**Government of India**
**(Ministry of Railways)**
**Research Designs & Standards Organization**
**Manak Nagar, Lucknow-226 011**

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# SPECIAL MAINTENANCE INSTRUCTIONS NO.RDSO/ELRS/SMI/0237 (Rev.'0')

## 1.0 Title:

Modified layout of cables from TFP to RSI blocks to avoid chances of on line failure/ fire in conventional Electric Locomotives.

## 2.0 Brief History:

Cases of overheating and burning of insulation of power cable from TFP to RSI block in electric locomotives have been reported by the Railways. The cables have been found burnt/damaged at the places of clamping/cleats. The insulation and sheath of the E-beam/ Elastomeric cables were found with pressed marks of clamps and on removing the insulation, discoloration of the conductor has been noticed. The failed sample of cable has been got tested at school of Materials Science and Engg. Bengal Engg. & Science University, Shibpur, Howrah and it has been concluded that the temperature of failed cable has reached to the level of more than 600 deg.C and burnt the insulation and sheathing of cable without propagating the fire to the adjacent layers of cable .In the existing cable layout, four cables of 240/300 $mm^2$ thin walled E-beam/Elastomeric cables are connected in parallel from each terminal of transformer secondary winding to RSI block and they are supposed to equally share the load during starting and run. On measuring the current carried by each cable, it has been observed that load distribution amongst the four cables is not uniform and varying from cable to cable. A detailed investigation has been carried out on no. of locos of ELS CNB, LGD and MGS including measurement of load current loco working coaching trains in Mughalsarai- Dhanbad section of ECR. The pattern of current distribution, as a result of testing is enclosed in **Annexure-I**.

From the above trial/ testing, it is seen that the failure of Elastomeric/E-beam cables are primarily on account of the followings:

a) One of the cable out of four carries abnormally high current and the cables do not share equal current and draws unbalanced current.

b) Use of flat metallic cleats and metallic bolts causing eddy current and over tightening of cleats & tight wrapping of cables with rubber sheet have caused

inadequate heat dissipation/cooling of cables, which have resulted into overheating / burning of insulation.

c) Cables are laid in very congested manner in which all types of cables are bunched/clubbed together without having any inter spacing between them. In this types of arrangement the current carrying capacity of cables do derate maximum and cannot carry rated current.

Further, investigation/studies have been carried out on the above aspects of cable failure and a brief on them is given below:

a) As per Siemens hand book on power cables and their application, for laying of cables, if two bus bar systems are coupled by a number of single core cables in parallel, the inductance of each of the parallel cables should be equal as for as is possible to ensure equal current load sharing between the cables. This inductance is most unbalanced when cables of one phase are grouped and laid side by side next to one another. This arrangement exists in conventional locomotives due to space constraint. The cables do not share equal load current as can be seen from Annexure-II. Keeping this in view trials have been conducted with different layout of cables from TFP to RSI block on the locos based at ELS/CNB & ELS/ LGD and the pattern of measured current with modified layout is enclosed at Annexure-II. It is seen that the current is more or less evenly distributed with the modified cable layout arrangement of WAG7 electric locomotives as shown in **Annexure-III**.

b) The thickness of insulation & sheath over the conductor of 240 $mm^2$ cable is1.10 mm & 1.30 mm in case of E-beam cable whereas in elastomeric cable of 300 $mm^2$ it is 3.5 mm & 2.2 mm respectively. During investigation it has been noticed that the cables found burnt/damaged at the places where they were clamped under the footplate. The insulation/sheath of the cables were found with pressed marks of clamps. The insulation/sheath were found charred and the discoloration/over heating noticed in few upper strands of conductors at clamping locations. Over tightening of cleats, inadequate cooling in the trench & unbalanced current are attributable to overheating , discoloration of conductor and resulting failures of cables.

c) The catalogue of M/s Huber+Suhner, Siemens & Studer, the manufacturers of cables have laid down the criteria for laying of single/multi-layered/bunched cables and given their corresponding current carrying capacity. If cables are laid free in air, having proper inter spacing they can carry rated current as per carrying capacity of cables. If the said cable are laid in conduit/pipe i.e. /covered trench of locos, the deration/reduction factor comes in to picture. For example if 08 cables are grouped the deration/reduction factor is 0.52. Therefore, the 240 $mm^2$ E-beam cable rated for 789 Amps carrying capacity can carry 395 Amps in the circumstances explained above. The capacity of cable will go further down in case of increase in ambient temperature. Since the present arrangement of cable laying in the Tap changer locomotive can not

be modified because of space constraint, the other option would be to provide higher size of cable that is 300 $mm^2$ e-beam cable in place of existing 240 $mm^2$ and modified layout as shown in Annexure III .

