

**BHARAT HEAVY ELECTRICALS LIMITED
ELECTROPORCELAINS DIVISION
BANGALORE 560 012**



PURCHASING SPECIFICATION

REF : EL-PS-36-00103
REV : 06
DATE : 27.04.2015
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CARBON STEEL / LOW ALLOY CARBON STEEL FORGINGS

- 1.0 GENERAL**
This specification governs the requirements of Carbon steel/ Low alloy carbon steel forgings.
- 2.0 SCOPE**
All Insulator fittings like Ball pins, Ball fittings, and Insulator Hooks.
- 3.0 CONDITION OF DELIVERY**
The Forgings shall be supplied in forged/ forged & heat treated / forged, heat treated and galvanized / forged, heat treated galvanized and machined as per Purchase order terms.
- 4.0 DIMENSIONS & TOLERANCES**
Shall confirm to relevant Forging drawings as referred in Purchase Order
- 5.0 MANUFACTURE**
- 5.1. FORGING**
Forging shall be manufactured from steel produced by reputed manufacturers, preferably sources approved by end customer and or BHEL. Steel should be purchased with proper identification of heat number and it will be ensured that materials from different heats are bunched separately and tagged/sealed with heat number identification.
It is suggested to have centerless grinding to remove the entire surface layer to remove surface discontinuities. Forging process for materials of new heat batches should begin with forgeability test to assess steel forgeability as well as this input will be used to set process parameters.
The amount of hot working and finishing temperature shall be such as to ensure complete soundness, adequate uniformity of structure and mechanical properties. Forgings shall be smoothly fettled by grinding/finishing.
- NOTE:**
- 5.1.1. Forging produced from steel belonging to different melts shall not be mixed together at any stage of the process.
- 5.1.2. When components are supplied in forged condition, they shall be segregated with reference to the original melt and the original melt reference shall be furnished by the supplier.
- 5.2. FINISHING/GRINDING**
Finishing or grinding shall be carried out to remove burr/fins/parting line of the die. Grinders with profile to match the product profile requirement are to be used. Grinding should be kept at minimum level for ensure that the gauge and dimensional requirements are maintained.

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5.3. HEAT TREATMENT

Forgings shall be normalized or normalized and subsequently hardened and tempered as indicated in the drawing. Following parameters are recommended for normalizing and hardening & tempering the forgings.

Process	Temperature	Cooling medium	Remarks
Normalizing	840 – 870 °C	Air	---
Hardening	840 – 870 °C	Oil / Water	Quenched hardness to be HRC 43 min.
Tempering	550 – 600 °C	Air	---

Note:

- Mechanical properties specified being binding; the recommended temperature may be altered. Record of actual heat treatment schedule follow for each batch shall be maintained and furnished for scrutiny to BHEL.
- Re-normalizing and re-hardening if warranted can be taken up twice only but with the approval of BHEL – EPD.
- Components belonging to different melts shall not be combined during heat treatment.
- When components are supplied in heat-treated condition they shall be segregated with reference to heat treatment batch and the supplier shall furnish the original melt

5.4. SHOT BLASTING AND MACHINING

Heat treated forgings are to be shot blasted to remove scales formed during heat treatment. The time of shot blast shall be set by trial. Shot size and type should be selected to ensure a finished surface completely clean from scales and also with minimum possible surface roughness.

5.5. GALVANISING

The forged and heat treated components shall finally be galvanized by hot dip galvanizing in accordance with IS 2629. Purity of zinc used for galvanizing shall not be less than 99.95% by weight. For detailed galvanizing requirement, specification for galvanizing.....to be followed.

5.6. FULLY FINISHING

Final machining/Fully finish operation are to be done on the galvanized forged components as specified in the drawing.

