



PLANT PURCHASING SPECIFICATION BHOPAL

BP 19393

REV NO. 03

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SUPERSEDES
BP 19393 Rev.02

3% CHROMIUM-MOLYBDENUM NITRIDING STEEL FORGINGS

1. GENERAL:

This specification governs the quality of 3% Chromium Molybdenum Nitriding Steel forgings.

2. APPLICATION:

For manufacture of nitrided gear wheels and pinions.

3. CONDITION OF DELIVERY;

Heat treated, rough machined & stress relieved.

4. COMPLIANCE WITH NATIONAL STANDARDS:

The material shall comply with chemical composition of IS:4367 - 1991 Reaffirmed 2001 Gr.25 Cr 13 Mo6, & meet the other requirements of this specification.

5. DIMENSIONS & TOLERANCES:

Dimensions & tolerances shall be as specified on the order or drawing referred to on the order.

6. MANUFACTURE:

The steel shall be made by an electric process and shall be fully killed. Sufficient discard shall be made from the top and bottom of the ingot to ensure freedom from piping and harmful segregation. During forging the cross-sectional area shall be reduced by a factor of at least 2½ and the axis of the forging shall coincide with the axis of the ingot.

7. HEAT TREATMENT:

Forgings shall be oil hardened from 890-940°C and tempered at not less than 580°C. Hardening by water quenching may be used subject to agreement with the BHEL, Bhopal.

8. FREEDOM FROM DEFECTS:

Forgings shall be rough machined and shall be sound, free from cracks, harmful inclusions and other harmful defects.

Revision :

Reviewed & Brought upto dated

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Rev. 03

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9. CHEMICAL COMPOSITION:

The ladle analysis of the steel and the permissible variation in the composition of the forgings from the ladle analysis shall be as follows :

Element	% Minimum	% Maximum	Permissible Variation %
Carbon	0.20	0.30	± 0.02
Silicon	0.10	0.35	± 0.03
Manganese	0.40	0.70	± 0.04
Nickel	-	0.30	± 0.03
Chromium	2.90	3.40	± 0.11
Molybdenum	0.45	0.65	± 0.04
Sulphur	0.015	0.030	± 0.005
Phosphorus	-	0.030	± 0.005

* Note : When the steel is Al killed total Aluminium content shall be between 0.02 to 0.05 percent.

10. TEST SAMPLES:

Test pieces shall be machined from the forgings after heat treatment and then blank nitrided at 500-520°C for a minimum of 72 hours.

Tensile and Impact test pieces shall be taken from the positions and in the directions indicated on the drawing supplied with the order; these will vary with the size and type of components.

Where the diameter over the teeth are 200 mm or less, test pieces shall be cut longitudinally from the outer part of the end of the forging. Where the diameter exceeds 200 mm they shall be cut in a transverse or circumferential direction adjacent to the portion where the teeth will be cut. If the shape of the forging makes this impossible, test pieces may be taken from the ends of journals. They shall be longitudinal where the finished diameter of the journal is 200 mm or less and transverse above this size. In the case of pinion forgings longer than 1.2 metres excluding journals, test pieces shall be taken from each end. In the case of wheels, where the finished diameter exceeds 2.4 metres or the weight exceeds 3 tonnes, two sets of test pieces shall be taken from diametrically opposite positions.

11. MECHANICAL PROPERTIES:

11.1 Tensile : When tested to IS:1608 / EN 10002 Part 1 the test pieces shall show the following properties.

Tensile Strength - 925 - 1020 N/mm².

0.2% Proof Stress - 740 N/mm² Minimum.

Elongation on 5.65 $\sqrt{S_0}$ gauge Length	}	Longitudinal - 13% Minimum Transverse - 10% Minimum
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Note : Reduction of Area shall be recorded for information purposes.

11.2 Impact:

At the supplier's discretion either a Charpy-V-Notch Impact Test to IS:1757 or Izod, Impact Test to IS:1598 shall be conducted.

The test piece shall show the following minimum values.

Direction of test piece	Izod Value Joules	Charpy V-Notch Joules
Longitudinal	38	32
Transverse	19	15

11.3 Hardness (Test to IS:1500)

Each forging shall be Brinell hardness tested using, where possible, a 10 mm ball and a load of 3000kg. In all cases tests shall be made on the face where teeth will be cut. A minimum of three tests shall be carried out, equally spaced round the circumference and the maximum circumferential distance between impressions shall be 1000 mm. When the width of the face exceeds 500 mm, tests shall be made at each side of the face. In this case the impressions at one end, when viewed axially, shall be mid-way between those at the other end.

