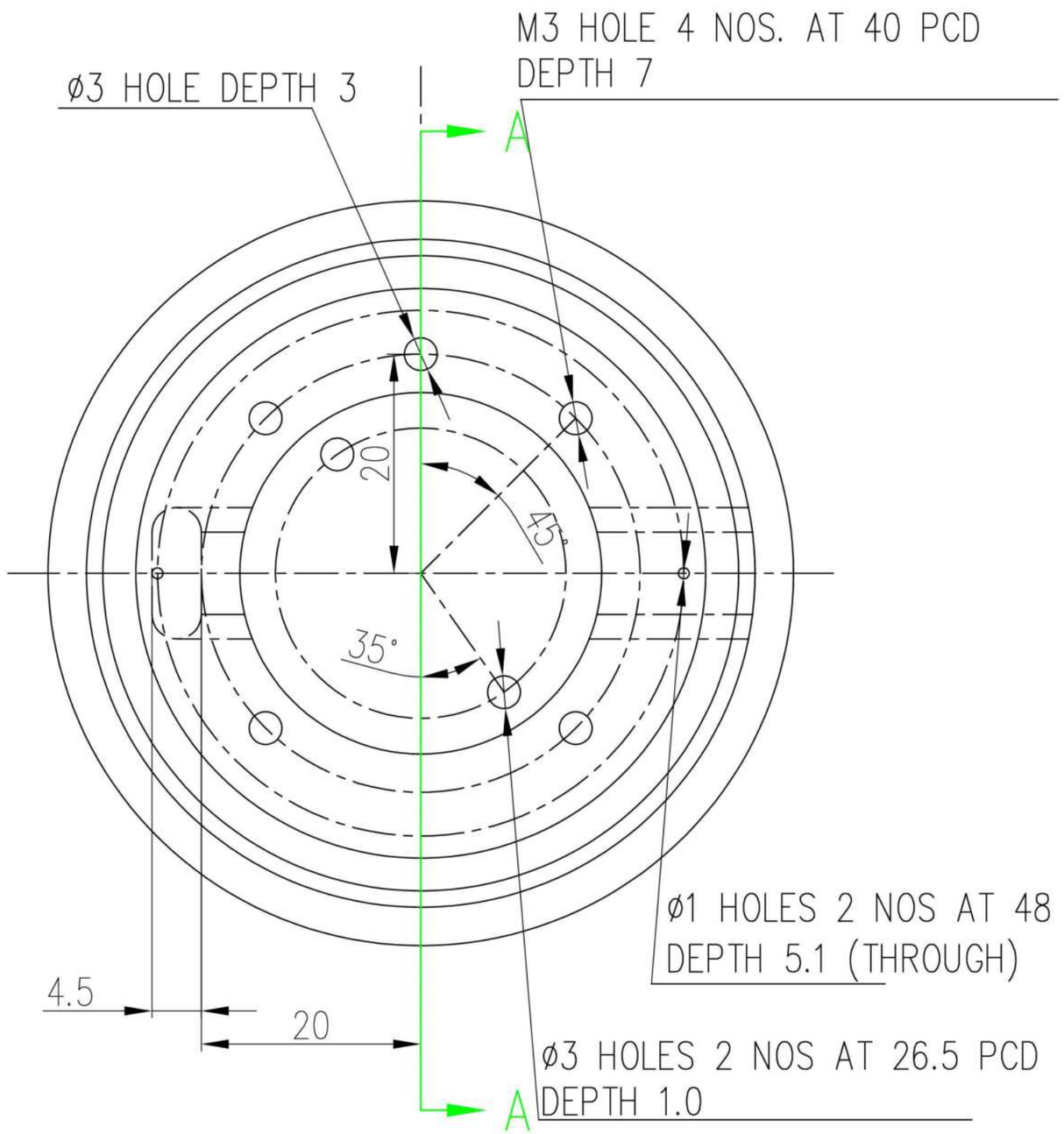
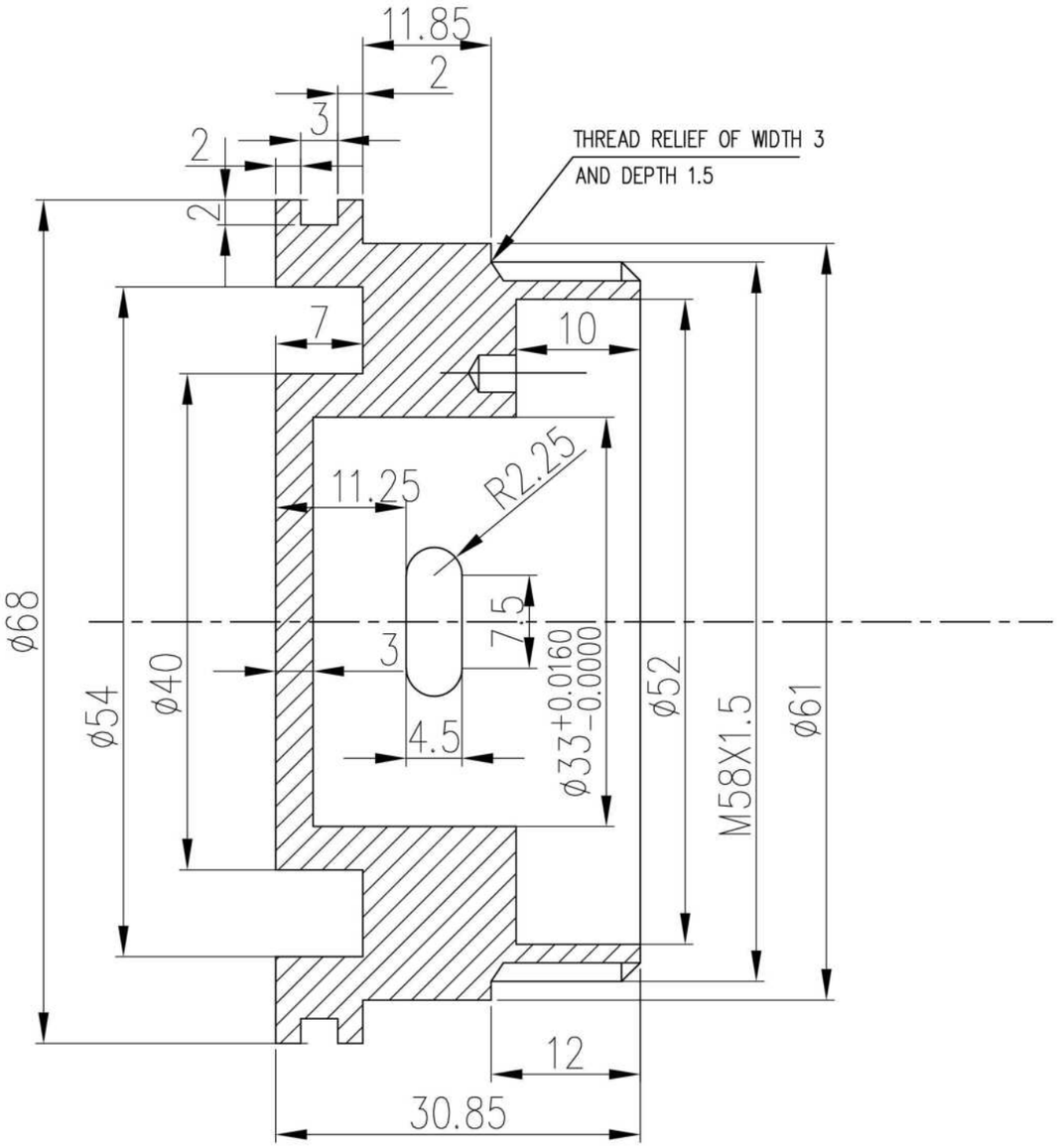
FIRST ANGLE PROJECTION

