

**CORPORATE PURCHASE SPECIFICATION**

AA 195 11

Rev. No. 09

PREFACE SHEET

**CARBON STEEL CASTINGS - FUSION WELDING QUALITY**

**FOR INTERNAL USE ONLY**  
**REMOVE THIS PREFACE BEFORE ISSUE TO SUPPLIERS**

**Comparable Standards:**

1. AMERICAN : ASTM A 216 - 1993  
Gr: WCC

**Suggested/Probable Suppliers and Grades:**

Use plant's vendor list.

**User Plant References:**

1. BHOPAL : PS 10 202  
2. HEER, HARDWAR : 0550.41, GR: 15Ω; 20Ω; 25Ω & 30Ω  
CSW - C 20 \$ CSW - C 25.  
3. HYDERABAD : ASTM A 216, Gr: WCA  
: CSN 422641.1  
: CSN 422643.1  
: CSN 422650.2  
: IS : 2986  
: γ 87 - 30, Type L  
4. TRICHY : ASTM A 216, Gr: WCB  
: ASTM A 216, Gr: WCC

**Revisions :**

CI 30.8.30 of MOM of MRC - FCF+HTM

**APPROVED :****INTERPLANT MATERIAL RATIONALISATION  
COMMITTEE-MRC (FCF+HTM)**

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MARCH, 1978



**CORPORATE PURCHASING SPECIFICATION**

AA 195 11

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**CARBON STEEL CASTINGS-FUSION WELDING QUALITY**

**1.0 GENERAL**

This specification governs the quality requirements of Carbon Steel Castings-Fusion Welding Quality.

**2.0 APPLICATION**

For pressure containing parts for high temperature service and of quality suitable for assembly with other castings or wrought steel parts by fusion welding.

**3.0 CONDITION OF DELIVERY**

Normalised / Normalised & tempered

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

Castings shall not be painted

**4.0 COMPLIANCE WITH NATIONAL STANDARDS**

There is no Indian standard covering this material. However, assistance has been derived from ASTM A 216-1993, Gr: WCC, in preparing this specification.

**5.0 DIMENSIONS AND TOLERANCES**

The castings shall be true to the pattern/drawing.

Holes for machining up to and including 50 mm in diameter are to be cast solid, unless otherwise stated in BHEL order/drawing.

Unless otherwise specified in BHEL order/drawing, untoleranced dimensions for the castings shall be as per tolerance class 4 of BHEL standard AA 023 04 02.

Revisions :  
CI 30.8.30 of MOM of MRC-FCF+HTM

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## 6.0 MANUFACTURE

The steel for the castings shall be made by basic electric furnace process or such other process as may be agreed to between BHEL and the manufacturer.

The steel shall be fully killed.

## 7.0 HEAT TREATMENT

Heat treatment shall be carried out at suitable temperatures to give the properties specified.

Any flame or arc cutting which may have to be done, shall be carried out before heat treatment.

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

## 8.0 FINISH

All castings shall be properly fettled and dressed and all surfaces shall be thoroughly cleaned.

Machined surfaces shall have the surface finish as indicated in the drawing

## 9.0 FREEDOM FROM DEFECTS

Castings shall be free from defects such as porosity, blow holes, sand inclusion, shrinkage, cavities, hard spots, cold shuts, cracks, etc., which may adversely affect machining and utility of castings.

When it is necessary to remove risers by flame cutting, care shall be taken to make the cut at a sufficient distance from the body of the casting so as to prevent any defect being introduced into the casting due to local heating.

## 10.0 CHEMICAL COMPOSITION

The melt analysis of steel and the permissible variation in the composition of the castings from the melt analysis shall be as specified below:

Element	Melt analysis, Percent, max	Permissible Variation, percent
*Carbon	0.25	0.02
Silicon	0.60	0.05
*Manganese	1.20	0.06
Sulphur	0.045	0.008
Phosphorus	0.040	0.008



**Note: 1.** In the interest of uniform welding, the concentration of the unspecified alloying elements shall not exceed the limits specified below. Whenever specified in the enquiry/order, the test results of these elements shall also be included in the test certificate. However, the manufacture shall ensure that these elements are within the limits specified.