## 3.0 Object:

To balance the load current in the cables from TFP to RSI blocks with modified layout of cables and improved/modified cleating/ clamping arrangement to avoid overheating & burning of cables /fire in the locomotives.

## 4.0 Instructions:

The following instruction should be follows:

4.1 **For CLW:**

a) The CLW to cut-in with modified cable layout as shown in annexure-III, for WAP4 & WAG7 class of locomotives.

b) CLW to cut-in cables from TFP to RSI blocks with 300mm2 e-beam cables in place of existing 240 mm2.

c) CLW should plan to replace existing slotted channel meant for clamping arrangement with non-metallic SRBGF cleats with half round and to be procured from CLW's approved sources for this item. Bolts holding the cleats should also be insulated to avoid circulation of eddy current, if any, in the vicinity of the clamping arrangement.

**4.2 For Railways:**

a) Railways should carry out cyclic check on all cables from TFP to RSI block on all tap changer locomotives and if any deep impressions of pressing with visible damage of insulation on these cables at the points of clamps are observed, the cables are required to be changed with 300mm2 cable as per modified cable layout as in annexure III. The modification on such loco should be taken on priority.

b) As a result of cyclic check even if no damage of insulation on the cables are observed, the modified cable layout as given in annexure III may be carried out during IOH/POH with 300 $mm^2$ cable. However, for the locomotive fitted with 3460/3900 KVA transformer, the modified cable layout arrangement shall also have to be carried out by using existing elastomeric cables only.

c) The sheds should also use non-metallic SRBGF cleats of appropriate size procured from CLW's approved sources as brought out in para 4.1 (c)

above. Bolts holding the cleats should also be insulated to avoid circulation of eddy current, if any, in the vicinity of the clamping arrangement.

## 5.0 Instruction Drawing:

Modified cable layout as shown in Annexure-III.

## 6.0 Application:

Conventional Electric Locos class WAP4 & WAG7
Cyclic check on WAM4/WAG5 class of locomotives.

## 7.0 Agency of Implementation:

-Chitranjan Locomotive Works, Chittranjan for new locos WAP4/WAG7..
-All electric loco sheds and POH workshops for WAM4,WAG5,WAP4,WAG7 etc.

## 8.0 Distribution:

As per mailing list enclosed.

Encl: Annexure I, II & III

(Hari Narayan)
for Director General (Elect.)

**ANNEXURE-I**

## Pattern of current distribution with different trials/testing

| SN | Loco No. | Current drawn by Cables (Amps) | | | | Remarks |
|---|---|---|---|---|---|---|
| | | A | B | C | D | |
| 1 | 22545 | 543 (39 °C) | 348 (37.5 °C) | 346 (42 °C) | 1363 (47.5 °C) | -Between MGS-DHN section. -Current as well as temp. measured from the cables of a3 bushings during foot plating. -TKN-GTD section of MGS-DHN |
| | | 174 (42.4 °C) | 96 (40 °C) | 198 (44 °C) | 530 (51 °C) | |
| | | 307 (39.2 °C) | 228 (44.2 °C) | 520 (47.7 °C) | 1334 (54 °C) | |
| | | 168 (44.3 °C) | 85 (44 °C) | 194 (47 °C) | 508 (53.5 °C) | |
| | | 389 | 494 | 545 | 1345 | |
| | | 640 (45.2 °C) | 520 (44.3 °C) | 820 (47.5 °C) | 1560 (55 °C) | |
| | | 600 (47 °C) | 490 (47 °C) | 810 (46 °C) | 1639 (58 °C) | |
| | | 540 (46 °C) | 460 (44.05 °C) | 742 (48.5 °C) | 1366 (61 °C) | |
| | | 560 (47 °C) | 440 (45 °C) | 720 (50 °C) | 1440 (63 °C) | |
| | | 512 (49 °C) | 440 (47 °C) | 710 (52 °C) | 1270 (66 °C) | |
| | | 336 (51.5 °C) | 301 (42°C) | 522 (54°C) | 1054 (68°C) | |
| 2 | 21338 | 807 | 670 | 440 | 550 | Between GAQ-PSE section of MGS-DOS On 628 DN |
| | | 850 | 724 | 465 | 585 | |
| | | 270 | 225 | 145 | 190 | |
| | | 930 | 805 | 530 | 645 | |
| | | 290 | 250 | 160 | 225 | |
| | | 825 | 700 | 470 | 587 | |
| | | 810 | 690 | 445 | 560 | |
| 3 | 21387 (Measurement at ELS/MGS) | 195 | 150 | 210 | 237 | Ist Notch |
| | | 410 | 310 | 440 | 495 | 2nd Notch |
| | | 618 | 468 | 625 | 715 | 3rd Notch |
| 4 | 27443 (Measurement at ELS/CNB | 304 | 495 | 327 | 176 | 2nd Notch |

