

**Enquiry items along with quantities:**

It. no.	Size & Item description	Technical requirement	Quantity in kg- Maximum
1	250mm dia X 2000mm – 6000mm LG.	Steel round bar as per BHEL spec AA19331 Rev11 (IS:2004 Class II) in rough machined condition with tolerance on diameter (+4.0 mm) (-0.0 mm). Straightness within 3 mm/metre. Material shall be supplied in forged, normalised and tempered condition duly ultrasonically tested to AA 0850118 Rev01 (acceptable category II). All other technical parameters to be maintained strictly as per BHEL specification. Inspection at source by BHEL or BHEL appointed third party shall be done as per QAP No.: QA/HT/1046 Rev00 only. Final acceptance of material will be given after inspection & testing at BHEL Bhopal.	11000
2	300mm dia X 2000mm – 6000mm LG.		11000
3	360mm dia X 2000mm – 6000mm LG.		22000
TOTAL			44000 kg

Quantity variation as per below:

**For item 1** - Supplies quantity are to be restricted between 11000 kg & 9000 kg.

**For item 2** - Supplies quantity are to be restricted between 11000 kg & 9000 kg.

**For item 3** - Supplies quantity are to be restricted between 22000 kg & 18000 kg.

**Pre-qualification criteria:**

Sl. No.	Description of pre-qualification requirement	Vendor Response	
		Complied (YES / NO)	Supporting Documents required to accept compliance
1	Manufacturer of Carbon steel round bar / their authorized representative.		Relevant certificate of being manufacturer / declaration of OEM/ declaration on company letter head else authorization letter with validity (for authorized representative) for enquired item.  Firm name, address, email and contact no. etc. from whom bars intended to be supply to be furnished.
2	Vendors should have experience of Manufacturing, Material testing & supplying of CARBON STEEL FORGING ROUND BAR as per IS:2004 -1991 (RA-2006), CLASS-2(20C8) H&T or comparable standard of carbon steel, during last 7 years (ending last day of month previous to the one in which NIT is published)		Purchase order, Mill test certificate.  In case of authorized dealer relevant documents of there OEM is also considered.
3	Company shall be certified with ISO 9001 or equivalent.		Valid certificate to be submitted.  In case of authorized dealer, Valid ISO certificate of OEM is required.

Note:

1. BHEL has right to verify information / confirmation furnished by asking additional documents, proof etc.

**ALL THE ABOVE POINT WISE PRE-QUALIFICATION REQUIREMENT ARE TO BE NECESSARILY ACCEPTED BY THE BIDDERS FOR THEIR OFFERS TO BE CONSIDERED FAILING WHICH OFFERS SHALL BE REJECTED.**

**MAKE IN INDIA format (to be filled by OeMs of the participating bidders)****BHARAT HEAVY ELECTRICALS LIMITED, BHOPAL****MATERIAL MANAGEMENT – STEEL DIVISION**

*For this Procurement, Government of India Public Procurement (Preference to Make in India), Order 2017 with its amendments and subsequent Orders issued by the respective nodal ministries shall be applicable even if issued after issue of this NIT but before finalization of contract/PO/WO against this NIT.*

*As per the Provisions of this order, please submit a **self-certification complying with the conditions below on company letterhead duly signed by competent authority.***

I ....., hereby declare on behalf of M/s. .... that we are participating in the Enquiry No. .... floated by BHEL, Bhopal (MP), India and shall comply with following:

Public Procurement (Preference to Make in India), Order 2017 *with its amendments* and subsequent Orders issued by the respective nodal ministries shall be applicable even if issued after issue of this NIT but before finalization of contract/PO/WO against this NIT.

- (a) A supplier will be treated as “**Class-I Local Suppliers**”, if the items quoted by bidder have local content equal to or more than 50%.
- (b) ‘**Local Content**’ means the amount of value added in India, which shall be total value of item quoted (excluding net domestic indirect taxes) minus the value of imported content in the item (including all custom duties) as a proportion of the total value, **in percent**.

We hereby certify that the quoted items offered by us against above Enquiry No. is having local content of..... %

Further, to certify that the local content % certified above is in line with definition of Local content given in point no 2 of Public Procurement (Preference to Make in India), Order 2017 dated 19.07.2024 and we qualify as Class —I. (Class-I/ CLASS-II/Non-Local supplier-fill in one which is applicable) local supplier. It is also certified that Repackaging/ Refurbishment/ Rebranding of imported products and the license fees/royalties paid/ technical charges paid out of India are not considered for calculation of local content and there is no such locally-sourced imported items.