Element	Percent, Max.
Copper	0.30
Nickel	0.50
Chromium	0.50
Molybdenum	0.20
Vanadium	0.03
1. Total content of these unspecified elements	1.00
2. For each reduction of 0.01% below the specified maximum carbon content, an increase of 0.04% Mn above the maximum specified will be permitted up to a maximum of 1.40%.	

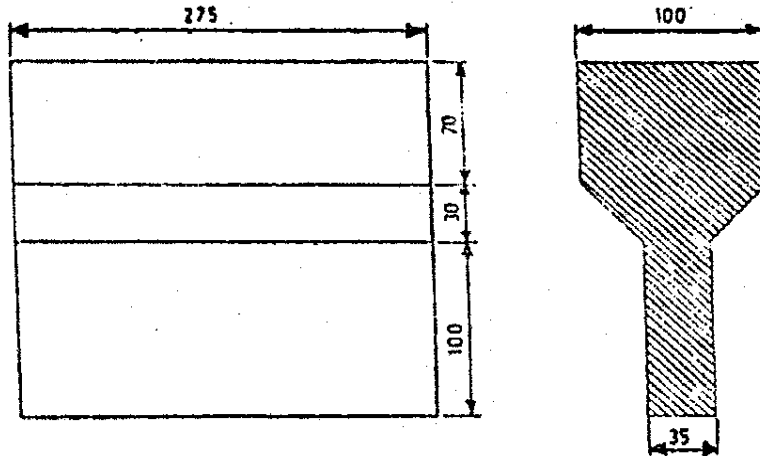
## 11.0 TEST SAMPLES

Manufacturers shall carryout mechanical testing as per following sampling plan.

- 11.1 Unless otherwise specified for castings weighting up to 500 kg. piece weight one keel block, separately cast per melt per heat treatment batch shall be supplied according to the sketch given below:
- 11.2 Unless otherwise specified castings weighing more than 500 kg shall be provided with integrally cast keel block.
- 11.3 Retests shall be carried out as per IS : 8800
- 11.4 Keel blocks with proper identification and representative of the castings shall be supplied along with the consignment for testing at BHEL works.



## DETAIL OF KEEL BLOCK



ALL DIMENSIONS IN mm

**12.0 MECHANICAL PROPERTIES:**

The test pieces, after being heat treated as per clause Cl.7.0 above, shall show the following properties:

**12.1 Tensile**

The test pieces shall show the following properties when tested in accordance with ASTM A 370

Tensile strength	:	485 - 655 N/mm <sup>2</sup>
Yield strength	:	275 N/mm <sup>2</sup> , min.
Elongation on 50mm gauge length	:	22 percent, min.
Reduction in area	:	35 percent, min.

**12.2 Hardness (Brinell): for information only:**

150 - 205 HB.

**13.0 NON-DESTRUCTIVE TESTS:**

The following tests shall be conducted:

- 1) Ultrasonic examination to BHEL standard AA 085 01 04 / AA 085 01 05
- 2) Liquid penetrate examination to BHEL standard AA 085 0131.
- 3) Magnetic particle examination to BHEL standard AA 085 01 33 and norms of acceptance as per BHEL standard AA 085 01 34.

Norms of acceptance shall be as specified in BHEL order/drawing



#### 14.0 REPAIR OF CASTINGS

The manufacturer without the prior permission of BHEL shall not carry out repair of castings.

#### 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 test certificates shall be supplied unless otherwise stated in BHEL 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 test certificate shall bear the following information:

- i) Dimensional inspection.
- ii) Detail of heat treatment
- iii) Chemical composition & unspecified alloying elements whenever called for
- iv) Results of mechanical tests
- v) Results of NDT tests.

#### 17.0 PACKING AND MARKING

Castings shall be suitably packed to prevent corrosion and damage during transit. Machined surfaces shall be properly protected with anticorrosive compounds. Each package or casting (when supplied separately) shall be legibly marked with the following information.