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6.0 DIFFERENT INSPECTION, TESTS AND SAMPLING SIZE:

The following table indicates various inspection and tests and their corresponding sampling plan for forgings supplied in black condition

Sl. No.	Type of inspection / test	SAMPLING PLAN	
		Vendor	BHEL
1	Visual Inspection	100%	IS:2500(Part I) inspection level II, AQL 0.65 %
2	Gauge Check	100%	IS:2500(Part I) inspection level II, AQL 0.65 %
3	Magnetic Particle Inspection	100%	IS:2500(Part I) inspection level II, AQL 0.25 %
4	Dimensional check	2 Nos per 1000 or part thereof	
5	Chemical analysis	2 sample / heat / lot	
6	Non-metallic inclusion rating	2 No's per lot of 10000 Nos. or part thereof	
7	*Tensile properties (UTS, YS/0.2% PS, % Elong)	4 test bar per batch of Heat Treatment	
8	*Component Mech. Strength	4 Nos. per batch of Heat Treatment	
9	Hardness	4 Nos. per batch of Heat Treatment	
10	Grain Size	1 Nos. per batch of Heat Treatment	
11	Macro etch Test (Grain Flow)	One no. per 2500 No's or part thereof	

- * i) In case of failure of any tensile test specimen of any heat treatment batch 'specimen, retest' can be taken up on double additional samples (8 samples) pertaining to the same batch and all the additional samples should pass.
ii) In case a test bar breaks out of the gauge length 'repeat test' can be taken up on a replacement test bar, also in the event of any defect traceable to the testing conditions or of unsoundness of the test specimen.

For forgings supplied in galvanized/machined and galvanized/fully finished condition, following inspection/tests to be carried out along with the above parameters on the samples as indicated below:

Sl. No.	Type of inspection / test	SAMPLING PLAN	
		Vendor	By BHEL
12	Visual Inspection	100%	IS:2500(Part I) inspection level II, AQL 0.65 %
13	Dimensional check	2 Nos per 1000 or part thereof	
14	Uniformity of Zinc Coating	3 Nos per 1000 or part thereof	
15	Mass of Zinc Coating	3 Nos per 1000 or part thereof	
16	Adhesion Test	5 Nos per 5000 or part thereof	
17	Purity of Zinc used	1 sample per ingot	

Visual inspection pertaining to Galvanizing defects to be noted separately.

Dimensional checks to be carried out especially on zinc sleeved components.

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7.0 DIFFERENT INSPECTION AND TESTINGS:

7.1. VISUAL INSPECTION (FREEDOM FROM DEFECTS):

Forging shall be free from defects such as cracks, flakes, mismatch, laps and folds, fins and burrs, forged in scales/scale impressions and dents etc Components after heat treatments shall be free from scale and cracks. Galvanized components shall be free from defects such as those mentioned in IS: 2629. Vendor to carry out 100% visual inspection.

7.2. GAUGE CHECK

Gauge check will be done with calibrated gauges of suitable designation as per drawing. For Galvanized components gauges as per IEC 60120 to be used, whereas gauges as per BHEL drawing to be used for forgings in black condition or machined condition as applicable in drawing. Vendor to carry out 100% gauge check

7.3. MAGNETIC PARTICLE INSPECTION

Magnetic Particle Inspection shall be carried out before galvanizing (in black condition), but after heat treatment in accordance with the EPD procedure EL-TP-011, on each and every component (on 100 % basis): Norms of acceptance shall also be as per EL-TP-011.

7.4. DIMENSIONAL CHECK

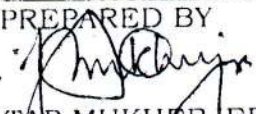
All the parameters mentioned in the drawing are to be measured and reported by the manufacturer as per the sampling scheme mentioned in section 6.0. BHEL also will carry out dimensional check to the same extent. Manufacturer to obtain detailed dimensional report from BHEL during sample approval stage.

7.5. CHEMICAL COMPOSITION

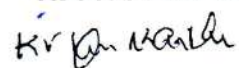
The chemical analysis on forgings manufactured from Steel grade 080M40 grade of BS:970 shall conform to the following.