(ALL DIMENSIONS ARE IN mm)





SECTION A–A

NOTE: 1. CARRY OUT ULTRASONIC TEST AS PER NDT 006 ON RAW MATERIAL
2. CARRY OUT FLUROSCENT DYE PENETRANT CHECK AS PER NDT 015 ON FINISHED PRODUCT
3. CARRY OUT THE DIMENSIONAL INSPECTION
4. REFER TO HY0230261 REV.03 FOR UNSPECIFIED TOLERANCES

Titanium Ti-6Al-4V (Grade 5)	0.195	
AMS 4928	1	
MATL. CODE	NET.WT. (KG)	GROSS WT
MATL. SPECN.	QTY.	

REV.	DATE		
01	30-03-2023	ALTERED	M NAVEEN
		CHECKED	D PAVITRAN
		APPROVED	G R RAO

ADDED NOTES

NAME OF CUSTOMER/PROJECT

PUMP MODULE FOR LCS–ADA

BHARAT HEAVY ELECTRICALS LTD.
CORPORATE R&D, HYDERABAD

DEPT. HTF		CODE 45	
	NAME	SIGN.	DATE
DRN.	M NAVEEN		28-02-2022
CHD.	D PAVITRAN		28-02-2022
APPD.	G R RAO		28-02-2022

SCALE NTS