The hardness shall be in the range 269-311 HB & the difference between the highest and lowest values shall not exceed 30 HB.

12. INSPECTION AND TESTING AT SUPPLIER'S WORKS:

The BHEL's representative shall have all reasonable facilities afforded to him at any time by the Supplier to satisfy himself that the material is being furnished in accordance with this specification.


Tests shall be witnessed at Supplier's works by the BHEL's Inspector and/or Customers or Consultant's representatives and the Supplier shall notify those concerned when the material is available for inspection and testing.

12.1 Sulphur Prints :

Prints from pinions shall be taken from all regions of the circumference and end faces where teeth will be cut. In the case of wheels and rims, prints shall be taken from one end face, or from both end faces where more than one gear blank will be taken from one forging. Additional sulphur prints or macroetching may be called for.

12.2 Ultrasonic Tests : (BS EN 10228)

Ultrasonic tests shall be carried out on the rough machined forgings to ensure that the region from which the teeth will be cut is free from harmful defects and in the case of pinions that the whole forging is sound and free from harmful defects.

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The tooth portion of the forging shall be tested with a 4 MHz twin crystal near surface compressional wave probe and shall be free from defects in the tooth depth.

The bulk of the forging shall be examined and shall be free from internal cracks and porosity.

Inclusions occurring in isolation with reflections not exceeding 6 mm dia. as measured (a) by equivalent flat bottom hole reflection (or AVG) and (b) by probe movement will be tolerated provided they are not closer than 25 mm to the root of the teeth, the finished outside diameters or the finished machined bore. Details or clusters of smaller inclusions should be submitted for consideration, of BHEL.

13. TEST CERTIFICATE:

Three copies of test certificate shall be supplied, unless otherwise specified on the order in the recommended test certificate proforma annexed to this specification (Annexure - I).

In addition, the supplier shall ensure to enclose one copy of the test certificate alongwith their despatch documents to facilitate quick clearance of the material.

The test certificate shall bear the following information.

BHEL Reference

BP 19393 : 3% Chromium, Molybdenum Nitriding Steel Forgings.
Rev.03.

Our Order No.

Serial No. (P.F.).

Supplier's References:

Name


Identification No.

Cast No.

Details of steel making, ingot dimensions, forging process, heat treatment Cycle charts.

Results of tests :

Results of the Chemical analysis and all Mechanical tests, Sulphur prints, Non-Destructive tests specified in this specification.

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14. PACKING AND MARKING:

Forgings shall be suitably packed to prevent corrosion and damage during transit. Machined surfaces shall be properly protected with anticorrosive compounds.

Each package or forging (when supplied separately) shall be legibly marked with following information.

BP 19393: 3% Chromium, Molybdenum Nitriding Steel Forgings.

Serial No. (PF)

Supplier's tests No.

BHEL Inspector's Acceptance Stamp.

15. REJECTION AND REPLACEMENT:

In the event of any forging proving defective in the course of preparation, machining testing or erection such forging shall be rejected, notwithstanding any previous certification of satisfactory testing and/or inspection.

The supplier shall undertake to replace the rejected forgings at his own cost and the rejected forgings shall be sent back to the supplier after fulfilling the commercial terms and conditions.