AA 195 11: C.S. Castings - F.W. Quality  
BHEL Order No.  
Consignment/Identification No.  
Melt No.  
Weight  
Supplier's Name

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

- |                 |                 |                 |                 |
|-----------------|-----------------|-----------------|-----------------|
| 1. AA 023 04 02 | 2. AA 085 01 04 | 3. AA 085 01 05 | 4. AA 085 01 31 |
| 5. AA 085 01 34 | 6. ASTM A 216   | 7. ASTM A 370   | 8. IS : 8800    |



## ANNEXURE 1 - RECOMMENDED TEST CERTIFICATE FORMAT FOR CASTINGS

SUPPLIERS'S NAME AND ADDRESS									
1. Customer :					6. Cast No. & Date :				
2. TO No. & Date :					7. Batch No. :				
3. PO No. :					8. Heat Code :				
4. Process of Melting :					9. Spec. No. :				
5. Deoxidisation Process :					10. Test Bar Size :				
II. CASTING COVERED BY T.C.									
Sl. No.	Drawing No. & Item No.				Description			Quantity & Weight	
12. CHEMICAL COMPOSITION (PERCENT)									
Element	C	Si	Mn	S	P				
As per Min.									
Spec. Max.									
Actual Values.									
13. HEAT TREATMENT (To be accompanied by Recorder Chart, wherever called for)									
Condition	Temp. °C			Soaking Time, Hrs.			Cooling Medium		
14. MECHANICAL PROPERTIES									
	T.S. N/mm <sup>2</sup>	Y.S. 0.5/0.2% Proof N/mm <sup>2</sup>	% E on GL 5.65 SO	% R.A. Mn	Hardness BHN Min. 3 Values	Impact Value, Joules	Bend		
As per Min.									
Spec. Max.									
Actual Values.									
15. Surface Finish (When called for in the order/dwg)									
16. DIMENSIONAL INSPECTION									
17. NON-DESTRUCTIVE TESTS									
Nature of Test	Acceptance Level	Instrument used			Range	Results	Any other details		
Ultrasonic									
Radiographic									
Dye Penetrant/ Magnetic Particle									
18. OTHER TESTS, IF ANY (MICRO- Seiple, Hydraulic, Etc.)									
19. IDENTIFICATION ON CASTING AS PER CPS.									
We hereby certify that the items mentioned above have been tested and inspected in our presence and are found to be in accordance with the drawings, specifications and purchase order.									
Signature & Seal of the Inspecting Officer (Purchase Representative)					Signature and Seal of the Chief of Quality Control Chief Metallurgist of the Supplier.				
Date :					Date :				
INSTRUCTION:									
a) If steel is produced by LD or Oxygen process, Nitrogen content should be furnished and shall not exceed 0.009%									
b) Test Certificates are to be furnished as per Purchase Order and Specifications, in A4 Size transparent paper.									
c) All the entries including signature should be in black ink.									
d) If testing is done by outside agencies, the original TCs shall be furnished.									
e) The actual Test Certificate may run into more than one A4 size paper, if needed, to facilitate filling up of details.									



# CORPORATE STANDARD

AA 085 01 05

Rev. No. 01

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## ULTRASONIC EXAMINATION, ACCEPTANCE STANDARDS AND CLASSIFICATION OF STEEL CASTINGS FOR HYDRO-TURBINES, HYDRO-GENERATORS & MOTORS

### 1.0 SCOPE:

This standard deals with the ultrasonic testing procedure, acceptance standards and classification of steel castings for hydro-turbines, hydro-generator and electrical motors.

This standard is not applicable for Austenitic castings.

### 2.0 STAGE OF EXAMINATION:

Ultrasonic examination shall be generally carried out after heat treatment and rough machining of the castings, as called for in the order/drawing. Ultrasonic examination shall be repeated after weld rectification, if any.

### 3.0 SURFACE PREPARATION:

Smooth "as cast" surface free from adhered or fused sand and irregularities is adequate for ultrasonic examination. Loose scales and excessive surface irregularities such as that caused by removal of runner and riser shall be ground off. While grinding care shall be taken to avoid surface undulations which would interfere with probe contact. To improve coupling efficiency of as cast surfaces or to remove rust or paint, shot blasting or sand-blasting may be carried out. Rough machined surfaces should have a minimum surface finish of 6.2 microns.

### 4.0 PERSONNEL REQUIREMENT:

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

### 5.0 EQUIPMENT CHARACTERISTICS:

#### 5.1 Frequency range:

The equipment shall be capable of operating over a frequency range of at least 0.5 to 6 MHz.