Constituent	Percentage by weight		
	Minimum	Maximum	Tolerance (±)
Carbon	0.36	0.44	0.03
Silicon	0.10	0.40	0.03
Manganese	0.60	1.00	0.04
Sulphur	--	0.050	0.008
Phosphorous	--	0.050	0.008

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The chemical analysis on forgings manufactured from Steel grade 709M40 grade of BS:970 shall conform to the following.

Constituent	Percentage by weight		
	Minimum	Maximum	Tolerance (±)
Carbon	0.36	0.44	0.03
Silicon	0.10	0.40	0.03
Manganese	0.70	1.00	0.04
Sulphur	--	0.040	0.008
Phosphorous	--	0.035	0.008
Chromium	0.90	1.20	0.04
Molybdenum	0.25	0.35	0.02

Note: For all ratings, original mill certificate for the forging stock employed shall be furnished for scrutiny. Manufacturer also shall carry out chemical analysis at third party lab (NABL accredited) and shall submit the report. There should be a correlation between these reports

7.6. STEEL CLEANLINESS TEST (NON-METALLIC INCLUSION RATING)

A longitudinal section of the component when assessed by microscopic method and employing reference charts in accordance with ASTM designation E 45-81 (Alternatively IS 4163 may be employed) shall reveal a rating not worse than class 2 in either heavy (thick) or thin series

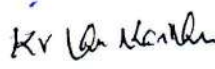
7.7. TENSILE PROPERTIES

Applicable to components in both the heat-treated and galvanized conditions. When tested in accordance with IS: 1608 the test piece shall show the following properties. The Tensile Mechanical Properties of forgings manufactured from Steel grade 080M40 grade of BS:970 shall conform to the following.

Condition	Tensile strength (Minimum)	Yield Strength (Minimum)	% Elongation on 5.65 x S ₀ (Minimum)
Value for "Normalized condition"	540 N/mm ² (55 Kg/mm ²)	275 N/mm ² (28 Kg/mm ²)	16
Value for "Normalized & subsequently hardened and tempered condition" (for ruling section up to & including 20mm Φ)	700 N/mm ² (71 Kg/mm ²)	460 N/mm ² (47 Kg/mm ²)	14
Value for "Normalized & subsequently hardened and tempered condition" (for ruling section over 20mm Φ)	620 N/mm ² (63 Kg/mm ²)	380 N/mm ² (39 Kg/mm ²)	14

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The Tensile Mechanical Properties of forgings manufactured from Steel grade 709M40 grade of BS:970 shall conform to the following.

Condition	Tensile strength (Minimum)	0.2% Proof Stress (Minimum)	% Elongation on 5.65 x S ₀ (Minimum)
Normalized & subsequently hardened and tempered condition (for ruling section over 20mm Φ upto 65 mm)	925 N/mm ² (94 Kg/mm ²)	740 N/mm ² (75.5 Kg/mm ²)	12

7.8. HARDNESS

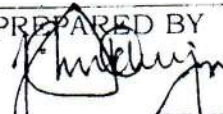
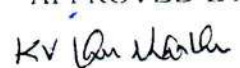
The Hardness of forgings manufactured from Steel grade 080M40 grade of BS:970 shall conform to the following.

Condition	Hardness (BHN)
Value for "Normalized condition"	150 Minimum
Value for "Normalized & subsequently hardened and tempered condition" (for ruling section upto & including 20mm Φ)	190 Minimum
Value for "Normalized & subsequently hardened and tempered condition" (for ruling section over 20mm Φ)	170 Minimum

The Hardness of forgings manufactured from Steel grade 709M40 grade of BS:970 shall conform to the following.

Condition	Hardness (BHN)
Normalized & subsequently hardened and tempered condition	269 Minimum

Hardness can be measured in HRB and HRC scale and can be converted in equivalent BHN scale

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7.9. COMPONENT MECHANICAL STRENGTH TEST

The component shall be subjected to a tensile load equal to 67 % of the rated load which shall be attained by increasing the load at a steady rate. The load shall be held for 5 minutes and then removed. There should be no visual deformation.