MODEL CASING SUCTION

REF.TO ASSY.DRG.	ITEM NO.	NO. OF ITEM
2-PM-45-00101	8	15

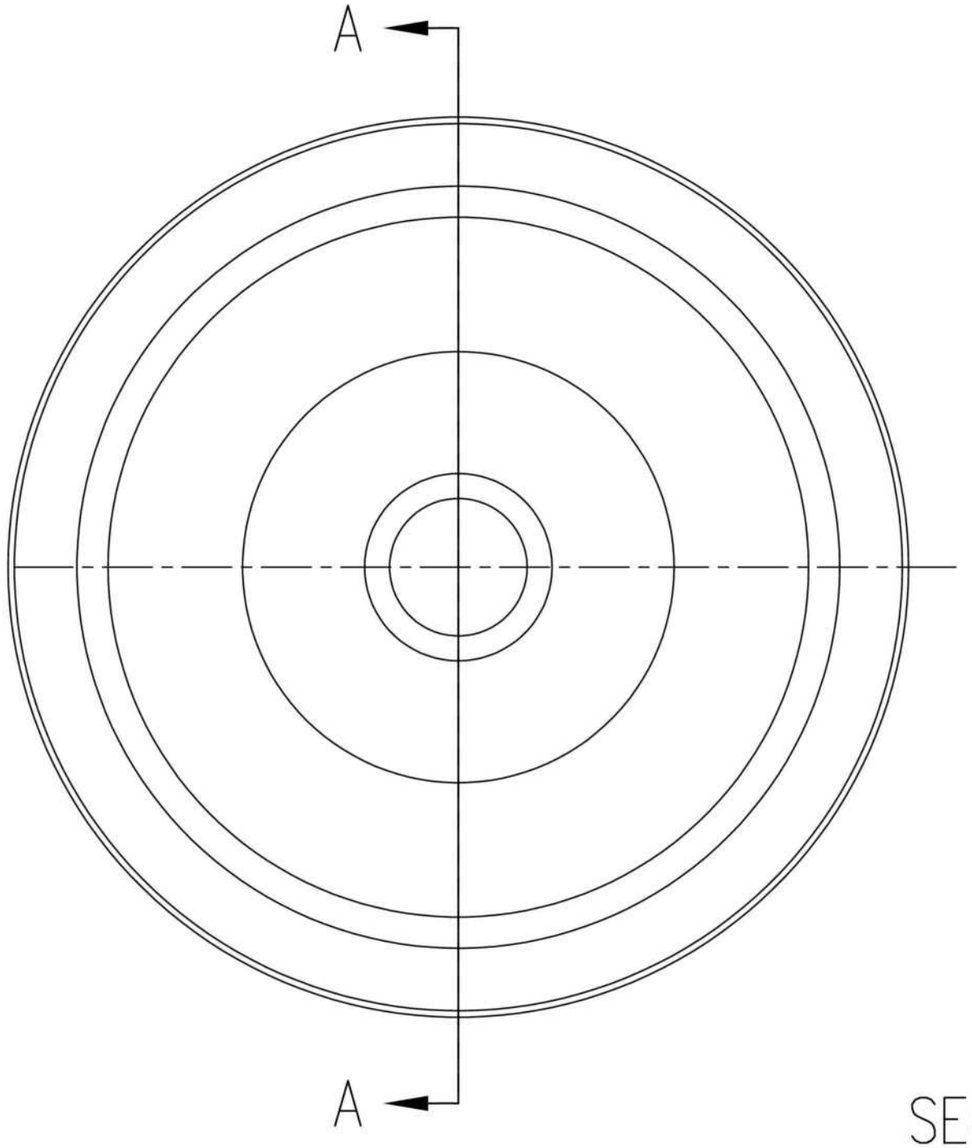
DRAWING NO. 3-PM-45-00004 REV. 01

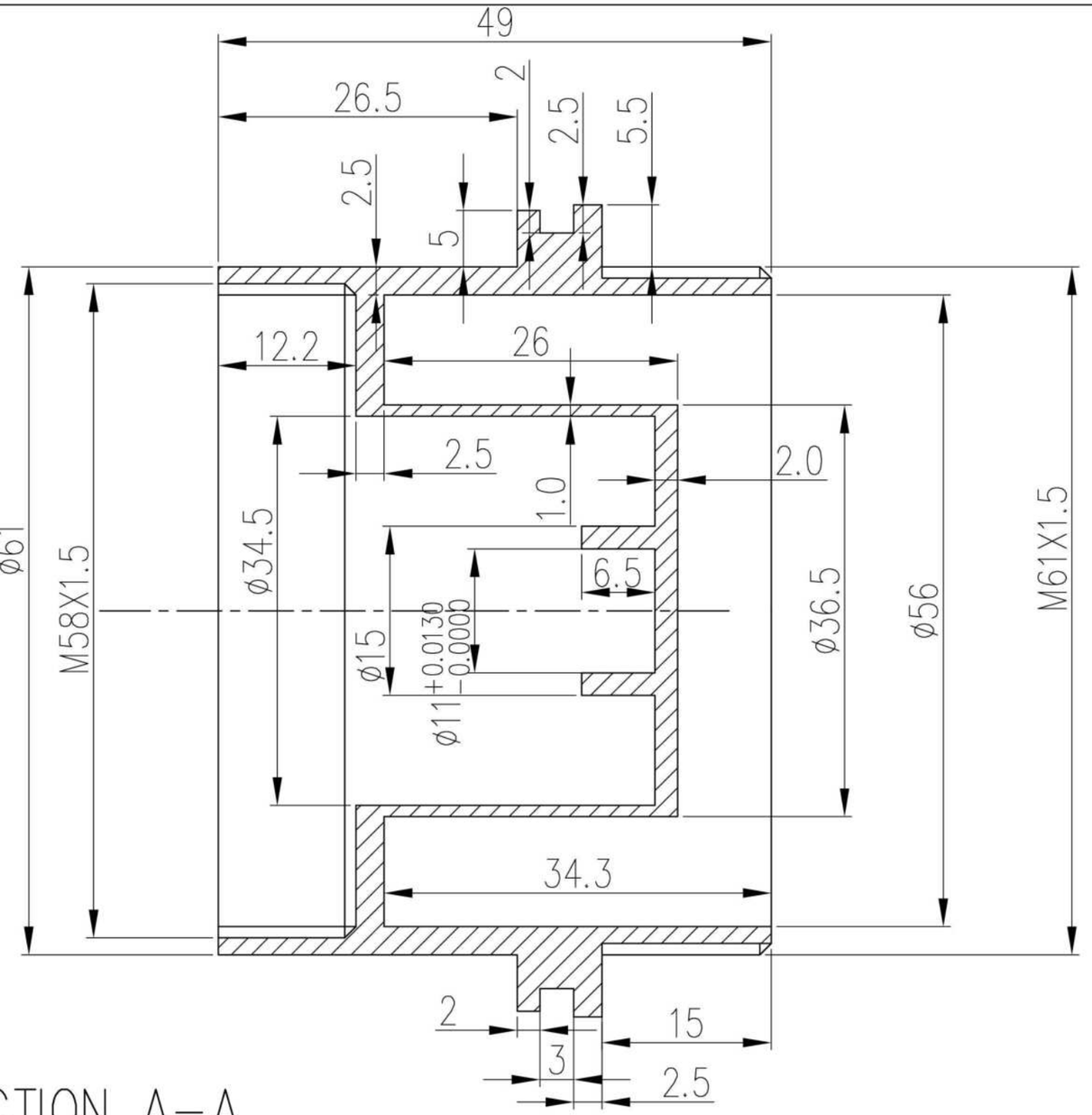
SHEET No. 1 NO OF SHEETS 1

INVENTORY NO | SIGN. AND DATE | REF. DRG. NO.

FIRST ANGLE PROJECTION

(ALL DIMENSIONS ARE IN mm)





SECTION A–A

NOTE: 1. CARRY OUT ULTRASONIC TEST AS PER NDT 006 ON RAW MATERIAL
2. CARRY OUT FLUROSCENT DYE PENETRANT CHECK AS PER NDT 015 ON FINISHED PRODUCT
3. CARRY OUT THE DIMENSIONAL INSPECTION
4. REFER TO HY0230261 REV.03 FOR UNSPECIFIED TOLERANCES

INVENTORY NO	SIGN. AND DATE	REF. DRG. NO.

Titanium Ti-6Al-4V (Grade 5)	0.166	
AMS 4928	1	
MATL. CODE	NET.WT. (KG)	GROSS WT
MATL. SPECN.	QTY.	