#### Revisions:

Cl 12.8.2 of MOM of WG-NDT

#### Approved:

INTERPLANT  
STANDARDIZATION COMMITTEE - (WG-NDT)

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CFFP  
HARDWAR

CORP. R&D

JAN '95

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5.2 CRT Screen Presentation:

"A" scan presentation shall be used. The trace shall be well defined, easy to read and associated with permanent graticule scale marking for both range and amplitude.

5.3 Screen Height Linearity:

The amplifier shall be linear within  $\pm 5\%$  upto at least 75% of full screen height and any deviation above this should be known to the operator. Suppression affects linearity and the effect of suppression over full range should be recorded.

5.4 Amplitude Control Linearity:

The equipment shall contain a signal attenuator or calibrated gain control that shall be accurate over its useful range to  $\pm 20\%$  of the useful range (20% to 80% of screen height)

5.5 Linearity Of Time Base:

The time base shall be linear as far as possible and non-linearity should not exceed 2% of the full scale graticule reading.

5.6 Resolution:

The resolution of probe and flaw detection apparatus shall be such as to show separately the indication from three reflecting surfaces of the vertical grooves in the IIW 'V1' block.

5.7 Sensitivity of the Equipment:

The sensitivity of the equipment shall be checked with the longitudinal wave probe used by placing the probe on the metalised surface of the plastic insert of IS 4904/ IIW test block. The minimum number of multiple echoes from the plastic insert at full gain setting shall be as given below:

<u>Frequency range, MHz</u>	<u>Number of multiple echoes</u>
1	5
2	4
4 to 6	2

6.0 COUPLANT:

To ensure adequate transmission of ultrasonic energy between probe and casting, a suitable couplant having good wetting characteristics shall be used. Oil, glycerin or polycell paste may be used. For better adoption of cast surfaces, a thin protective plastic cover over the longitudinal probe is recommended.

**7.0 SEARCH UNIT:**

7.1 Longitudinal wave internally grounded having a 1/2 to 1 in (13 to 25 mm) diameter or 1 in (25 mm) square piezo-electric elements. Based on the signal to noise ratio of the response pattern of the casting a frequency in the range from 1 to 5 MHz shall be used. The back ground noise shall not exceed 25% of the distance amplitude correction curve (DAC). Transducers shall be utilized at their rated frequencies.

7.2 Dual-Element, 4 MHz 1/2 by 1 in (13 by 25 mm), 12° included angle search units are recommended for sections 1 in (25mm) and under.

7.3 Other frequencies and sizes of search units may be used for evaluating and pin pointing indications.

**8.0 TESTING PROCEDURE:****8.1 Selection of Probes:**

For all ultrasonic examinations, the highest frequency compatible with the size, metallurgical condition and thickness of the casting shall be used.

**8.2 Testing Techniques:**

While selecting testing technique the following factors must taken into account:

- i. Type, orientation, position and incidence of defects likely to be encountered in the casting under consideration.
- ii. Thickness and profile of the section.
- iii. Structural condition.

All parts of the casting surface where a contact probe can be used, shall be tested by overlapping scans 15% with normal beam probes, irrespective of casting geometry and availability of reference back echo. Normal beam probe of 1 to 5 MHz frequency shall be used.

**9.0 EQUIPMENT CALIBRATION:****9.1 Depth Range:**

The depth range of the equipment shall be adjusted for normal and shear wave probes using known thickness of the casting or standard calibration block. When latter is used, velocity difference, if any, should be taken into account.



## 9.2 Sensitivity:

The scanning sensitivity of the apparatus shall be adjusted using either DGS diagram or standard test block with flat bottomed hole so that maximum acceptable equivalent defect will give an indication height of 75% of screen height +6 db. When test block is used for sensitivity calibration, distance amplitude curve shall be plotted on CRT screen to facilitate correct defect size assessment. While estimating the size of the defect compensation shall also be made for the difference in the surface condition and attenuation in the test block and casting.

## 10.0 ACCEPTANCE STANDARD:

Following reference blocks shall be used for ultrasonic examination.

