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सत्यमेव
जयते

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

No. EL/3.2.172 **Dated: 03.10.2012**

Modification Sheet No. RDSO/2012/ELRS/MS/0414(Rev.`0')

Title:

Modified interferences between TM assembly components, in order to ensure adequate interference between assembly components of traction motor type HS15250A.

1. **Object** :

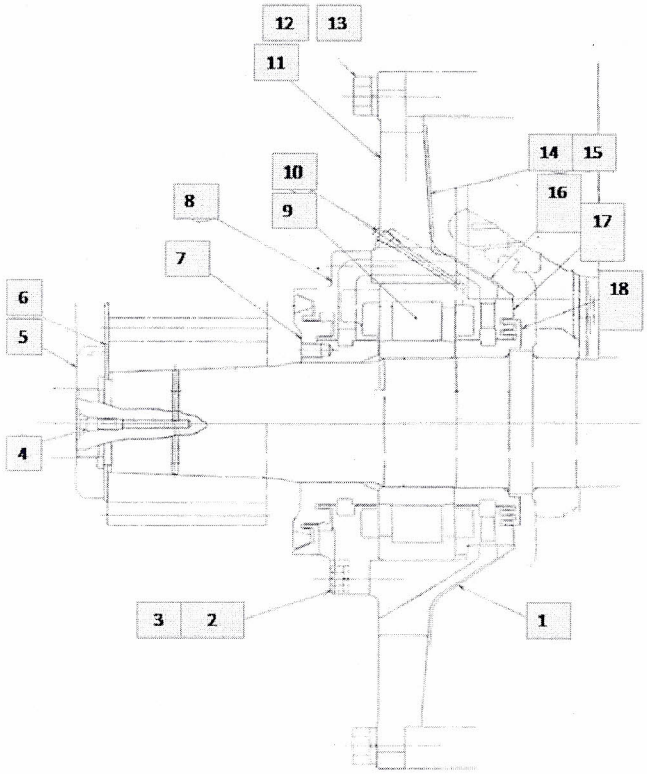
To obtain adequate interference between associated TM assembly components of traction motors type HS15250A by correcting dimensions and machining tolerances of vital assembly components in order to have proper fitment of these components to prevent failures of traction motors.

2. **Existing arrangement :**

The failures on traction motors bearings and its assembly components have taken place on traction motor type HS15250A mainly on account of the following defects.

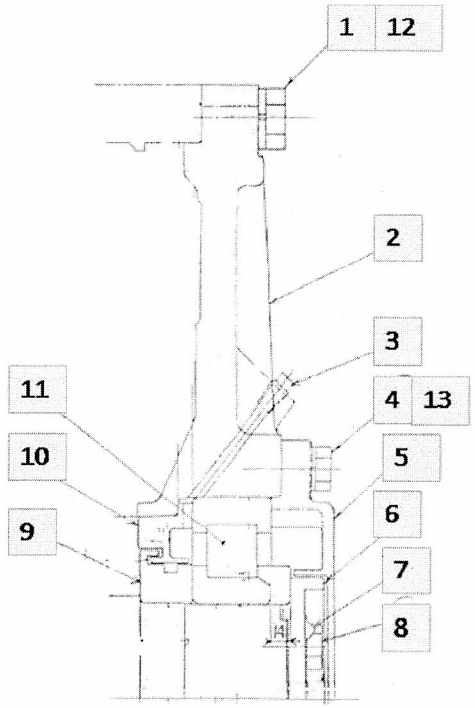
i. Looseness of Inner bearing stopper (CE) inside CE bearing bracket (End shield)
ii. Looseness of CE bearing inside CE bearing bracket (End shield).
iii. Looseness of Inner bearing stopper (PE) inside PE bearing bracket (End shield).
iv. Looseness of PE bearing inside PE bearing bracket (End shield).

RDSO carried out the in depth analysis of these problems. A detailed study on concentricity & parallelism of stators, appropriate fits and tolerances for end/bearing components TM type HS15250A has been carried out. Manufacturers of bearings, traction motors complete and vital components were also involved in this study. A sketch of the traction motor with bearing arrangement has been given below for better appreciation:



S. No.	Name of Part
1.	COVER
2.	SPRING WASHER M16
3.	HEX.HD.BOLT M16L45
4.	RUBBER PLUG
5.	PINION NUT
6.	LOCK WASHER
7.	DEFLECTOR
8.	BEARING COVER
9.	ROLLER BEARING
10.	PLUG R1/4 (PT1/4)
11.	BEARING BRACKET
12.	HEX.HD.BOLT M24L55
13.	SPRING WASHER M24
14.	NET OF BEARING BRACKET
15.	NET OF BEARING BRACKET
16.	COVER
17.	BEARING COVER
18.	INNER BEARING STOPPER