Again the component shall be subjected to tensile load and the load shall be increased at a steady rate, till failure and the load at failure recorded. This load at failure shall not be less than the rated load / load indicated in drawing of the component.

The failure load also may be stopped once the component withstands the minimum failure load indicated in the drawing. This is applicable for components with high failure load requirement (300kN and above).

7.10. GRAIN SIZE

A sample cross section of the component when duly prepared for and examined under a microscope shall reveal a uniform Tempered martensite structure in case the component is in normalized & subsequently in hardened and tempered condition. Ferrite pearlite structure in case the component is in normalized condition only.

Grain size shall be No. 5 or above as per IS 2853. (Alternative reference standard: ASTM E 112-80).

7.11. MACROETCH TEST (GRAIN FLOW)

A longitudinal section of the component when macro etch shall reveal a satisfactory pattern of grain flow in accordance with the external profile of the component

8.0 TEST FOR ZINC COATING (APPLICABLE TO GALVANISED COMPONENTS)

Tests for uniformity of coating and Mass of zinc coating shall be done on galvanized components in accordance with EPD Test procedure EL-TP-012. The component should with stand minimum 6 dips and mass of zinc coating shall be 610 gm/m² minimum. In case of requirement of higher values for these characteristics the same shall be indicated in the order. Details of test for galvanizing inspection, Purchase specification reference..... Shall be referred along with IS: 2629 and IS: 2633.

9.0 INSPECTION AT VENDOR'S PREMISES

BHEL's representative shall have free access to all parts of Vendors' premises at all times when work on the contract is being executed. The vendor shall offer BHEL's representative all reasonable testing / inspection facilities to convince the latter that the part is being manufactured and furnished in accordance with this specification.

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10.0 TEST CERTIFICATE

The vendor shall submit test certificate in their relevant formats containing name of the firm and following information's

- Purchase order no. & Date
- Purchase specification no. & Revision status
- Delivery Challan / Invoice No. & Date
- Copy of the Heat No. TC of Original Manufacturer
- Heat treatment No's (with correlation to quantity) and identification of bags
- Results of various test called for in this specification.

11.0 LOT SIZE

Lot size at different operational stages are defined as follows:

Sl. No.	Stage	Lot size
1	After forging (before heat treatment)	Components belonging to the same melt shall be considered as belonging to one single lot.
2	After heat treatment (before galvanizing)	Components belonging to the batch of heat treatment shall be considered belonging to one single lot.
3	After galvanizing	Components shall be grouped and offered in lots of size not exceeding 1000 Nos. If Supply is being made in fully finished condition, correlation between galvanized lot and heat no. to be maintained.

12.0 PACKING AND MARKING

Forging shall be packed in gunny bags or in wooden boxes to prevent damage during transit. Supplies shall be made in as mentioned above. Each lot shall be legibly identified with the following information

- Supplier's Name
- Invoice No. / Date
- Quantity

It is suggested to have different identification color code on bags for different type forgings

13.0 REJECTION

Forgings not conforming to the above stipulations shall be rejected. Also in the event of forgings proving defective in the course of any further processing the same shall be rejected not withstanding any previous certification of satisfactory testing and/or inspection. Rework on rejected forgings are to be taken up with consent of BHEL. Forgings will be rejected and are to be destroyed by the vendor if rejected because of non-compliance of chemical composition (7.5).

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REVISION RECORD

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DATE	REVISION NO.	DETAILS
17.04.1995	00	Original issue
10.05.2003	01	Sampling plan for various Type of tests / inspection are modified.
03.05.2006	02	Hand Corrections made due to typing error are regularized
03.05.2007	03	Specification for metals parts for insulators of rating more than 300kN is added.
08.12.2008	04	Change of sample size from '4 No's per batch of 1000 No's to '4 No's per heat treatment batch', the word malleablizing was replaced with more appropriate term 'heat treatment'
16.08.2010	05	Specification for metal parts for insulators of rating more than 300kN is modified in line with customer (POWERGRID) requirement. Sampling scheme for continuous is added.
27.04.2015	06	Restructured issue with more detailing.