The above declaration does not include services such as transportation, insurance, installation, commissioning, training and after sales service support like AME/CMC etc. as local value addition. We also understand, false declarations will be in breach of the Code of Integrity under Rule 175(1) (i) (h) of the General Finance Rules for which a bidder or its successors can be debarred for up to two years as per Rule 151 (iii) of the General Finance Rules along with such other actions as may be permissible under law.

We further confirm that details of location(s) in India at which the local value addition is made will be at

- a. ....
- b. ....

I hereby declare that the details furnished above are true and correct to the best of my knowledge and belief and I undertake to inform you of any changes therein, immediately. In case any of the above information is found to be false or untrue or misleading or misrepresenting, I am aware that I may be held liable for it.

(.....)

For M/s. ....

(Seal & Sign)

## Annexure-1

### DECLARATION (To be given by Bidder)

GeM Bid No.....

Item Description: .....

With reference to above reference bid, we M/s..... (Bidder's Name)  
confirm/declare the following.

1. Quoted Make-.....
2. We are OEM or Reseller - .....
3. Valid OEM Authorization certificate with OEM's Contact Details attached (In case of reseller)  
- Yes / NA .....
4. We confirm Nil deviation from GeM bid document (NIT).

Note:

1. OEM details such as name, designation, address, e-mail Id and Phone number required to be furnished along with the technical bid. (also refer ATC clause).
2. Commercial Deviation/deviation in delivery shown separately or found hidden in the offer, will not be taken cognizance of.

**(Vendor's Seal & Sign)**

**BHARAT HEAVY ELECTRICALS LIMITED, BHOPAL**  
**QA-HYDRO**  
**STANDARD QUALITY ASSURANCE PLAN FOR BAR MATERIAL**

QAP NO. : QA/HT/1046 Rev. 00  
 Dated :- 16.05.2018  
 SPECIFICATION : AA 19331 Rev. 11 (carbon Steel Bars)  
 SUPPLY CONDITION : Forged, Normalised & Tempered, Rough Machined

1	2	3	4	5	6	7	8	9	10	11	12
SL. NO	STAGE	CHARACTERSTIC	METHOD	QUANTUM OF CHECK	REFERENCE DOCUMENT	ACCEPTANCE NORMS	FORMAT OF RECORD	P	V	W	REMARKS
1	Raw Material	Chemical	Chemical test	1 Sample / Heat	AA 19331 Rev. 11	AA 19331 Rev. 11	Mill Test Certificate	1	2	-	-
2	Heat Treatment	Normalised & Tempered	Normalised & Tempered	1 Sample / Heat & H.T. Batch	AA 19331 Rev. 11	AA 19331 Rev. 11	H.T. Chart	1	2	-	-
3	Final Stage	Stamping on test bar for mechanical Testing	Hard Stamp by TPIA	-do-	-do-	-do-	Stage Inspection Report	1	-	2	Test Piece duly stamped by TPIA
		Mechanical Properties	i) Tensile Test	As Specified in AA 19331 Rev. 11	-do-	-do-	Supplier,s Test Certificate	1	-	2	-
			ii) Charpy Impact Test (on 3 samples )	-do-	-do-	-do-	Supplier,s Test Certificate	1	-	2	-
			iii) Yield strength	-do-	-do-	-do-	Supplier,s Test Certificate	1	-	2	-
			iv) % Elongation	-do-	-do-	-do-	Supplier,s Test Certificate	1	-	2	-
		Ultra Sonic Test	As Specified in AA 19331 Rev. 11	100%	AA0850118 Rev. 01	Category II	U.T. report	1	-	2	1) 100% UT to be done by vendor. 2) 15% UT to be witness by TPIA on sample basis
		Chemical Composition	Chemical test	1 sample / Heat	AA 19331 Rev. 11	AA 19331 Rev. 11	Supplier,s Test Certificate	1	-	2	-
		Visual Examination	Visual	100%	-do-	Bars shall be free from surface defects, bends & twists	Supplier,s Dimensional Report	1	-	2	-
4	Dispatch	Identification Marking	Hard Stamping	100%	AA 19331 Rev. 11	AA 19331 Rev. 11	1. Heat No. 2. P.O. No. 3. Spec No. 4. Size 5. Supplier's Name	1	-	2	Identification & marking shall be done on face of each bar & TPIA hard stamp to be done on both face of each bar.
		Dimension & Tolerance	Measurement	100%	AA 19331 Rev. 11	+ 4 , -0 mm	-DO-	1	-	2	-
5	Document submission duly certified by TPIA	1) Mill test certificate (Mechanical & Chemical) 2) Supplier Test certificate (Mechanical & Chemical) 3) Dimensional Inspection report. 4) Heat Treatment chart 5) U.T. Report									