- A. Calibration block as indicated in Fig.1 shall be used for normal beam scanning.
- B. Calibration block as indicated in Fig.2 shall be used for double crystal probe scanning.
- C. Calibration block as indicated in Fig.3 shall be used for angle beam scanning.

10.1 Acceptance criterion for quality levels are specified in the table given below. Applicable quality level/ levels shall be specified in the drawing or the purchase order. Applicable quality level for weld zones, bearing seating areas, deep machining zones, etc., shall be clearly specified in the drawing.

10.2 No indication equal to or greater than DAC over an area specified for applicable quality level of Table 1.

10.3 Indications producing a continuous response equal to or greater than DAC with a dimension exceeding a maximum length shown for the applicable quality level shall be unacceptable.

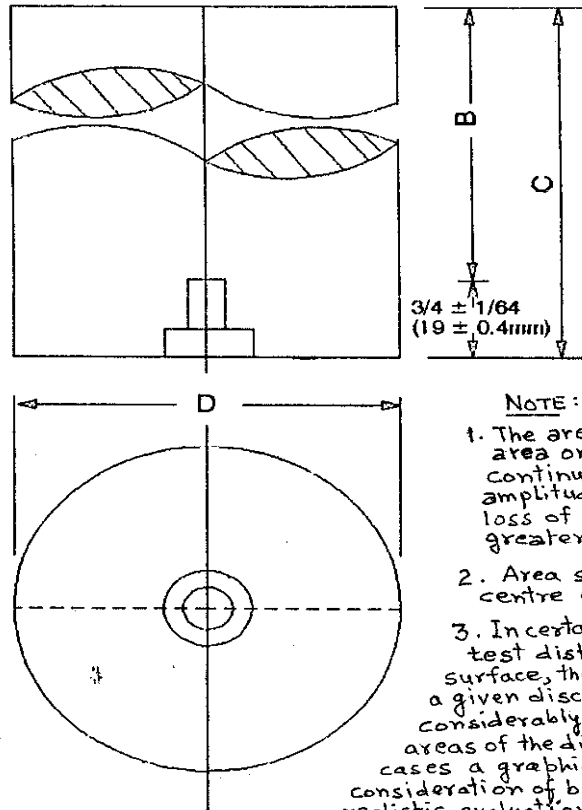
10.4 No reduction of back reflection of 75% or greater that has been determined to be caused by a discontinuity over an area specified for the applicable quality level of Table.1

TABLE 1:- Ultrasonic testing Quality level

Area in <sup>2</sup> (cm <sup>2</sup> )	Max. Length in (mm)
0.8 (5)	1.5 (40)
1.5 (10)	2.2 (55)
3.0 (20)	3.0 (75)
5.0 (30)	3.9 (100)
8.0 (50)	4.8 (120)
12.0 (80)	6.0 (150)
16.0 (100)	6.9 (175)

NOTE: SEE PAGE 5

**FIG. 1 Ultrasonic Standard Reference Block**



**NOTE:**

1. The areas in the table refer to the surface area on the casting over which a continuous indication exceeding the amplitude reference line of a continuous loss of back reflection of 75% or greater is maintained.
2. Area shall be measured from the centre of the search unit.
3. In certain castings, because of very long test distances or curvature of the test surface, the casting surface area over which a given discontinuity is detected may be considerably larger or smaller than the actual areas of the discontinuity in the casting, in such cases a graphic plot that incorporates the consideration of beam spread should be used for realistic evaluation of the discontinuity.

**Notes:**

1. Opposite ends of reference block shall be flat and parallel within 0.001 in (0.025 mm)
2. Bottom of flat-bottom hole shall be flat within 0.002 in (0.050 mm) and the finished diameter shall be  $1/4 + 0.002$  in (6.4 + 0.050 mm)
3. Hole shall be straight and perpendicular to entry surface within 0°, 30 min. and located within 1/32 in. (0.80 mm) of longitudinal axis.
4. Counter bore shall be 1/2 in. (13mm) diameter by 1/8 in (3 mm) deep.