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ANNEXURE - 1: RECOMMENDED TEST CERTIFICATE FORMAT FOR FORGINGS

SUPPLIER'S NAME AND ADDRESS									
TEST CERTIFICATE FOR FORGINGS									
1. Customer:	2. TC No. & Date:	3. PO No.:	4. Process of Melting Ingot:	5. Deoxidation Process:	6. Forging Method:	7. BHEL's Reference for Approval of Bloom:	8. Discard: Top _____ %; Bottom _____ %	9. Reduction Ratio } Ingot to Bloom Bloom to Blank	10. Batch No.:
									11. Heat/Melt No.
									12. Spec. No.
									13. Test Bar Size & Nos.
									14. Supplier of the Ingot/billet/ Bloom and TC reference.
15. FORGINGS COVERED BY TEST CERTIFICATE									
S.No.	Drawing No. & Item No.			Description			Quantity & Weight		
16. CHEMICAL COMPOSITION (PERCENT)									
Element	C	Si	Mn	S	P				
As Per Specn.	Min.								
	Max.								
Actual Values									
17. HEAT TREATMENT (To be accompanied by Recorder Chart, Whenever called for)									
Condition	Heating Rate, °C/hr.		Temp. °C		Soaking Time, Hrs.		Cooling Rate, °C/hr		Cooling Medium
18. MECHANICAL PROPERTIES									
	T.S. N/mm ²	Y.S. 0.5/0.2% Proof N/mm ²	% Elongation 5.65√S ₀ GL	% R.A. Min.	Hardness BHN (Min. 3 values)	Impact Value Joules	Bend Test		
							Angle of bend	Dis of mandrol	Result
As Per Specn.	Min.								
	Max.								
Actual Values									
19. SURFACE FINISH (When called for in the order/drg.)									
20. DIMENSIONAL INSPECTION									
21. NON-DESTRUCTIVE TESTS									
Nature of Test	Acceptance level		Instrument used		Range	Results	Any other detail		
Ultrasonic									
Radiographic									
Dye penetrant/ Magnetic Particle									
22. METALLOGRAPHIC EXAMINATION (To be conducted if called for and photo micrographs to be attached along with a report)									
Location of Sample	Etchant used	Magnification	Constituent observed	Relative %					
Microstructure	Macroetch	Inclusion Rating							
23. OTHER TESTS IF ANY (MICROSCOPIC, SULPHUR PRINTS, ETC)									
24. IDENTIFICATION OF FORGINGS AS PER PURCHASE SPEC.									
We hereby certify that the items mentioned above have been tested and inspected in our presence and are found to be in accordance with drawings, specifications and purchase order.									
SIGNATURE, NAME & SEAL OF THE INSPECTING OFFICER DATE:					SIGNATURE, NAME & SEAL OF THE CHIEF OF QUALITY CONTROL/ CHIEF METALLURGIST OF THE SUPPLIER DATE:				
INSTRUCTIONS									
a) Details of all heat treatment processes carried out should be furnished sequentially in 17.									
b) Test certificates are to be furnished as per Purchase order and specification, in A4 size preferably in transparent paper.									
c) All the entries including signature should be in block colour ink.									
d) If testing is done by outside agencies, the original TCs shall be furnished.									
e) The actual TC may run into more than one A4 size paper, if needed, to facilitate filling up of details.									



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CARBON STEEL FORGINGS, CLASS-3

↑

1.0 GENERAL:

This specification governs the quality requirements of Carbon Steel Forgings, class 3.

↑

2.0 APPLICATION:

Suitable for general engineering purposes.

3.0 CONDITION OF DELIVERY:

Normalised/Normalised and tempered.

Rough machining of the forgings shall be carried out, unless otherwise specified in the BHEL order/drawing.

4.0 COMPLIANCE WITH NATIONAL STANDARDS:

The forgings shall comply, in general with the requirement of the following National standards and also meet the requirements of this specification.

IS::2004: 1991 (RA-2006) } Carbon Steel Forgings For General Engineering

Gr: 3 (30C8), } Purposes.

↑

5.0 DIMENSIONS AND TOLERANCES:

The dimensions and tolerances shall be as specified in the order/ drawing. Wherever these are not specified, specified, the machining allowances and tolerances shall be as specified below:

For finish machined drawings : 3 ± 1 mm

For rough machined drawings : ± 1 mm

Revisions : 36th MOM OF MRC FCF+HTM

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INTERPLANT MATERIAL RATIONALISATION
COMMITTEE-MRC (FC&F+HTM)

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Corp. R&D

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6.0 MANUFACTURE:

Forgings shall be manufactured from steel produced by the open hearth, electric or such other ↑ process as may be agreed to between BHEL and the manufacturer.

Steel shall be fully killed.

Sufficient discard shall be made from each ingot to ensure freedom from pipe, segregation and other defects.

The amount of hot working and finishing temperature shall be such as to ensure complete soundness and adequate uniformity of structure and mechanical properties after heat treatment. The forgings shall not be overheated.

The minimum reduction ratio when forgings are made out of ingots shall be 4:1.

For sizes above 250 mm ruling section, the minimum reduction ratio shall be 3.5:1

Note: Raw material like Ingots/Blooms/Billets required for forgings should be procured from BHEL approved sources along with test certificate."

7.0 HEAT TREATMENT:

Forgings shall be normalised / normalised and tempered at suitable temperature to achieve ↑ the mechanical properties specified.

Test pieces shall also be heat treated along with the forgings they represent.

8.0 FINISH:

As mentioned in the drawing.

9.0 FREEDOM FROM DEFECTS:

The forging shall be free from defects, such as cracks, fold, flakes, seams, segregation, nonmetallic inclusions and other defects which may affect the utility of the forging.