Note : Final Testing of Material will be done at BHEL Bhopal works before clearance of SRV.

1 = Manufacturer / Trader  
 2 = BHEL / BHEL's TPIA

H.T.E. *[Signature]*  
 16/05/18  
 शिवेंद्र कुमार / Shivendra Kumar  
 बरिष्ठ प्रबंधक / Sr. Manager  
 - टी.ई. विभाग / H.T.E. DIVISION  
 भोपाल / BHEL, Bhopal

*[Signature]*  
 16/05/18  
 WTM  
 उप प्रबंधक (उत्पादन) / MAHENDRA SONI  
 Dy. Manager (Production) WTM Division  
 भोपाल / BHEL, Bhopal



## CORPORATE PURCHASE SPECIFICATION

AA 193 31

Rev. No. 11

PAGE 1 OF 6

# CARBON STEEL FORGINGS, CLASS 2

↑

## 1.0 GENERAL:

This specification governs the quality requirements of Carbon Steel Forgings, Class 2.

↑

## 2.0 APPLICATION:

Suitable for general engineering purposes and for use in welded constructions.

## 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 material shall comply with the following National standards and also meet the requirements of this specification.

IS::2004 – 1991 (RA -2006) } Carbon Steel Forgings For General Engineering  
Gr: 2 (20C8), } Purposes.

↑

## 5.0 DIMENSIONS AND TOLERANCES:

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

For finish machined drawings :  $3 \pm 1$  mm

For rough machined drawings :  $\pm 1$  mm

## REVISIONS :

36<sup>th</sup> MOM OF MRC (FCF+HTM)

## APPROVED :

INTERPLANT MATERIAL RATIONALISATION  
COMMITTEE-MRC (FCF+HTM)

Rev. No. 11

Amd.No.

Reaffirmed

Prepared

Issued

Dt. of 1st Issue

Dt. 30.01.2008

Dt :

Year:04-11-2011

HARDWAR

Corp. R&D

JULY, 1980

**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 FREEDOM FROM DEFECTS:**

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

**8.0 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.

**9.0 FINISH:**

As mentioned in the drawing.

**10.0 CHEMICAL COMPOSITION:**

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

Element	Percent		Permissible variation , percent
	min.	max.	
Carbon	0.15	0.25	± 0.02
Silicon	0.15	0.35	± 0.03
Manganese	0.60	0.90	± 0.04
Sulphur	---	0.040	+ 0.005
Phosphorus	---	0.040	+ 0.005



## CORPORATE PURCHASE SPECIFICATION

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### NOTE:

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:

<u>Element</u>	<u>Percent, max.</u>
Nickel	0.30
Chromium	0.30
Copper	0.25
Molybdenum	0.05
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. Percent Cu + 10 X (percent Tin) shall not exceed 0.5%.
4. Carbon equivalent (Melt analysis) value (C.E.) = 0.42%, max.

$$C.E. = C + \frac{Mn}{6} + \frac{Cr+Mo+V}{5} + \frac{Ni + Cu}{15}$$

5.  $Mo \leq 0.15\%$ , 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 heat treatment batch. Test samples should be cut from the heat treated forgings by cold process only and shall receive no further heat treatment.

Test samples shall be cylindrical or rectangular in shape and cut at a distance of 12.5 mm 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 12.5 mm below heat treatment 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 : IS: 1608

12.2 Hardness Test (Brinell) : IS:1500

12.3 Charpy Impact Value (2mm U-Notch) : IS:1499

The test is applicable for forgings of sizes above 16mm only.