| 5 | 27731 (Measurement at ELS/LGD) | AG24 | BG24 | CG24 | DG24 | AG23 | BG23 | CG23 | DG23 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 385 | 258 | 380 | 870 | 900 | 415 | 244 | 354 | 2nd Notch |

**Annexure-II**

## Measured Current with different Layout of cables

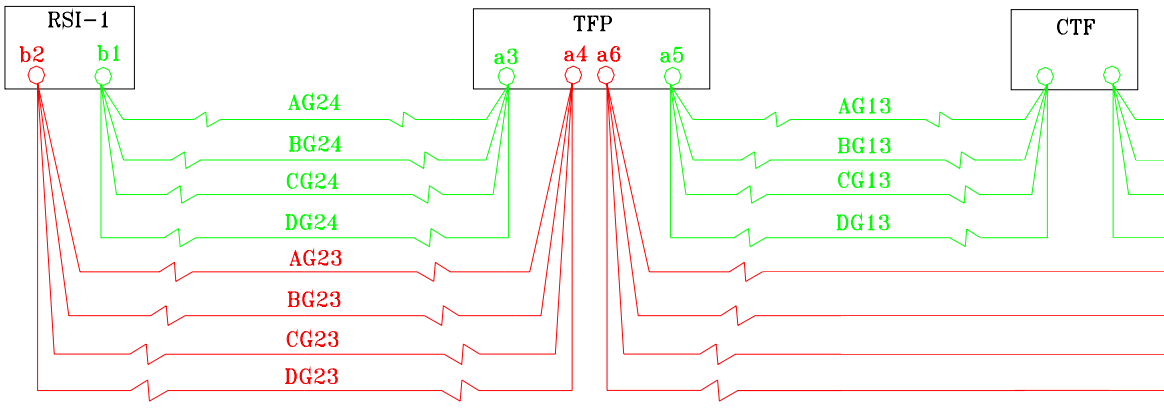
| SN | Loco No. | Current drawn by Cables (Amps) | | | | Remarks |
|---|---|---|---|---|---|---|
| | | A | B | C | D | |
| 1 | 27423 (Measurement at ELS/CNB) | 304 | 495 | 327 | 176 | 2nd Notch |
| | | 271 | 220 | 421 | 360 | 2nd Notch, when two cables crossed each other |
| | | 252 | 263 | 382 | 286 | 2nd Notch, when cables run parallel |
| | | 274 | 294 | 331 | 332 | 2nd Notch, when cables twisted each other |
| | | 318 | 464 | 314 | 168 | 2nd Notch with normal arrangement |
| | | 285 | 401 | 267 | 317 | 2nd Notch when cables B & D interchanged |
| | | 346 | 345 | 318 | 217 | 2nd Notch with single loop in all cables |

## Measured current with Modified layout of cables as shown in Annexure-III

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 2 | Loco no. 27731 (Measurement at ELS/LGD) | AG24 | BG24 | CG24 | DG24 | AG23 | BG23 | CG23 | DG23 | |
| | | 234 | 231 | 293 | 417 | 417 | 271 | 248 | 296 | 2nd Notch |
| | | AG13 | BG13 | CG13 | DG13 | AG12 | BG12 | CG12 | DG12 | 2nd Notch |
| | | 291 | 387 | 267 | 237 | 267 | 320 | 288 | 277 | |
| 3 | Loco no. 27247 (ELS/CNB) | AG24 | BG24 | CG24 | DG24 | AG23 | BG23 | CG23 | DG23 | 18th Notch Measurement taken between Kanpur-Fatehpur Section of NCR |
| | | 160 | 105 | 126 | 138 | 102 | 101 | 99 | 97 | |

| | | | | |
|---|---|---|---|---|

# EXISTING CABLE LAYOUT IN ELECTRIC




# MODIFIED CABLE LAYOUT OF