10.0 CHEMICAL COMPOSITION:

The melt analysis of steel and permissible variation in the composition of the forgings from the melt analysis shall be as follows:

Element	Melt analysis, percent		Permissible variation, percent
	Min.	Max.	
Carbon	0.25	0.35	± 0.03
Silicon	0.15	0.35	± 0.03
Manganese	0.60	0.90	± 0.04
Sulphur	---	0.040	+ 0.005
Phosphorus	---	0.040	+ 0.005



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Notes:

1. Elements not quoted above shall not be added to the steel, other than for the purpose of finishing the heat and shall not exceed the following limits:

Element	Percent, max.
Nickel	0.30
Chromium	0.30
Copper	0.25
Molybdenum	0.15
Vanadium	0.05
Tin	0.05
Boron	0.0003

2. When steel is aluminium killed or killed with both aluminium and silicon, the requirements of minimum silicon content shall not apply. For aluminium killed steel the total aluminium content shall be within 0.02 to 0.05 percent.
3. $Mo \leq 0.15\%$, limiting to meeting conditions of $Cr + Mo + Ni = 0.5\%$.

11.0 TEST SAMPLES:

- 11.1 Unless otherwise specified in the order/drawing, test samples shall be taken from each melt and each heat treatment batch. Test samples should be cut from the heat treated forgings by cold process only and shall not have further heat treatment.

Test samples shall be taken from locations indicated on the drawing, leaving enough material, if required for testing at BHEL's end, integral with forgings.

The samples shall be cylindrical or rectangular in shape and cut at a distance of 12.5mm below the heat treated surface.

- 11.2 When integral test pieces are not called for, a test sample, having similar reduction ratio and heat treatment, as the forgings it represents, shall be provided per heat, per heat treatment batch, for check testing at BHEL, along with the forgings. The samples shall be properly identified and correlated with the Heat/Heat treatment Batch No./ Test Certificate No. Test samples shall be taken, at a distance of 12.5mm below the heat-treated surface.
- 11.3 Test samples shall generally be taken in the longitudinal direction. However, for economic reasons or where the size/ configuration does not permit the same, test samples may be taken in the transverse or radial direction.

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12.0 MECHANICAL PROPERTIES:

The test pieces, after being heat treated as per clause 7.0 above, shall show the following properties upto a limiting ruling section of 800 mm. Properties for thicker sections shall be subject to agreement between BHEL and the manufacturer. Test methods are specified below:


- 12.1 Tensile test : IS:1608
- 12.2 Hardness test (Brinell) : IS:1500
- 12.3 Charpy Impact Value (2mm U-Notch) : IS:1499

This test applicable for forgings of sizes above 16mm only.

Property	Sample (See Cl.11.3)	Limiting ruling section, mm			
		Upto & incl 100	>100 & upto 300	> 300 & upto 500	>500 & upto 800
Tensile strength N/mm ²	Longitudinal/	490	470	450	450
	Transverse/ Radial/Tangential	490	470	450	450
Yield strength min, N/mm ²	Longitudinal/	270	245	230	220
	Transverse/ Radial/Tangential				
Elongation on 5.65 $\sqrt{S_0}$ gauge length percent, min	Longitudinal	21	19	18	17
	Transverse	10	9	8	7
	Radial	14	12	11	10
	Tangential	16	14	13	12
Reduction in area, percent min.	Longitudinal	42	40	35	32
	Transverse	25	24	22	20
	Radial	27	26	24	22
	Tangential	34	32	32	30
*Hardness, Brinell, HB	—	140-192	140-192	135-190	135-190
Charpy Impact Value (2mm, U-Notch) min., Joules	Longitudinal	35	31	27	23
	Transverse	18	16	14	12
	Radial	21	19	17	15
	Tangential	26	23	20	17

Note: 1. Unless otherwise stated on the order/drawing, small forgings of non-critical nature weighing less than 300kg shall be accepted on the basis of chemical composition and hardness.

* 2. Hardness test can be conducted only, when tensile test can not be performed.

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13.0

ULTRASONIC TESTS:

13.1

For forgings ordered by BHEL, Hyderabad: Unless other wise specified on the drawing, ultrasonic test shall be carried out as per BHEL standard AA 085 01 18 and norms of acceptance shall be as per category 2.

3.13.2

For forgings ordered by other units: If specified on the drawing/order, ultrasonic test shall be carried out as per BHEL standard AA 085 01 18 and norms of acceptance shall be as per category 2, unless otherwise specified.