REV.	DATE		
01	30-03-2023	ALTERED	M NAVEEN
		CHECKED	D PAVITRAN
		APPROVED	G R RAO

ADDED NOTES

NAME OF CUSTOMER/PROJECT

PUMP MODULE FOR LCS–ADA

BHARAT HEAVY ELECTRICALS LTD.
CORPORATE R&D, HYDERABAD

DEPT. HTF		CODE 45	
	NAME	SIGN.	DATE
DRN.	M NAVEEN		28-02-2022
CHD.	D PAVITRAN		28-02-2022
APPD.	G R RAO		28-02-2022

SCALE 2:1

MODEL CASING DRIVE–END

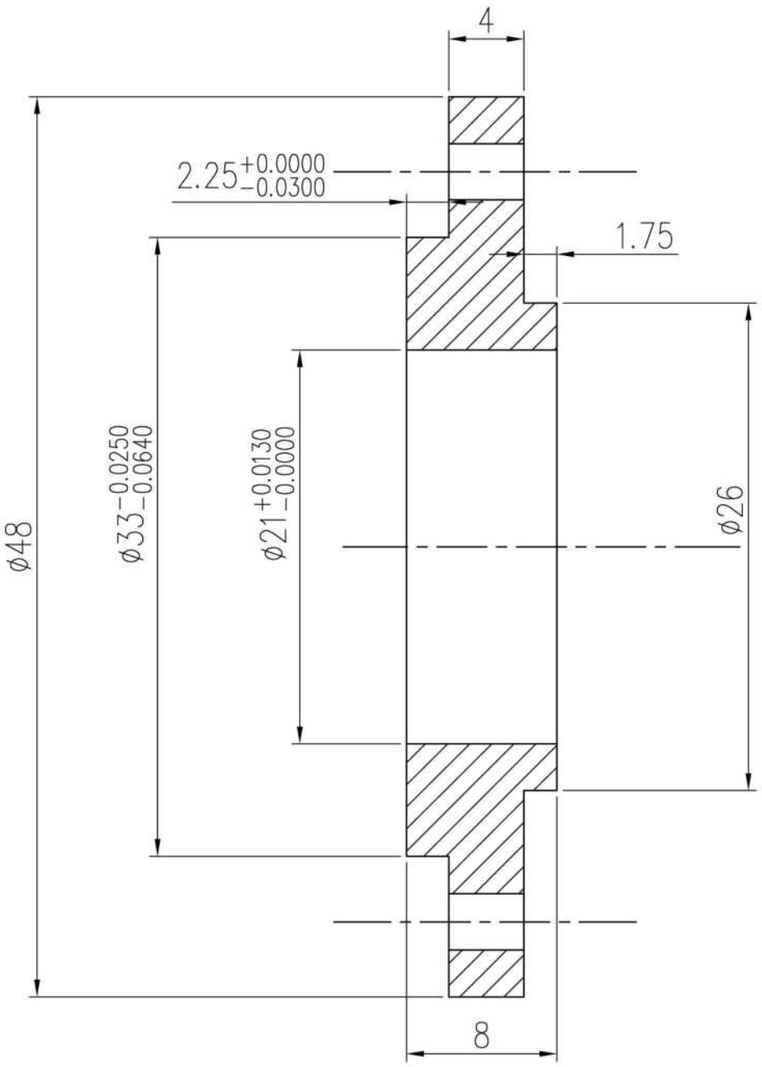
REF.TO ASSY.DRG.	ITEM NO.	NO. OF ITEM
2–PM–45–00101	9	15

DRAWING NO. 3–PM–45–00005 REV. 01