Fig-1:PE Bearing Assembly



Item No.	Part Name
1.	HEX HEAD BOLT M20l70
2.	BEARING BRACKET
3.	PLUG R1/4(PT1/4)
4.	HEX HEAD BOLT M16L45
5.	BEARING COVER
6.	OUTER BEARING STOPPER
7.	LOCK WASHER
8.	HEX HEAD BOLT M16L35
9.	INNER BEARING STOPPER
10.	BEARING COVER
11.	ROLLER BEARING
12.	SPRING WASHER M20
13.	SPRING WASHER M6

Fig-2:CE Bearing Assembly

Dimensions and tolerances given as per Hitachi's TOT Documents/CLW's Drawings have been studied in detail. The combinations of the dimensions for four extreme possibilities have been calculated. Following Table A gives the type of fits available in two mating components in extreme conditions:

Table A : Existing Dimensions

Table A 1: CE Inner Bearing Stopper(10T.806.919 Rev.1) and Armature Shaft(10Q.738-278 Rev G)

ID of Inner Bearing Stopper		Outer dia of Shaft		Interference / Clearance; all negative values are interferences and positive are clearances.			
A =Min.	B =Max.	C =Min.	D= Max.	E=A-C	F=A-D	G=B-C	H=B-D
121.000	121.012	121.015	121.040	-0.015	-0.040	-0.003	-0.028

Table A 2:PE Inner bearing Stopper (10T.806.918 Alt.4) and Armature Shaft (10Q.738-278 Rev G)

ID of Inner Bearing Stopper		Outer dia of Shaft		Interference / Clearance; all negative values are interferences and positive are clearances.			
A =Min.	B =Max.	C =Min.	D= Max.	E=A-C	F=A-D	G=B-C	H=B-D
151.000	151.040	151.027	151.052	-0.027	-0.052	0.013	-0.012

Table A 3: CE Bearing Bracket (10Q.750.246 Alt. N) and Outer Racer of CE Bearing :NH3244(SKF& FAG make)

ID of CE Bearing Bracket		OD of Outer Racerof Bearing		Interference / Clearance; all negative values are interferences and positive are clearances.			
A =Min.	B =Max.	C =Min.	D= Max.	E=A-C	F=A-D	G=B-C	H=B-D
259.959	259.991	259.975	260.000	-0.016	-0.041	0.016	-0.009

Table A 4: PE Bearing Bracket (10Q.750.245 Alt. M) and Outer Racer of PE Bearing :NU330 (SKF, FAG & NSK make)

ID of PE Bearing Bracket		OD of Outer Racer of Bearing		Interference / Clearance; all negative values are interferences and positive are clearances.			
A =Min.	B =Max.	C =Min.	D= Max.	E=A-C	F=A-D	G=B-C	H=B-D
319.954	319.99	319.972	320.000	-0.018	-0.046	0.018	-0.010

Table A 5: Shaft Dia (10Q.738.278 rev G)and Inner Racer of Bearings PE:NU330(SKF, FAG & NSK make): NO CHANGE is required

ID of Inner Racer		Shaft dia		Interference / Clearance; all negative values are interferences and positive are clearances.			
A =Min.	B =Max.	C =Min.	D= Max.	E=A-C	F=A-D	G=B-C	H=B-D
149.982	150	150.043	150.068	-0.061	-0.086	-0.043	-0.068

Table A 6.1: Shaft Dia (10Q.738-278 Rev G) and Inner Racer of Bearing CE :NH324 (SKF & FAG make) : NO CHANGE is required

ID of Inner Racer		Shaft Dia		Interference / Clearance; all negative values are interferences and positive are clearances.			
A =Min.	B =Max.	C =Min.	D= Max.	E=A-C	F=A-D	G=B-C	H=B-D
119.985	120	120.037	120.059	-0.052	-0.074	-0.037	-0.059

Table A 6.2 : (10Q.738.278 Rev G) and Inner Racer of Bearings CE :NH324 (NSK make): NO CHANGE is required

ID of Inner Racer		Shaft Dia.		Interference / Clearance; all negative values are interferences and positive are clearances.			
A =Min.	B =Max.	C =Min.	D= Max.	E=A-C	F=A-D	G=B-C	H=B-D
119.981	120	120.037	120.059	-0.056	-0.078	-0.037	-0.059