Property	Sample (CI 11.3)	Limiting ruling section, mm		
		Upto & incl.100	> 100 & upto 400	> 400 & upto 800
Tensile strength, min, N/mm <sup>2</sup>	Longitudinal Transverse/ Radial/ Tangential	430	390	370
Yield strength, min, N/mm <sup>2</sup>	Longitudinal Transverse/ Radial/ Tangential	230	195	185
Elongation on 5.65√So gauge length percent, min.	Longitudinal Transverse/ Radial/ Tangential	24 12 16 18	23 11 15 17	21 9 13 15
* Hardness, Brinell, HB	----	120 – 167	111 – 156	111 - 156
Charpy Impact value (2mm U-Notch) min., joules	Longitudinal Transverse/ Radial/ Tangential	47 24 28 35	43 22 26 32	40 20 24 28

### Note:

1. Unless otherwise stated on the order/drawing small forgings of non-critical nature weighing less than 300 kg 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.

## 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. ↑





## CORPORATE PURCHASE SPECIFICATION

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### 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 on 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 CERTIFICATES:

Three copies of a test certificates shall be supplied, unless otherwise stated in the order, in the Test Certificate proforma annexed to this specification (Annexure -I).

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:

Dimensional inspection.

Details of heat treatment.

Reduction ratio

Chemical composition including trace elements.

Results of mechanical tests.

Results of Ultrasonic test

Results of ultrasonic examination.

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

### 17.0 PACKING & MARKING:

Forgings shall be suitably packed to prevent 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 31 - Carbon Steel Forgings, Class 2 (20C8).

BHEL Order No.

Suppliers Name

Consignment/ Identification No.

Batch No.

Weight.

### 18.0 REFERRED STANDARDS (Latest publications Including Amendments):

1) IS:1499

2) IS:1500

3) IS:1599

4) IS:1608

5) IS:2004

6) AA 085 01 18

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## CORPORATE PURCHASE SPECIFICATION

**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/					
7. BHEL's Reference for Approval of Bloom						Bloom and TC reference.					
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 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 <sup>2</sup>	Y.S. 0.5/0.2% Proof N/mm <sup>2</sup>	% Elongation 5.65√So GL	% R.A. Min.	Hardness BHN (Min. 3 values)	Impact Value Joules	Bend Test			
As Per Specn.		Min.						Angle of bend	Dia of mandrel	Result	
		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.											



## CORPORATE STANDARD

AA 085 01 18  
REV.No. 01  
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### ULTRASONIC TESTING, CLASSIFICATION AND ACCEPTANCE STANDARDS FOR STEEL FORGINGS, BILLETS AND BLOOMS

#### 1.0 SCOPE:

This standard deals with the ultrasonic testing of steel forgings, billets and blooms. The procedure covers pulse echo direct contact manual ultrasonic flaw detection technique. This standard does not apply to austenitic steel forgings.

#### 2.0 PERSONNEL REQUIREMENT:

Personnel performing non-destructive examination and evaluation shall be qualified to the recommended practice SNT - TC - 1A or any other recognised practice.

#### 3.0 EQUIPMENT CHARACTERISTICS:

##### 3.1 Frequency range:

The ultrasonic equipment shall be suitable for operating at frequencies within the range of 0.5 to 6 MHz.

##### 3.2 Sensitivity:

The sensitivity of the equipment shall be tested to ensure that the number of full screen back wall echo is not less than that given below, when the appropriate probe is placed on the metalised surface of plastic insert of the Indian Standard reference block (IS:4904)/IIW block.


<u>Frequency range, MHz</u>	<u>Min.No. of full screen back echoes</u>
1	5
2	4
4 to 6	2

##### 3.3 Resolution:

The resolution of the equipment and probe combined shall be such as to show separately indications of the three grooves in the IIW - VI block.

Revision: CL.9.4 OF MOM OF WG(NDT)			Approved: INTERPLANT STANDARDIZATION COMMITTEE - ( WG-NDT )		
Rev.No. 01	Amd.No.	Reaffirmed	Prepared CFFP	Issued CORP. R&D	Dt. of 1st issue Jan '80
Dt. Jan '95	Dt.	Year:	HARDWAR		

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**4.0 SURFACE CONDITION:**

The test surface shall be free from loose scales, rust and such other extraneous material that would interfere with the ultrasonic energy transmission. In case of machined surface, it is desirable to have a surface finish of 6.25 microns or better. A gramophone record type of finish and tear produced by machining tools shall be avoided since these give rise to spurious echoes and cause probe wear.

