS/WAG5/242 for provision of a rubber bush inside the open end of the longitudinal tube to prevent seepage of water entry into the tube resulting in rusting and consequent breakage.
- Modification Sheet No. ELRS/MS/0333, Rev. '0' with Amendment-1 on the subject "Standardization of Panto Pan Assembly of AM-12 or similar Pantograph for Electric Locomotive and EMUs" to restrict swivel/ measurement of degree of freedom of collector head of the Panto Pan and standardize the horn and support rod. Moreover, due to increase in weight of Panto Pan with Metallised Carbon strips, the plunger springs have to be compensated by increasing the stiffness.
- SMI No. RDSO/ELRS/SMI/75 on the subject ensuring proper raising and lowering of pantograph type AM12, to ensure lowering of Pantograph with out jerk by providing damping towards the end of the motion while the pantograph is being lowered.
- SMI No. RDSO/ELRS/SMI/192 on subject periodic maintenance / checks for pantograph AM-12 type and similar design to balance and correct horizontality of the pantograph during every IC.
- SMI No. RDSO/ELRS/SMI/198 on subject lubrication schedule for improving reliability of pantograph AM-12 and similar design to avoid breakage / cracks of moving parts due to inadequate lubrication of moving parts.
- Technical circular No. RDSO/2007/EL/TC/0094 (Rev. '0') on subject to change the component of AM-12 and similar pantographs during AOH / IOH & POH, to avoid fatigue failures of components.
- Modification Sheet No. RDSO/ELRS/EL/MS/0389 Rev. '0' Dated 31.08.2010 on subject, "Provision of additional spring catcher to prevent the main raising spring to fly off in case of breakage of spring of AM-12 or similar design pantographs used on electric locomotives and EMU/ MEMU."
- RDSO have advised Railways to procure spare component as AOH/IOH/POH kits only from RDSO's approved sources.