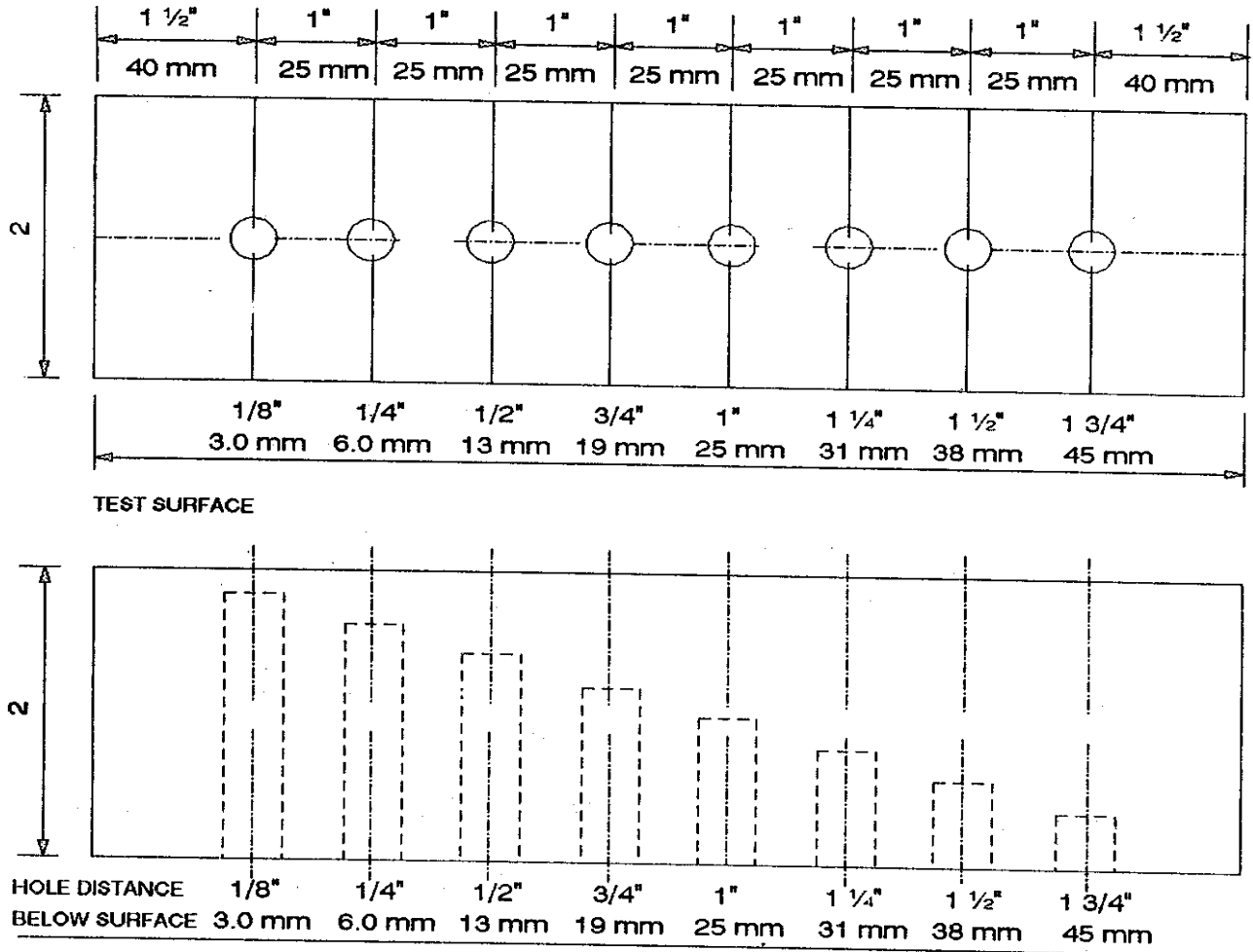
**Dimensions and Identification of Reference blocks in the basic set (See Fig. 1)**

Hole diameter, in 1/64 ths. in. (mm)	Metal distance (B) <sup>A</sup> in. (mm)	Overall length C in. (mm)	Width or diameter D min. in. (mm)	Block Identification number
16(6.30)	1(25)	1 3/4(45)	2(50)	16-0100
16(6.30)	2(50)	2 3/4(70)	2(50)	16-0200
16(6.30)	3(75)	3 3/4(95)	2(50)	16-0300
16(6.30)	6(150)	6 3/4(170)	3(75)	16-0600
16(6.30)	10(255)	10 3/4(275)	4(100)	16-1000
16(6.30)	B	B + 3/4 (B + 20)	5(125)	16-B00 <sup>B</sup>

A - Tolerance  $\pm 1/8$  in. (3 mm)

B - Additional supplemental blocks for testing thickness greater than 10in. (250 mm).