Table A 7: Deflector (10R823-234 Alt. 2) and Shaft Dia (10Q.738-278 rev G) PE: <u>NO CHANGE is required</u>							
ID of Deflector		Shaft Dia.		Interference / Clearance; all negative values are interferences and positive are clearances.			
A =Min.	B =Max.	C =Min.	D= Max.	E=A-C	F=A-D	G=B-C	H=B-D
140	140.04	140.092	140.117	-0.092	-0.117	-0.052	-0.077
Table A 8.1: Inner Bearing Cover (10Q750-259 Alt H fig-2) towards armature and Bearing Bracket CE (10Q750-246 Alt-N)							
Inner Dia of Bearing Bracket for Inner Bearing Cover		Outer Dia of Inner Bearing Cover		Interference / Clearance; all negative values are interferences and positive are clearances.			
A =Min.	B =Max.	C =Min.	D= Max.	E=A-C	F=A-D	G=B-C	H=B-D
234.976	235.005	235.004	235.033	-0.028	-0.057	0.001	-0.028
Table A 8.2 : Outer Bearing Cover (10Q750-259 Alt H fig-1) away from armature and Bearing Bracket CE(10Q750-246 Alt-N) : fitted with bolts							
Inner Dia of Bearing Bracket for Outer Bearing Cover		Outer Dia of outer Bearing Cover		Interference / Clearance; all negative values are interferences and positive are clearances.			
A =Min.	B =Max.	C =Min.	D= Max.	E=A-C	F=A-D	G=B-C	H=B-D
259.959	259.993	259.9	259.92	0.059	0.039	0.093	0.073
Table A 9.1: Inner Bearing Cover(10Q750-258 Alt -6 , fig-2) and Bearing Bracket PE(10Q750-245 Alt-M)							
Inner Dia of Bearing Bracket for Inner Bearing Cover		Outer Dia of Inner Bearing Cover		E=A-C	F=A-D	G=B-C	H=B-D
A =Min.	B =Max.	C =Min.	D= Max.	Interference / Clearance; all negative values are interferences and positive are clearances.			
284.973	285.005	285.004	285.036	-0.031	-0.063	0.001	-0.031
Table A 9.2: Outer Bearing Cover(10Q750-258 Alt -6 fig-1) and Bearing Bracket PE(10Q750-245 Alt-M) : fitted with bolts: <u>NO CHANGE is required</u>							
ID of Bearing Bracket		OD of Outer Bearing Cover		Interference / Clearance; all negative values are interferences and positive are clearances.			
A =Min.	B =Max.	C =Min.	D= Max.	E=A-C	F=A-D	G=B-C	H=B-D
319.954	319.99	319.900	319.920	0.054	0.034	0.090	0.070

From the above table, it can be inferred that existing dimensions of components both on PE and CE sides are such that

1. Over the range of machining tolerances, outer racer of bearings and bearing brackets have got fits from clearance to interference, i.e. at certain combinations of dimensions within specified tolerances; there is possibility of rotation of bearing in the bearing racket due to the clearance.
2. Similarly, because of existing tolerances of inner bearing labyrinth and its seating in end frame allow clearance to interference fits.
3. Inner racers of bearings and shaft also should have only interference fits.

4. Similarly, other sets of components, which should be interference fits, there manufacturing tolerances allow clearances.

But in IR applications , at CLW and in sheds/workshops , where there is no measurement of interferences of mating surfaces during assembly , if no positive interference to the tune of 10 micron is given , there is possibilities of excessive higher clearances, as explained in the table A with certain combinations of existing dimensions. If this is the case the possibility for the rotation of the outer race in its housing is remote. However, in the circumstances where clearances are as high as 40 micron as given in **Table A**, because of vibration in the traction motors, the outer race may start creeping or doing a stick-slip rotation. This will cause severe overheating resulting in total evaporation of lubricant and eventual bearing failure.

The inner races of bearings are usually fitted with an interference fit on their shafts. The extent of this may vary with size, speed, load, vibration, operating temperature, etc. It is necessary to ensure that the inner race does not slip and rotate on the shaft, or even creep around because this may soon develop into rotation. If such rotation occurs sliding friction will generate heat and inner race temperature will rise, causing it to expand. Slipping may increase and bearing clearance will get reduced. Lubrication of active surfaces will be affected; surface flaws will develop and get worse. This all will lead to bearing failure.

The same logic is applicable to other components, also.

Study reveals that the standards machining tolerances as per fits and dimensions has led to such situation, where we have got interference to clearance fits over the complete range of machining tolerances of two mating components. In traction motor applications, where the dimensions are customized, in order to provide necessary fits, tolerance bands are also required to be customized.