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REV : 01

DATE : 29.08.2006

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TECHNICAL REQUIREMENT PERTAINING TO HOT DIP GALVANISING OF FERROUS COMPONENTS

1. The components are to be hot dip galvanised in accordance with IS:2629/1985 (Refer Table-3 : General Galvanising procedure in line with IS:2629/1985 for ferrous components)
2. The Zinc used for hot dip galvanising should be of grade Zn 99.95 as per IS:209/1979
3. Adequate facilities should be available to ensure process control as per IS:2629/1985 and product testing as detailed at Clause '6'
4. The records of the following parameters checked as per the periodicity indicated against each of them to be maintained by sub-contractor and submitted for scrutiny to BHEL when asked for :

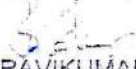
	Parameter		Peroidicty
4.1	Acid concentration	Of the pickling bath	At an interval of 4 hours
4.2	Specific gravity		
4.3	iron content		
4.4	Specific gravity of the flux solution		
4.5	Temperature of galvanising bath		At an interval of half an hour
4.6	Purity of zinc ingot		Every consignment purchased by vendor (One sample)

5. Galvanised components shall be inspected for freedom from surface defects (100% Visual Inspection) such as those mentioned in IS:2629/1985. Dimensions of component are altered by galvanising. Hence, dimensional inspection is necessary after galvanising (for critical dimensions only). Inspection of profiles / contours may call for suitable gauges (100% Gauge check) and the same gauges shall be provided by BHEL

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6. Further, coating characteristics described below shall be tested for, on the galvanised products.

	Coating characteristic	Acceptance norms	No. of samples to be tested per lot of 1000 or part thereof
6a)	Uniformity of Zinc coating (Copper sulphate dip test as per IS:2633/1986)	As indicated in Table 1	As indicated in table 2 below
6b)	Mass of Zinc coating as per IS:6745/1972	As indicated in Table 1 below	As indicated in table 2 below
6c)	Adhesion of coating (knife test as per IS:2629/1985)	The coating shall not peel off	2

TABLE 1: ACCEPTANCE NORM FOR UNIFORMITY OF ZINC COATING & MASS OF ZINC COATING TESTS

Acceptance Norm	Under Category				
Characteristic	A	B	C	D	E
Uniformity of zinc coating (no. of one minute dips to be withstood)	6	8	6	6	6
Mass of zinc coating (gm/m ²)	610	650	650	800	1150

TABLE 2 : SAMPLING PLAN FOR UNIFORMITY OF ZINC COATING & MASS OF ZINC COATING TESTS

Acceptance Norm	Under Category				
Characteristic	A	B	C	D	E
Uniformity of zinc coating	3	9	6	5	6
Mass of zinc coating	3	3*	3	6	6

* Test coupons also may be processed for determining mass of zinc coating whenever provided.

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7. Items of a particular type with a total quantity in number of continuous production not exceeding 1,000 shall constitute a lot. Number of samples indicated refers only to normal conditions of galvanising process. It is liable to be enhanced from time to time at the instance of performance proving not satisfactory.

8. In case of socket caps bituminous paint must be applied inside the bell portion uniformly. The bituminous paint used should have following properties as per IS:158/1981

Sl. No.	Test Description	Acceptance Norms
1.	Visual Inspection	Glossy & Smooth Coating
2.	Specific gravity	0.84
3.	Viscosity (For B4 Fort Cup)	> 60 sec.
4.	Drying Time	8 Hours Maximum

(In case bituminous paint application, asked at particular portion of Metal parts other than socket caps the same will be applicable.)