14.0

ADDITIONAL TESTS:

If specified in the drawing/order, the following tests shall be conducted:

14.1

Bend Test (Longitudinal):

The test pieces (230mm long and 32 mm square with edges rounded off, where the dimensions permit) shall be capable of being bent cold by direct pressure without fracture, until the sides are parallel, round a mandrel having a diameter of 44 mm when tested as per IS:1599.

14.2

Magnetic particle test.

14.3

Any other tests: Norms of acceptance shall be as specified in the drawing/order.

15.0

SCOPE OF THIRD PARTY INSPECTION:

Wherever, separate quality plan is not attached, the scope of third party inspection shall be as follows:

1.

Review of supplier's declared chemical composition.

2.

Selection of test samples for mechanical tests and witness of mechanical tests.

3.

Witness of Non-destructive tests as applicable.

4.

Review of HT charts.

5.

Dimensional inspection.

16.0

TEST CERTIFICATE:

Three copies of test certificates shall be supplied unless otherwise stated in the order, preferably in the test certificate format annexed to this specification (Annexure 1).

In addition, the supplier shall ensure to enclose one copy of the test certificate along with their dispatch documents to facilitate quick clearance of the material.

The following details shall be furnished in the test certificate:

i)

Reduction ratio

ii)

Dimensional Inspection.

iii)

Chemical composition including trace elements.

iv)

Results of mechanical tests.

v)


Results of Ultrasonic test

vi)

Details of heat treatment

vii)

Results of additional tests called for in the drawing/order.

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17.0 PACKING & MARKING:

Forgings shall be suitably packed to prevent corrosion and damage during transit.

Machined surfaces shall be properly protected with anticorrosive compounds.

Each package or forging (when supplied separately) shall be legibly marked with the following information:

AA 193 32 : Carbon Steel Forgings, Class 3 ↑

BHEL Order No.

Suppliers Name

Consignment/ Identification No.

Batch No.

Weight.

18.0 REFERRED STANDARDS (Latest publications Including Amendments):

1) AA 085 01 18	2) IS:1499	3) IS:1500	4) IS:1599
5) IS: 1608	6) 2004		



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ANNEXURE-I: RECOMMENDED TEST CERTIFICATE FORMAT FOR FORGINGS

SUPPLIER'S NAME AND ADDRESS TEST CERTIFICATE FOR FORGINGS															
1. Customer:					9. Reduction Ratio } Ingot to Bloom Bloom to Blank										
2. TC No. & Date:					10. Batch No.:										
3. PO No.:					11. Heat/Melt No.										
4. Process of Melting Ingot:					12. Spec. No.										
5. Deoxidisation Process:					13. Test Bar Size & Nos.										
6. Forging Method:					14. Supplier of the ingot/billet/ Bloom and TC reference.										
7. BHEL's Reference for Approval of Bloom															
8. Discard: Top % Bottom %															
15. FORGINGS COVERED BY TEST CERTIFICATE															
S.No.		Drawing No. & Item No.			Description					Quantity & Weight					
16. CHEMICAL COMPOSITION (PERCENT)															
Element		C	Si	Mn	S	P									
As Per Min.															
Specn. Max.															
Actual Values															
17. HEAT TREATMENT (To be accompanied by Recorder Chart, Whenever called for)															
Condition		Heating Rate, °C/hr.		Temp. °C		Soaking Time, Hrs.		Cooling Rate, °C/hr		Cooling Medium					
18. MECHANICAL PROPERTIES															
		T.S. N/mm ²		Y.S. 0.5/0.2% Proof N/mm ²		% Elongation 5.65√S ₀ %		% R.A. Min.		Hardness BHN (Min. 3 values)		Impact Value Joules		Bend Test Angle of bend Dia of mandrel Result	
As Per Min.															
Specn. Max.															
Actual Values															
19. SURFACE FINISH (When called for in the order/drg.)															
20. DIMENSIONAL INSPECTION															
21. NON-DESTRUCTIVE TESTS															
Nature of Test		Acceptance level		Instrument used		Range		Results		Any other detail					
Ultrasonic															
Radiographic															
Dye penetrant/ Magnetic Particle															
22. METALLOGRAPHIC EXAMINATION (To be conducted if called for and photo micrographs to be attached along with a report)															
Location of Sample		Etchant used		Magnification		Constituent observed		Relative %							
Microstructure		Macroetch		Inclusion Rating											
23. OTHER TESTS IF ANY (MICROSCOPIC, SULPHUR PRINTS, ETC)															
24. IDENTIFICATION OF FORGINGS AS PER PURCHASE SPEC.															
We hereby certify that the items mentioned above have been tested and inspected in our presence and are found to be in accordance with drawings, specifications and purchase order.															
SIGNATURE, NAME & SEAL OF THE INSPECTING OFFICER DATE:										SIGNATURE, NAME & SEAL OF THE CHIEF OF QUALITY CONTROL/ CHIEF METALLURGIST OF THE SUPPLIER DATE:					
INSTRUCTIONS															
a) Details of all heat treatment processes carried out should be furnished sequentially in 17.															
b) Test certificates are to be furnished as per Purchase order and specification, in A4 size preferably in transparent paper.															
c) All the entries including signature should be in block colour ink.															
d) If testing is done by outside agencies, the original TCs shall be furnished.															
e) The actual TC may run into more than one A4 size paper, if needed, to facilitate filling up of details.															