However, certain components like Outer Bearing Cover (10Q750-259 Alt H ,fig-1) away from armature and Bearing Bracket (10Q750-246 Alt-N) on commutator end side are loose fit and they are fitted with bots. Same is true for Outer Bearing Cover(10Q750-258 ,Alt 6 fig-1) and Bearing Bracket (10Q750-245 Alt-M) on pinion end side. Since clearances are adequate and no change in these dimensions is required.

3. Modified arrangement:

3.1. Maximum interferences have been left untouched as these have been derived by the designer based on various factors. Manufacturing tolerances of bearings can't be revised as these are as per ISO. Customized bearings can be manufactured with added cost. Dimensions of armature shafts are also left un touched in order to avoid machining. Only minimum interferences have been ensured as 10 micron.

3.2. Dimensions of bearings and shaft have also been left untouched.

3.3. Minimum 10 micron of interference fit at room temperature is ideal between bearing bracket and outer racers, considering the possibility of rise in temperature during operation, which will increase the interference. Higher interference at room temperature will get increased at operating temperature, results in reduced radial clearances of the bearings will remain within specified limits.

3.4. Better interference fits between labyrinths and bearing brackets(end frames) can be achieved as there is no restrictions imposed on account of bearing operating clearance, as discussed above.

3.5. While keeping the dimensions of bearings and shaft unchanged and leaving maximum interference untouched, a major constraint on achieving interference within ideal limits is accuracy of CNC machines. Closer tolerances can be achieved on more accurate and precision machine tools, of course at higher cost. A trade off has been done to revise dimensions of labyrinths and end frames .The change in these dimensions are of the order of few microns , which are not going to affect the process of manufacturing and affect their cost of machining.

3.6. After six months long intense deliberations and debates with manufacturers of bearings, mechanical components and OEM of traction motors , followed by extensive literature survey and trying various combinations of dimensions , following changes are recommended in the respective drawings:

Table B : Modified Dimensions

Table B 1: CE Inner Bearing Stopper(10T.806.919 Rev.1) and Armature Shaft(10Q.738-278 Rev G)

ID of Inner Bearing Stopper		Outer dia of Shaft		Interference / Clearance; all negative values are interferences and positive are clearances.			
A =Min.	B =Max.	C =Min.	D= Max.	E=A-C	F=A-D	G=B-C	H=B-D
120.985	121.005	121.015	121.040	-0.030	-0.055	-0.010	-0.035

Table B2:PE Inner Stopper (10T.806.918 Alt.4) and Armature Shaft (10Q.738-278 Rev G)

ID of Inner Bearing Stopper		Outer dia of Shaft		Interference / Clearance; all negative values are interferences and positive are clearances.			
A =Min.	B =Max.	C =Min.	D= Max.	E=A-C	F=A-D	G=B-C	H=B-D
151.000	151.015	151.027	151.052	-0.027	-0.052	-0.012	-0.037

Table B3: CE Bearing Bracket (10Q.750.246 Alt.N) and Outer Racer of CE Bearing :NJ324, (SKF & FAG make)

ID of CE Bearing Bracket		OD of Outer Racerof Bearing		Interference / Clearance; all negative values are interferences and positive are clearances.			
A =Min.	B =Max.	C =Min.	D= Max.	E=A-C	F=A-D	G=B-C	H=B-D
259.949	259.965	259.975	260.000	-0.026	-0.051	-0.010	-0.035

Table B4: PE Bearing Bracket (10Q.750.245 Alt. M) and Outer Racer of PE Bearing :NU330(SKF & FAG make)

ID of PE Bearing Bracket		OD of Outer Racer of Bearing		Interference / Clearance; all negative values are interferences and positive are clearances.			
A =Min.	B =Max.	C =Min.	D= Max.	E=A-C	F=A-D	G=B-C	H=B-D
319.944	319.962	319.972	320.000	-0.028	-0.056	-0.010	-0.038

Table B5: Shaft Dia (10Q.738.278 Rev G)and Inner Racer of Bearings PE :NU330(SKF & FAG make: **NO CHANGE is required**

ID of Inner Racer		Shaft dia		Interference / Clearance; all negative values are interferences and positive are clearances.			
A =Min.	B =Max.	C =Min.	D= Max.	E=A-C	F=A-D	G=B-C	H=B-D
149.982	150	150.043	150.068	-0.061	-0.086	-0.043	-0.068