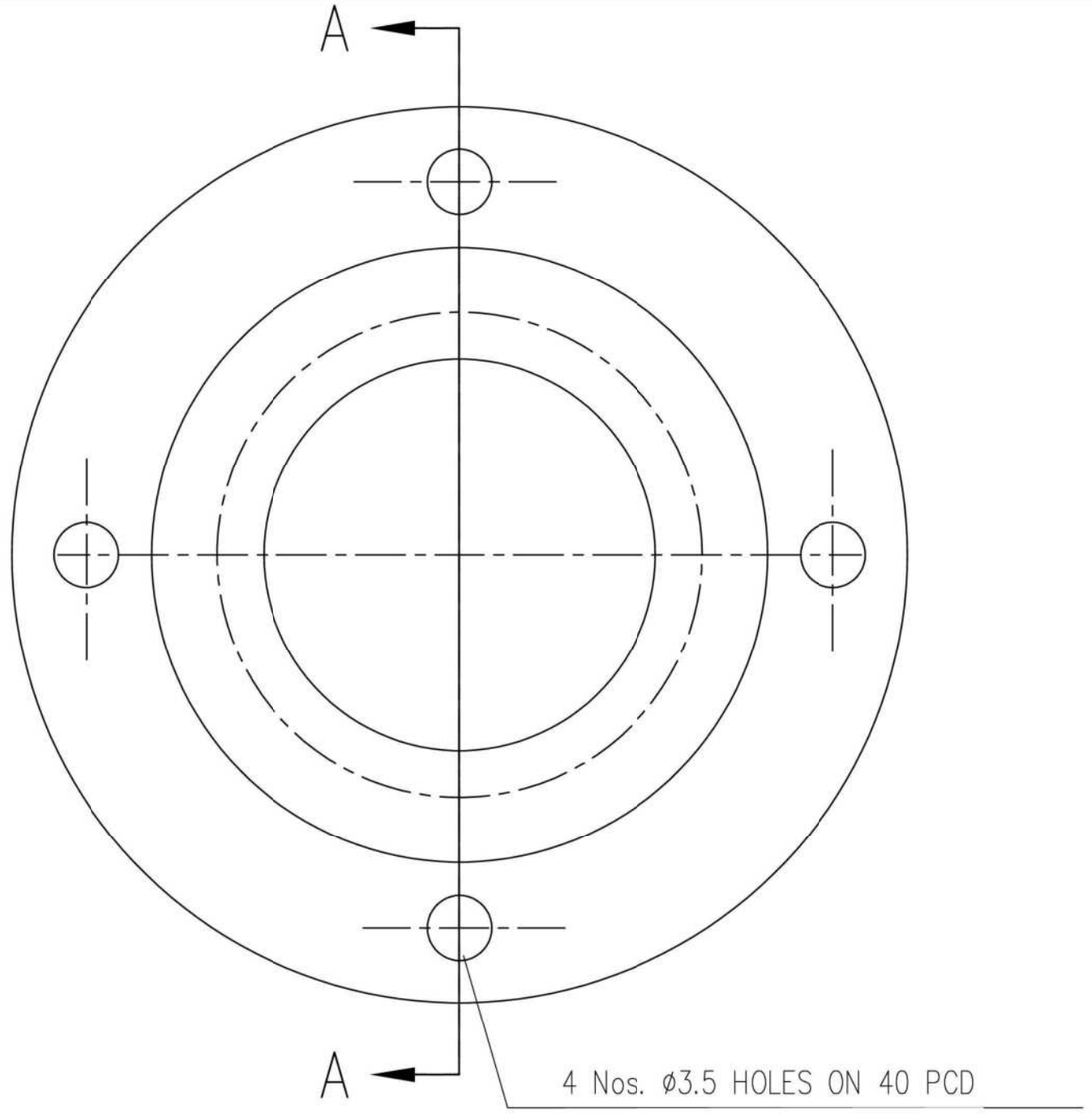
SHEET No. 1 NO OF SHEETS 1

FIRST ANGLE PROJECTION

(ALL DIMENSIONS ARE IN mm)



SECTION A–A



REF. DRG. NO.

SIGN. AND DATE

INVENTORY NO

NOTE: 1. CARRY OUT ULTRASONIC TEST AS PER NDT 006 ON RAW MATERIAL
2. CARRY OUT FLUROSCENT DYE PENETRANT CHECK AS PER NDT 015 ON FINISHED PRODUCT
3. CARRY OUT THE DIMENSIONAL INSPECTION
4. REFER TO HY0230261 REV.03 FOR UNSPECIFIED TOLERANCES

Titanium Ti-6Al-4V (Grade 5)	0.032	
AMS 4928	1	
MATL. CODE	NET.WT. (KG)	GROSS WT
MATL. SPECN.	QTY.	