FIG. 2 Ultrasonic Standard Reference Block for Dual-Search Unit Calibration



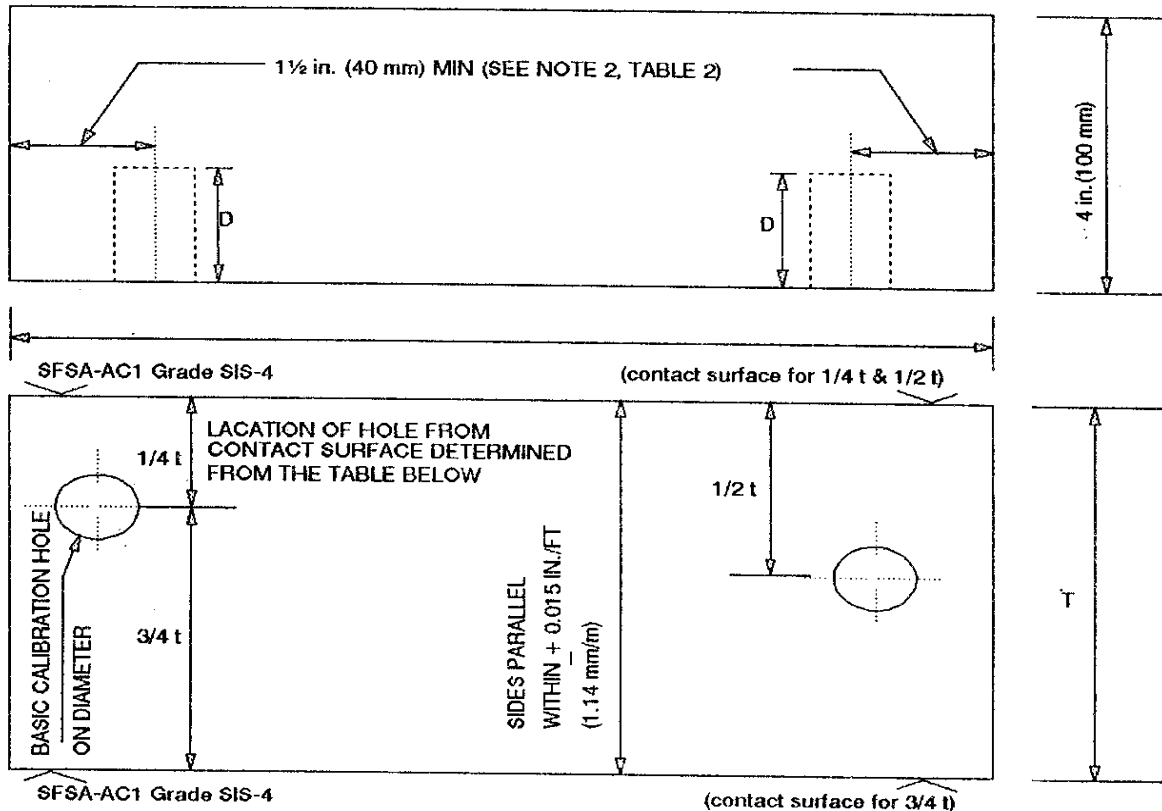
Note 1: Entrant surface shall be 250  $\mu$ in. (6.3  $\mu$ m) or finer.

Note 2: The 3/32 in. (2.4 mm) flat bottom hole must be flat within 0.002 in. (0.050 mm). Diameter must be within +0.005 in. (0.13 mm) of the required diameter. Hole axis must be perpendicular to the block and within an angle of 0°, 30 min.

Note 3: Hole shall be plugged following checking for ultrasonic response.

in.	(mm)	in.	(mm)
1/8	(3)	1 1/4	(32)
1/4	(6)	1 1/2	(38)
1/2	(13)	1 3/4	(44)
3/4	(19)	2	(50)
1	(25)	10	(254)

**FIG. 3 Basic Calibration Block for Angle Beam Examination**



- L = Length of block determined by the angle of search unit and the vee-path used
- T = Thickness of basic calibration block (see table 2)
- D = Depth of the side drilled hole (see table 2)
- d = Diameter of the side drilled hole (see table 2)
- t = nominal production material thickness.