Table B 6.1: Shaft Dia (10Q.738-278 Rev G) and Inner Racer of Bearing CE : NH324 (SKF & FAG make) : NO CHANGE is required							
ID of Inner Racer		Shaft Dia		Interference / Clearance; all negative values are interferences and positive are clearances.			
A =Min.	B =Max.	C =Min.	D= Max.	E=A-C	F=A-D	G=B-C	H=B-D
119.985	120	120.037	120.059	-0.052	-0.074	-0.037	-0.059
Table B 6.2 : (10Q.738.278 rev G) and Inner Racer of Bearings CE : NH324(NSK make): NO CHANGE is required							
ID of Inner Racer		Shaft Dia.		Interference / Clearance; all negative values are interferences and positive are clearances.			
A =Min.	B =Max.	C =Min.	D= Max.	E=A-C	F=A-D	G=B-C	H=B-D
119.981	120	120.037	120.059	-0.056	-0.078	-0.037	-0.059
Table B 7: Deflector (10R823-234 Alt. 2) and Shaft Dia (10Q.738-278 Rev G) PE: NO CHANGE is required							
ID of **Deflector**		Shaft Dia.		Interference / Clearance; all negative values are interferences and positive are clearances.			
A =Min.	B =Max.	C =Min.	D= Max.	E=A-C	F=A-D	G=B-C	H=B-D
140	140.04	140.092	140.117	-0.092	-0.117	-0.052	-0.077
Table B 8.1: Inner Bearing Cover (10Q750-259 Alt H fig-2) towards armature and Bearing Bracket CE (10Q750-246 Alt-N)							
Inner Dia of Bearing Bracket for Inner Bearing Cover		Outer Dia of Inner Bearing Cover		Interference / Clearance; all negative values are interferences and positive are clearances.			
A =Min.	B =Max.	C =Min.	D= Max.	E=A-C	F=A-D	G=B-C	H=B-D
234.976	234.994	235.004	235.033	-0.028	-0.057	-0.010	-0.039
Table B 8.2 : Outer Bearing Cover (10Q750-259 Alt H fig-1) away from armature and Bearing Bracket CE(10Q750-246 Alt-N) : fitted with bolts : NO CHANGE is required							
Inner Dia of Bearing Bracket for Outer Bearing Cover		Outer Dia of outer Bearing Cover		Interference / Clearance; all negative values are interferences and positive are clearances.			
A =Min.	B =Max.	C =Min.	D= Max.	E=A-C	F=A-D	G=B-C	H=B-D
259.959	259.993	259.9	259.92	0.059	0.039	0.093	0.073
Table B 9.1: Inner Bearing Cover(10Q750-258 Alt -6 fig-2) and Bearing Bracket PE(10Q750-245 Alt-M)							
Inner Dia of Bearing Bracket for Inner Bearing Cover		Outer Dia of Inner Bearing Cover		E=A-C	F=A-D	G=B-C	H=B-D
A =Min.	B =Max.	C =Min.	D= Max.	Interference / Clearance; all negative values are interferences and positive are clearances.			
284.973	285.005	285.015	285.036	-0.042	-0.063	-0.010	-0.031
Table B 9.2: Outer Bearing Cover(10Q750-258 Alt-6 fig-1) and Bearing Bracket PE(10Q750-245 Alt-M) : fitted with bolts: NO CHANGE is required							
ID of Bearing Bracket		OD of Outer Bearing Cover		Interference / Clearance; all negative values are interferences and positive are clearances.			
A =Min.	B =Max.	C =Min.	D= Max.	E=A-C	F=A-D	G=B-C	H=B-D
319.954	319.99	319.900	319.920	0.054	0.034	0.090	0.070

Note : All components shall be manufactured with mean dimensions.

It is therefore recommended to modify the dimensions as recommended in above tables.

4. **Application to class of locomotives**

   Traction motors type HS15250A used in WAG5/WAG7/WAP4 class of Locomotives

5. **Material Required**
   Nil (Only Dimensions modified)
6. **Material rendered surplus** :
   Nil
7. **Modification Drawing No.** :

   CLW shall make necessary changes in respective drawings mentioned in tables above

8. **Periodicity of Implementation** :

   (1) All new traction motors type HS15250A.
   (2) During overhauling, if components are replaced.
   (3) In case of any repair/dis-assembly of TM is undertaken.

9. **Agency of Implementation** :

   Traction Motor Manufactures& Repairers, Workshops and Electric Loco Sheds.

10. **Distribution:**

    As per enclosed list.

Ganesh 03/10/11

(Ganesh)
for Director General (Elec.)