9. The sub-contractor shall satisfy himself first as to the quality of the lot for carrying out the inspection / tests detailed above. Lots shall be offered for inspection to BHEL, along with reports of inspection / tests carried out by the sub-contractor. Lot offered without prior inspection / testing by the sub-contractor shall not be entertained.
10. Prior intimation in advance of atleast one day in case of local parties or one week in case of outstation parties should be given for arranging inspection. All necessary documents like, purchase order and records maintained should be furnished for raising necessary inspection documents.
11. At the time of lot offering for BHEL inspection, internal test reports comprising details like date of galvanising, results of various tests on products and also process parameters mentioned earlier shall be produced to BHEL personnel for verification.
12. Surveillance checks to be carried out at least once in 6 months irrespective of whether supplies have been effected or not, as long as the vendor is on the PMD listing.
13. Rejection
Components not conforming to the above stipulations shall be rejected. However, re-galvanising of the components may be taken up with due approval of BHEL in case of rejection.

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Table 3 : GENERAL GALVANISING PROCEDURE IN LINE WITH IS:2629/1985 FOR FERROUS COMPONENTS

STEPS	OPERATION DESCRIPTION
Step - 1	If oil, Grease or paint is/are present on the component surface, cleaning of the components using NaOH solution (Concentration approximately 10 to 15 kg per 100 Liter) or suitable solution may be used. Note: In general Components for galvanising are shot blasted and are free from oil, Grease or paint.
Step - 2	Pickling - To clean the scale (due to aging after shot blasting) on the metal surface dilute Sulphuric acid to be used followed by water rinse. Then any of the following solution may be used for pickling - Dilute Technical Grade Hydrochloric acid (Concentration 100 to 150 gm/Liter) should be used with suitable inhibitor. - Dilute Technical Grade Sulphuric acid (Concentration approximately 100 to 150 gm/Liter) should be used with suitable inhibitor. This Sulphuric acid solution at elevated temperature (60° C to 80° C) gives better results. Brushing / Scrubbing may be resorted if necessary.
Step - 3	Rinsing - After pickling, the component should be rinsed using fresh water (preferably running water)
*Step - 4	Fluxing - Any one of the following process may be adopted Dry process- Strong solution of Zinc Ammonium Chloride (in general concentration is 200 to 400 gm Zinc Ammonium Chloride per liter) is prepared and some wetting agent also must be added in the flux solution. The components are dipped in the solution. The temperature may be around 80° C. Wet process- A deep flux cover is used on the zinc bath. The component immerses through the flux layer with or without prior fluxing.
*Step - 5	Pre-heating Dry process- Component should be dried on hot mesh or an air oven. Pre-heating of component shall be undertaken by taking care of non-decomposition of flux. Wet process- Component drying is not considered essential

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Step - 6 Galvanising

Quality of Zinc – Purity of zinc used for Galvanising should be greater than 99.95 %

Immersion in molten Zinc bath – Bath temperature may vary from 440° C to 460° C and the working temperature is 450° C. Dross should be allowed to settle at the bottom of the zinc bath and should not disturb more than necessary during dipping operation. The component should be immersed as rapidly as possible.

Component will be left in the bath until it reaches the temperature of the bath, which is usually indicated by the stopping of the boiling action.

Withdrawal – The rate of withdrawal determines the thickness of the unalloyed zinc layer left on the component. The rate of withdrawal should be controlled so that zinc drains freely from the surface. While component withdrawal access zinc removal should be taken care by shaking / vibrating the component.

Water quenching – After withdrawal, the galvanised component should be immediately dipped into water to allow the coating to set and prevent the components from sticking to each other. Water used in quenching should be clean (preferably running water)

Step - 7 Post treatment – To avoid the "white rust" and "wet storage stain" post treatment like Chromating should be done. Chromating solution contains 1% Sodium dichromate and 0.5% sulphuric acid solution. The solution is kept at room temperature and its temperature should never be more than 65° C while usage. The galvanised components are dipped into the chromating solution after the galvanising and water quenching operations.

* In place of Fluxing and Preheating processes hot flux solution to be used particularly for socket caps and similar design casting and forging. In this process component after rinsing must be dipped in hot flux solution (Concentration 200 to 400 gm Zinc Ammonium Chloride per liter at Temperature around 80° C) for some time and taken out and kept for drying. Dried component to be taken for galvanising.

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