REV.	DATE		
01	30-03-2023	ALTERED	M NAVEEN
		CHECKED	D PAVITRAN
		APPROVED	G R RAO

ADDED NOTES

NAME OF CUSTOMER/PROJECT

PUMP MODULE FOR LCS–ADA

BHARAT HEAVY ELECTRICALS LTD.
CORPORATE R&D, HYDERABAD

DEPT. HTF		CODE 45	
	NAME	SIGN.	DATE
DRN.	M NAVEEN		21-02-2022
CHD.	D PAVITRAN		21-02-2022
APPD.	G R RAO		21-02-2022

REF. TO ASSY. DRG.	ITEM NO.	NO.OF ITEM.
2–PM–45–00101	5	15

SCALE 3:1

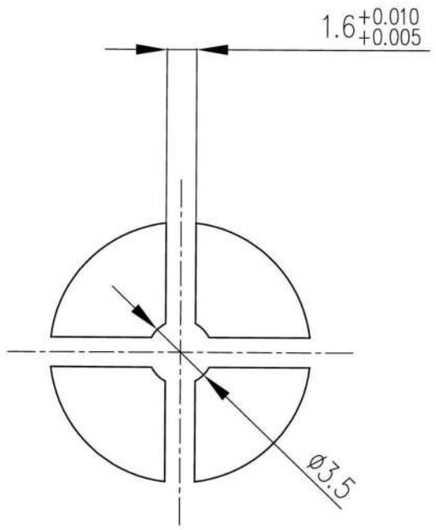
MODEL END COVER PLATE

DRAWING NO. 3–PM–45–00006 REV. 01

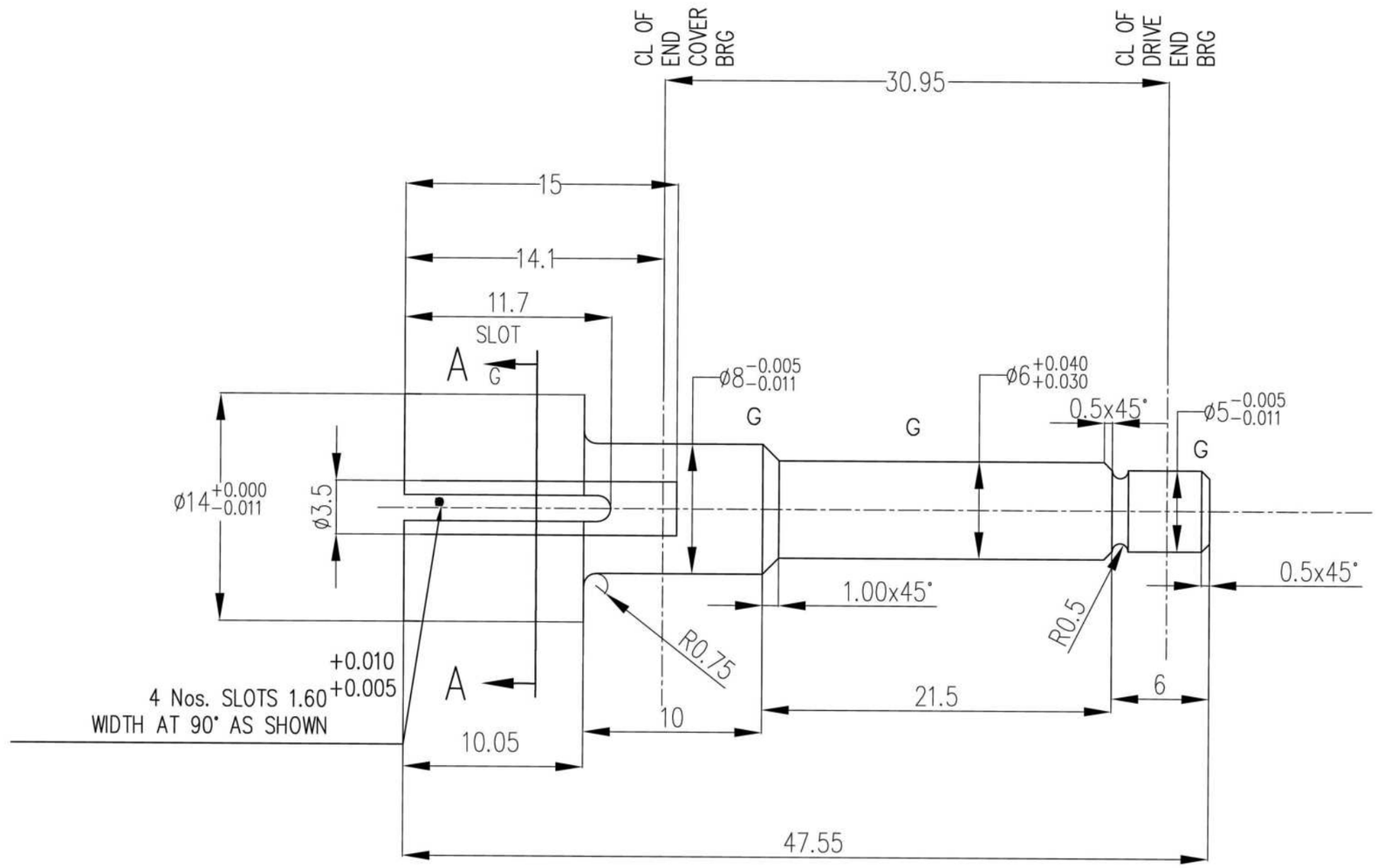
SHEET No. 1 NO OF SHEETS 1

FIRST ANGLE PROJECTION

(ALL DIMENSIONS ARE IN mm)



SECTION A–A



NOTE: 1. CARRY OUT ULTRASONIC TEST AS PER NDT 006 ON RAW MATERIAL
2. CARRY OUT FLUROSCENT DYE PENETRANT CHECK AS PER NDT 015 ON FINISHED PRODUCT
3. CARRY OUT THE DIMENSIONAL INSPECTION
4. GENERAL TOLERANCE +0.000
−0.050
5. 60 (+/−6) HRC UPTO 0.05MM DEPTH SHALL BE OBTAINED AFTER MACHINING THROUGH HARDENING

INVENTORY NO	SIGN. AND DATE	REF. DRG. NO.