**5.0 COUPLANT:**

To ensure adequate transmission of ultrasonic energy between the probe and the test object, a suitable couplant having good wetting characteristics such as oil, grease, water, glycerine or cellulose paste shall be used.

**6.0 TESTING TECHNIQUE:**

**6.1** Selection of testing technique shall be made after giving due consideration to the method of manufacture and shape of the object tested. Testing technique should be such that each and every part of the object volume is scanned at least once. Successive scans shall overlap a minimum of 15% of the probe width. Uniform contact shall be maintained between probe and object and scanning speed shall not exceed 100 mm/ second. The following techniques are considered to be minimum for providing adequate coverage.

**6.2 Scanning Scheme (Solid And Hollow Forgings):**  
Complete length of the forging shall be scanned radially from sides / cylindrical surface through 360° using longitudinal wave probe. Whenever practicable the forging shall be scanned in axial direction also. Hollow forgings, and when necessary, solid forgings also shall be scanned using appropriate shear wave probes to detect axial and radial cracks. Hollow forgings are the forgings made hollow on the press by punching or ring rolling operation.

**6.3 Solid Rectangular Forgings, Billets And Blooms:**  
Complete length of the object shall be scanned from two adjacent faces and whenever practicable one end face using longitudinal wave probe.

**6.4** Radial cracks on round sections which can not be detected by normal testing method may be subjected to other crack detection methods such as MPI.

**7.0 SCANNING:**

**7.1 Probes and Frequency:**  
Overall scanning shall be done using 2 MHz nominal, 20-25 mm diameter probes except when large grain size and path length make it necessary to use a lower frequency. Smaller probes may be used when necessary. However, for forgings intended for backing material for white metal lined bearings, the examination shall be carried out by 4 MHz probes.

**7.2 Time Base Calibration:**

The time base shall be calibrated using a calibration block or a known dimension of forging under examination.

**7.3 Sensitivity:**

**7.3.1 When Calibrated Attenuator Is Not Available:**

Reference sensitivity of equipment shall be set such that the maximum acceptable defect equivalent flat bottomed hole in the test block is equal to 75% of the full screen height. Testing shall be carried out at the highest sensitivity possible.

**7.3.2 When Calibrated Attenuator Is Available:**

The sensitivity of the equipment during scanning shall be set 6 dB more than the sensitivity required to give a full screen height echo from the maximum acceptable size of defect.

Note: The above sensitivity level adjustment is purely for scanning purposes. Once a defect is encountered, the sensitivity shall be brought down to estimate the size of defect for evaluation of the material under test.

**8.0 ESTIMATION OF FLAW SIZE:**

**8.1 Large Size Flaws:**

The size of large flaws can be estimated by moving the probe in all directions and plotting the midpoint of the probe when echo falls to 50 percent or 6 dB.

**8.2 Small Size Flaws:**

**8.2.1 When Calibrated Attenuator Is Not Available:**

**8.2.1.1** The size of the flaw may be estimated by comparing with the echoes of the flat bottomed holes at appropriate depths in a test block of ultrasonically similar material.

**8.2.1.2** The size of the flaw may also be estimated by moving probe successively in all the four directions at right angles to each other and plotting the mid point of the probe when echo height falls to 50% or 6 dB. Due allowance shall also be made for beam spread, depth and orientation of flaw and diameter of the forging if the scanning is done from the curved surface.

**8.2.2 When Calibrated Attenuator Is Provided With The Equipment:**

The size of the flaw (smaller than the beam spread) can be estimated accurately in millimetres of equivalent circular flaw with the help of Krautkramer's DGS (Distance - gain - size) diagram. Method of estimating flaw size using a DGS diagram is given in Annexure - A.