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ALLOY STEEL BARS FOR HIGH TEMPERATURE BOLTS UPTO 565° C – H&T (20CrMoVTiB4 – 10)

1.0 GENERAL:

This specification governs the quality requirements of alloy steel bars suitable for machining.

2.0 APPLICATION:

Used mainly for bolts, nuts and studs etc.

3.0 CONDITION OF DELIVERY:

Hot rolled/forged bars shall be supplied in the hardened and tempered condition according to EN10269 to comply with the mechanical properties specified in the specification.

4.0 COMPLIANCE WITH NATIONAL STANDARDS:

There is no Indian standard covering this material. However, assistance has been derived from EN 10269 material grade 20CrMoVTiB4 – 10 “Steels and Nickel alloys for fasteners with specified elevated and / or low temperature properties”.

5.0 DIMENSIONS AND TOLERANCES:

5.1 Sizes:

Bars shall be supplied to the dimensions specified in BHEL order.

5.1.1 Length:

Unless otherwise specified, hot rolled bars shall be supplied in 3 to 6 meters length or in multiples with maximum of 10 per cent, shorts down to 1 meter.

Forged bars shall be supplied in lengths of 1.5 to 6 meters

5.2 Tolerances:

5.2.1 Hot rolled bars:

The bars shall not vary from specified diameter or distance across flats by more than $\pm 2\frac{1}{2}$ %.

5.2.2 Forged bars:

The tolerance on the forged bars shall be as follows:

<u>Diameter, mm</u>	<u>Tolerance, mm</u>
> 50 to 125	+ 6.0
>125 to 175	+ 8.0
>175	+ 12.5

Revisions:

As per Clause No.39.7.3 A) of MOM of MRC – FCF+HTM

APPROVED:

INTERPLANT MATERIAL RATIONALISATION
COMMITTEE – MRC(FCF+HTM)

Rev No.10

Amd No.

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Prepared

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Dt:05-09-2014

Dt:

Year:

HPEP, Hyderabad

Corp.R&D

June, 1977

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Note: (FOR HOT ROLLED & FORGED BARS)

Insignificant surface defects in the form of dent and ripple marks are permissible provided their depth does not exceed half the tolerances on each size.

6.0 MANUFACTURE

The steel shall be made by electric furnace process and degassed (e.g. vacuum degassed). Any other process shall be subjected to the mutual agreement between BHEL and the manufacturers.

Note: The material as per this specification shall be supplied by the manufacturers who are having complete in-house steel melting, refining, hot rolling/forging/blooming/etc., heat treatment and testing facilities.

7.0 HEAT TREATMENT

Following heat treatment parameters are suggested to achieve the mechanical properties specified in Clause 11.0 of this specification.

Bars shall be annealed at 660 – 700°C followed by air cooling, hardened by heating uniformly to 970 – 990°C and quenching in air / water / oil. They shall be tempered at temperatures between 680 – 720°C.

If bars need to be straightened after heat treatment, stress relieving is mandatory after completion of the entire straightening process. Stress relieving shall be carried out at 30°C below the actual tempering temperature with a subsequent slow cooling rate.

8.0 FREEDOM FROM DEFECTS

The bars shall be straight, sound and free from internal defects. Cracks, other material separations or more severe linear inclusion lines are only acceptable when located in the dimensional tolerance areas.