EN 25	0.018	
BS 2S 96	1	
MATL. CODE	NET.WT. (KG)	GROSS WT
MATL. SPECN.	QTY.	

REV.	DATE	
01	30-03-2023	ALTERED M NAVEEN
		CHECKED D PAVITRAN
		APPROVED G R RAO

ADDED NOTES

TYPE OF PRODUCT OR NAME OF CUSTOMER/PROJECT: PUMP MODULE FOR LCS–ADA

BHARAT HEAVY ELECTRICALS LTD.
CORPORATE R&D, HYDERABAD

	NAME	SIGN	DATE
DRN.	M NAVEEN		26-02-2022
CKD.	D PAVITRAN		26-02-2022
APPD.	G R RAO		26-02-2022

NO.OF VAR.

DEPT.		SCALE	WEIGHT(K.G.)	REF.TO ASSY.DRG.	ITEM NO.	NO.OF ITEM
HTF		3:1		2-PM-45-00101	2	15
CODE 45						

TITLE: SHAFT

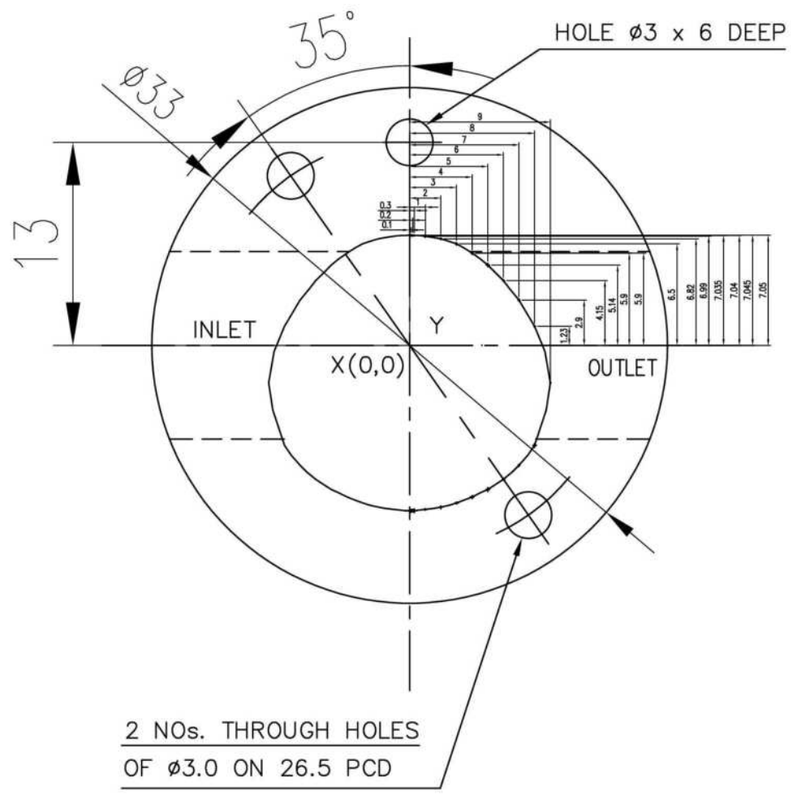
DRAWING NO. 3-PM-45-00007 REV. 01

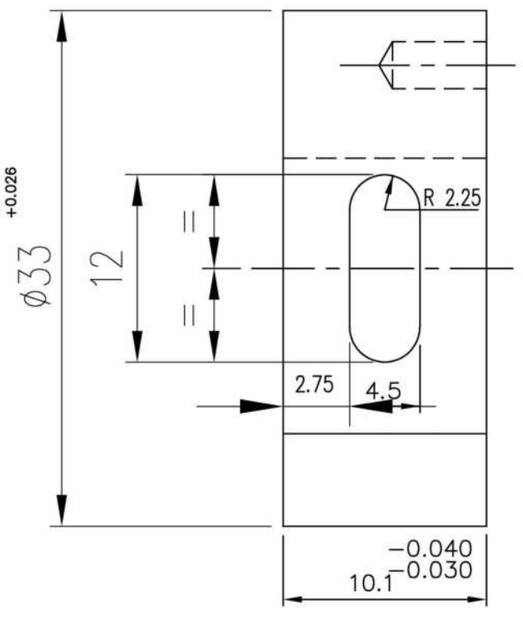
SHT.NO. 01 NO.OF SHT. 01

FIRST ANGLE PROJECTION

(ALL DIMENSIONS ARE IN mm)