AA 085 01 18	<h1 style="margin: 0;">CORPORATE STANDARD</h1>	<div style="font-size: 0.8em; margin: 0;">भारतीय</div> <div style="font-size: 2em; font-weight: bold; margin: 0;">BHEL</div>
REV.No. 01		
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**9.0 CLASSIFICATION OF FORGINGS, BILLETS AND BLOOMS:**

9.1 Forgings, billets and blooms are classified into the following five categories depending upon the defect size admissibility for the purpose of ultrasonic testing:

<u>Category</u>	<u>Unacceptable defects</u>
1	<ul style="list-style-type: none"><li>(i) Cracks, flakes, seams &amp; laps.</li><li>(ii) Defects giving indication larger than that from a 2 mm diameter equivalent flaw.</li><li>(iii) Groups of defects with maximum indication less than that from a 2 mm diameter equivalent flaw which cannot be separated at testing sensitivity if the back echo is reduced to less than 70%.</li><li>(iv) Defects giving indications of 1 to 2 mm diameter equivalent flaw separated by a distance less than four times the size of the larger of the adjacent flaws.</li></ul>
2	<ul style="list-style-type: none"><li>(i) Cracks, flakes, seams &amp; laps.</li><li>(ii) Defects giving indication larger than that from a 4 mm diameter equivalent flaw.</li><li>(iii) Groups of defects with maximum indication less than that from a 4 mm diameter equivalent flaw which cannot be separated at testing sensitivity if the back echo is reduced to less than 50%.</li><li>(iv) Defects giving indications of 2 to 4 mm diameter equivalent flaw separated by a distance less than four times the size of the larger of the adjacent flaws.</li></ul>
3	<ul style="list-style-type: none"><li>(i) Cracks, flakes, seams &amp; laps.</li><li>(ii) Defects giving indication larger than that from a 6 mm diameter equivalent flaw.</li><li>(iii) Groups of defects with maximum indication less than that from a 6 mm diameter equivalent flaw which cannot be separated at testing sensitivity if the back echo is reduced to less than 40%.</li><li>(iv) Defects giving indications of 3 to 6 mm diameter equivalent flaw separated by a distance less than four times the size of the larger of the adjacent flaws.</li></ul>
4	<ul style="list-style-type: none"><li>(i) Cracks, flakes, seams &amp; laps.</li><li>(ii) Defects giving indication larger than that from a 10 mm diameter equivalent flaw.</li><li>(iii) Groups of defects with maximum indication less than that from a 10 mm diameter equivalent flaw which cannot be separated at testing sensitivity if the back echo is reduced to less than 20%.</li></ul>

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- (iv) Defects giving indications of 5 to 10 mm diameter equivalent flaw separated by a distance less than four times the size of the larger of the adjacent flaws.
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- (i) Cracks, flakes, seams & laps.
- (ii) Defects giving indication larger than that from a 15 mm diameter equivalent flaw.
- (iii) Groups of defects with maximum indication less than that from a 15 mm diameter equivalent flaw which cannot be separated at testing sensitivity if the back echo is reduced to less than 10%.

Note: Loss of back wall echo not attributable to the presence of defects or geometry and exceeding the limits mentioned in item (iii) of each category of unacceptable defects shall be a cause for rejection.

### ANNEXURE - A

The equivalent flaw size curves of the DGS diagram is prepared by plotting the amplitude in decibels from a series of circular reflectors with increasing distance from the probe in water and so the graph incorporates only the loss in water. When it is found that the attenuation in the material under test is more (this can be checked using back echo curve of DGS diagram), this shall be taken into account while calculating the flaw size. Corrections will not be required for majority of heat treated forgings when tested with 2-4 MHz probes. A step by step method of estimating flaw size using universal DGS diagram is given below:

- (a) Adjust the depth range of the equipment to the required depth.
- (b) Adjust the back echo to 70% of screen height from a defect free area parallel wall of the material under test or ultrasonically similar test block and note the dB value (A) on the calibrated gain control.
- (c) Mark on the back echo curve of the diagram, the back wall of the distance in terms of near field in millimetres in the case of universal DGS diagram.
- (d) Move the probe to the defective area and get the maximum defect echo. Read off the flaw depth. Increase the gain with the calibrated gain control until echo height reaches 70% of screen height. Note the attenuator reading in dB (B).
- (e) Calculate the gain (G) in dB by subtracting 'A' from 'B'. Count off the gain 'G' downwards from the marked point on the back echo curve, and then move horizontally to intersect the vertical line from the base line corresponding to the flaw depth 'D' in terms of near field in the case of universal diagram.

(f) Note the equivalent flaw size curve passing through the above point. Multiply the reduced flaw dimension (S) of the curve by the probe diameter to give the equivalent flaw size in millimetres.

ANNEXURE - A

### KRAUTKRAMER'S DCS DIAGRAM