9.0 CHEMICAL COMPOSITION:

The analysis of the material shall be as follows:

Element (wt%)	C	Si	Mn	Cr	Mo	V	Ti	B	S	P*	Al**
Minimum	0.17	–	0.35	0.90	0.90	0.60	0.07	0.001	–	–	0.015
Maximum	0.23	0.4	0.75	1.20	1.10	0.80	0.15	0.010	0.020	0.020	0.080

The following trace elements shall be restricted to the following maximum limits:

Copper	--	0.20
Tin	--	0.020*
Arsenic	--	0.020
Ni	--	0.20

* The elements P and Sn shall be controlled according to the formula $P+3.6XS_{n} \leq 0.055\%$

** A maximum Al-value of 0.03% is to be aimed.

10.0 TEST SAMPLES

10.1 CHEMICAL ANALYSIS:

Each melt shall be analysed for chemical composition.



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10.2 MECHANICAL TESTS

A hardness test is to be carried out to verify the uniformity of the strength within the delivery lot (per melt and heat treatment batch). Hardness check shall be conducted on 10% of the bars or a minimum 10 numbers of bars whichever is higher. In case the lot consist of less than or equal 10 bars, then all the bars need to be checked for hardness. Mechanical properties shall be tested on hardest and softest bar.

Specimens are to be taken in longitudinal direction according to EN 10083-1. For bars with diameter (d) respectively side lengths (a, b) > 100mm, the specimens shall be taken at a distance d/3 respectively a/3 and b/3 from the respective surfaces. In this case transverse specimens are also allowed.

11.0 MECHANICAL PROPERTIES

11.1 When tested in accordance with IS:1608, the test pieces shall show the following properties tensile properties at room temperature (EN 10269):

Properties	d ≤ 100	100 < d ≤ 250
Ultimate tensile strength	820–1000 N/mm ²	820–1000 N/mm ²
0.2% proof stress	660 N/mm ² (min.)	660 N/mm ² (min.)
Elongation on $5.65\sqrt{s_0}$ gauge length	15 % (min.)	15 % (min.)
Reduction in area	50% (min.)	50% (min.)
Charpy 2mm V notch (J)	40 (min.)	27 (min.)

11.2 Charpy Impact Value (V notch)

When tested in accordance with IS:1757, using a test specimen of 10 mm x 10 mm x 55 mm and having a 2 mm V notch, the materials shall show a minimum Charpy impact value (in Joules) at room temperature as mentioned in the above table. This test is applicable for Bars of sizes above 16mm only.

11.3 Hardness (Brinell) - for information only

When tested in accordance with IS: 1500, the material shall have a Brinell hardness in the range of 245 – 310 BHN.

Note: In lieu of IS:1608, IS:1757 & IS:1500, any other National or International may be used.

12.0 NON-DESTRUCTIVE TEST

12.1 Verification test of all bars.

12.2 100% Ultrasonic inspection of all bars according to EN 10308 type 1a-1c (table 1). Acceptance criteria shall be quality class 4 according to EN 10308 (table 2). In general, the decision limits for loss of back wall echo is 4 dB for all bar dimensions. Every linear or surface-like in-homogeneity larger than 10mm in any direction is not acceptable.

13.0 RETESTS

As per EN10021.

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14.0 TEST CERTIFICATE:

Three copies of test certificates in English shall be supplied unless otherwise stated in the order.

In addition the supplier shall ensure to enclose one copy of test certificate alongwith their dispatch documents to facilitate quick clearance of material.

The test certificate shall bear the following information:

BHEL references:

BHEL order No.

AA10622 (Rev.No.10):ALLOY STEEL BARS FOR HIGH TEMPERATURE BOLTS UPTO 565° C – H&T (20CrMoVTiB4 – 10)

Supplier References:

Supplier's Name

Heat or Cast No.

Process of manufacture

Identification No.

Particulars of heat treatment and Batch No.

Results of Tests:

Chemical analysis

Non-destructive tests

Mechanical properties

Results of dimensional inspection

The certificate must be signed by the Chief, Inspection Department / Chief Metallurgist of the supplier's plant.

15.0 PACKING AND MARKING

Bars shall be suitably packed to prevent corrosion and damage during transportation.

Bars over 63 mm diameter shall be individually stamped / painted on one end face with cast number and AA10622.

Bars of 63 mm diameter and less shall be bundled together and identified by means of a metal label stating the cast number and specification No. AA10622 attached to the bundle.

Each package shall, in addition bear the following information:

AA10622:Alloy steel bars for high temperature bolts up to 565 °C-H&T(20CrMoVTiB4 – 10)

BHEL Order No.

Cast / Batch No.

Identification No.

Weight.

Supplier's Name.