**TABLE 2: Dimensions of Calibration Blocks for Angle-Beam Examination**

- Note 1: For each increase in thickness of 2 in. (50 mm) or a fraction thereof the hole diameter shall increase 1/25 in. (1.0 mm)
- Note 2: For block size over 3 in. (75 mm) in thickness, 'T', the distance from the hole to the end of the block shall be 1/2 T min. to prevent coincident reflections from the hole and the corner. Block fabricated with a 2 in. (50 mm) min. dimension need not be modified if the corner and hole indications can be easily resolved.

Nominal production material thickness (t), in. (mm)	Basic Calibration Block thickness (T) in. (mm)	Hole Diameter (d) in. 1.002 (mm ± 0.05)	Minimum depth (D) in. (mm)
Upto 1 (25) incl.	1 (25) or t	3/32 (2.4)	1 1/2 (40)
Over 1 to 2 (25-50)	2 (50) or t	1/8 (3.2)	1 1/2 (40)
over 2 to 4 (50-100)	4 (100) or t	3/16 (4.8)	1 1/2 (40)
over 4 to 6 (100-150)	6 (150) or t	1/4 (6.3)	1 1/2 (40)
over 6 to 8 (150-200)	8 (200) or t	5/16 (7.9)	1 1/2 (40)
over 8 to 10 (200-250)	10 (250) or t	3/8 (9.5)	1 1/2 (40)
over 10 (250)	t	See Note 1	1 1/2 (40)



EVALUATION AND ACCEPTANCE STANDARD FOR MAGNETIC PARTICLE EXAMINATION OF CASTINGS

1.0 SCOPE:

1.1 This standard is applicable for Magnetic Particle Examination of Castings.

1.2 The procedure adopted for this examination is as per Corporate Standard AA 085 01 33

2.0 DEFINITION OF INDICATIONS:

2.1 Circular indications are those more or less elliptical with major axis not more than three times the minor axis.

2.2 Linear indications are those having length in excess of three times average width.

2.3 In-line indications are those in group of three or more indications aligned side by side in line with intervening gaps of less than 2mm measured edge to edge.

3.0 EVALUATION OF INDICATIONS:

3.1 Discontinuities and defects will be indicated by the retention of magnetic particles. All such indications are not necessarily defects, since exclusive surface roughness, magnetic permeability variations and machining marks may also produce similar indications.

3.2 Any indication suspected to be non-relevant is to be considered relevant till it is proved otherwise.

3.3 Broad areas of particle accumulation which could mask indications or discontinuities are unacceptable and those areas shall be cleaned and re-examined.

3.4 Relevant indications are those which results from unacceptable mechanical discontinuities.

4.0 ACCEPTANCE STANDARD:

5.1 Castings are classified into four levels as detailed below according to the size and number of flaws permissible.

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CS-0346

Approved: INTERPLANT NON-DESTRUCTIVE TESTING COMMITTEE

Table with columns: REV.No., Amd. No., Reaffirmed, Prepared, Issued, Date. Values include DT., Year. 1997, Corp. R&D, CORP: R & D, 10 SEPT 79



# CORPORATE STANDARD

AA 085 01 34

PAGE 2 OF 2

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Level	No. & size of acceptable indications per 100 sq. cm. area and length not exceeding 25 cm.	Unacceptable indications.
1	2 Nos. of 3mm long indication.	Cracks & hot tears.
2	3 Nos. of 3mm long indication. One of 5mm long indication.	-do-
3	3 Nos. of 3mm long indication. 2 Nos. of 4mm long indication. One of 6mm long indication. One in line indication of - (10mm Max. lgth. )	-do-
4	4 Nos. of 3mm long indication. 3 Nos. of 4mm long indication. 2 Nos. of 8mm long indication. One in line indication of - (15mm Max. lgth. )	-do-

Note: The minimum permissible distance between any two or more acceptable individual flaws shall not be less than the major dimension of the larger flaw.

CS-0346

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