16.0 REFERRED STANDARD (Latest publications including amendments)

1) IS:1500

2) IS:1608

3) EN10021

4) EN 10204

5) EN 10308

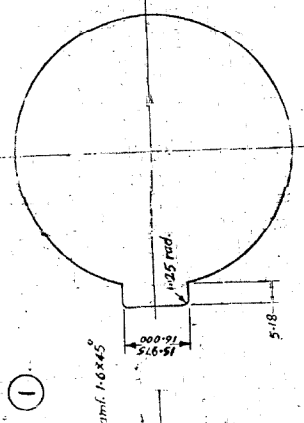
6) EN10083-1

7) IS 1757

THIRD ANGLE PROJECTION

ALL DIMENSIONS ARE IN MM, UNLESS OTHERWISE STATED.

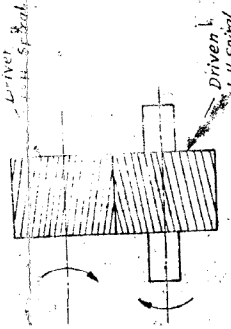
DRG. E2760714		BILL OF MATERIAL	
COL. ITEM NO.	DESCRIPTION, SIZE OR WEIGHT	COMPONENT OR MATERIAL	PATTERN CAT. OR DRAWING
1	Gear Wheel (Driver), Carbon Shaft, S. Freeing (Annealed)	PS-10203	De-Haired
2	Gear Wheel (Driven), Carbon Shaft, S. Freeing (Annealed)	PS-10203	De-Haired



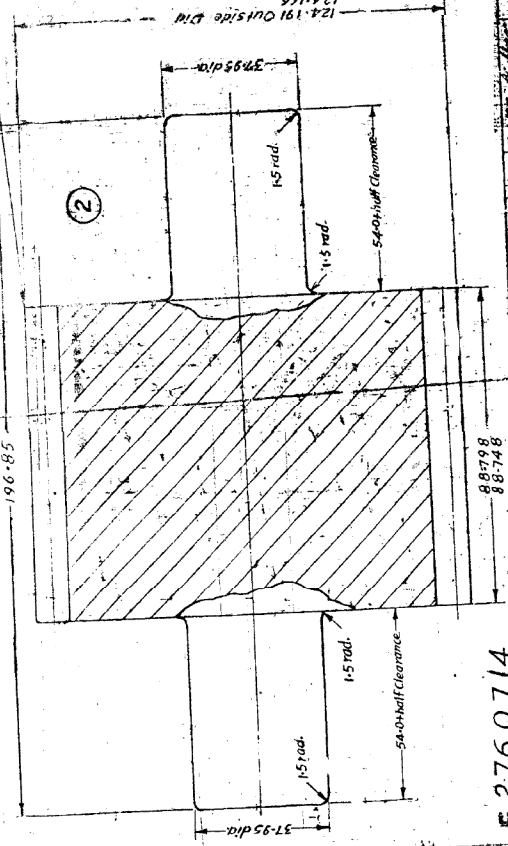
Particulars of Gears.	
Pitch Circle Dia.	117.25
Outside Dia.	124.191
No. of Teeth.	27
Spiral Angle.	9° 0' 10.15"
Face Width.	8.1
Modul.	4.535
Circular Pitch.	13.4652
Exact Centres.	15.725
Pressure Angle.	20°
Back Lash.	0.077 ± 0.254

TOOL LIST

ITEM	TOOL	DI.	PT.
1	1426838	Modul.	9
2	1426839	Pressure	20
3	1426840	Exact	15.725
4	1426841	Face	8.1
5	1426842	Back	0.077 ± 0.254



All ends of fit. to be rounded off with R5.00±0.2



Dimensions will limit to be made to gauges
Machining tolerances ± 0.25 mm
Unless shown otherwise in mm
Non-machining tolerances in mm

DRAWING ISSUED BY:
DRN: [Signature]
CHKD: [Signature]
APPD: [Signature]

DRAWING REFERENCE

REF. E 2760714	SEE E 2760715
SEE E 2760716	SEE E 2760717

BEHAT HEAVY ELECTRICALS
BHOPAL

GEARS FOR GOVERNOR OIL PUMP

2H-275 FRAME

DATE	CHKD.	APPD.
88-798	88-748	88-748

DATE	CHKD.	APPD.
88-798	88-748	88-748

DATE	CHKD.	APPD.
88-798	88-748	88-748

DATE	CHKD.	APPD.
88-798	88-748	88-748

DATE	CHKD.	APPD.
88-798	88-748	88-748

DATE	CHKD.	APPD.
88-798	88-748	88-748

SCALE: 1:1

MO. 1910030-01

E 2760714

DRG. E2760714