S.No.	X	Y
1.	0.0	7.05
2.	0.1	7.045
3.	0.2	7.04
4.	0.3	7.035
5.	1.0	6.99
6.	2.0	6.82
7.	3.0	6.50
8.	4.0	5.90
9.	5.0	5.14
10.	6.0	4.15
11.	7.0	2.90
12.	8.0	1.23
13.	9.0	−2.40
14.	8.0	−6.40
15.	7.0	−7.68
16.	6.0	−8.57
17.	5.0	−9.21
18.	4.0	−9.705
19.	3.0	−10.08
20.	2.0	−10.35
21.	1.0	−10.50
22.	0.3	−10.57
23.	0.2	−10.57
24.	0.1	−10.57
25.	0.0	−10.57





NOTE:
1. CARRY OUT ULTRASONIC TEST AS PER NDT 006 ON RAW MATERIAL
2. CARRY OUT FLUROSCENT DYE PENETRANT CHECK AS PER NDT 015 ON FINISHED PRODUCT
3. CARRY OUT THE DIMENSIONAL INSPECTION
4. GENERAL TOLERANCE +0.050
   −0.000
5. 60(+/−5) HRC SHALL BE OBTAINED AFTER MACHINING THROUGH HARDENING
6. HALF CAMRING PROFILE GEOMETRY IN X−Y CO−ORDINATE SYSTEM IS GIVEN ABOVE. OTHER HALF IS MIRROR IMAGE OF THE GIVEN DATA

REF. DRG. NO.	SIGN. AND DATE	INVENTORY NO

EN 31	0.04	
BS S 135	1	
MATL. CODE	NET.WT. (KG)	GROSS WT
MATL. SPECN.	QTY.	

REV.	DATE		
01	30-03-2023	ALTERED	M NAVEEN
		CHECKED	D PAVITRAN
		APPROVED	G R RAO

ADDED NOTES

NAME OF CUSTOMER/PROJECT

PUMP MODULE FOR LCS−ADA

BHARAT HEAVY ELECTRICALS LTD.
CORPORATE R&D, HYDERABAD

DEPT. HTF CODE 45

	NAME	SIGN.	DATE
DRN.	M NAVEEN		25-02-2022
CHD.	D PAVITRAN		25-02-2022
APPD.	G R RAO		25-02-2022

REF. TO ASSY.DRG.	ITEM NO.	NO.OF ITEM.
2-PM-45-00101	3	15

SCALE NTS

DRAWING NO. 3-PM-45-00010 REV. 01

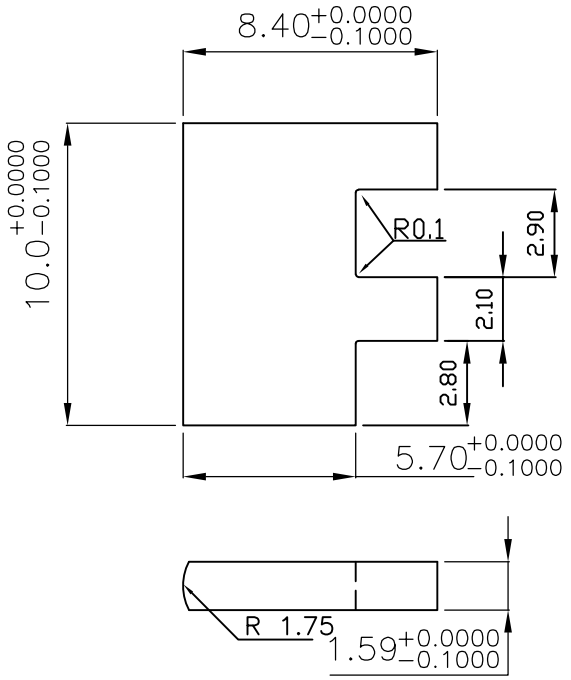
TITLE CAM RING

SHEET No. 1 NO OF SHEETS 1

FIRST ANGLE PROJECTION

ALL DIMENSIONS ARE IN mm.

REV.	DATE	ALTERED	REV.	DATE	ALTERED	REV.	DATE	ALTERED M NAVEEN
		CHECKED			CHECKED	01	30-03-2023	CHECKED PAVITRAN
		APPROVED			APPROVED			APPROVED G R RAO
								ADDED NOTES



NOTE:
1. CARRY OUT ULTRASONIC TEST AS PER NDT 006 ON RAW MATERIAL
2. CARRY OUT FLUROSCENT DYE PENETRANT CHECK AS PER NDT 015 ON FINISHED PRODUCT
3. CARRY OUT THE DIMENSIONAL INSPECTION
4. REFER TO HY0230261 REV.03 FOR UNSPECIFIED TOLERANCES
5. 60 (+/−5) HRC SHALL BE OBTAINED AFTER MACHINING THROUGH HARDENING

EN 31	0.00084	
BS S 135	4	
MATL. CODE	NET.WT. (KG)	GROSS WT
MATL. SPECN.	QTY.	

TYPE OF PRODUCT OR NAME OF CUSTOMER/PROJECT: PUMP MODULE FOR LCS−ADA

BHARAT HEAVY ELECTRICALS LTD.
CORPORATE R&D, HYDERABAD

	NAME	SIGN	DATE
DRN.	M NAVEEN		24-02-2022
CKD.	D PAVITRAN		24-02-2022
APPD.	G R RAO		24-02-2022

DEPT. HTF		SCALE 4:1	REF.TO ASSY.DRG. 2−PM−45−00101	ITEM NO. 1	NO.OF ITEM 15
CODE 45					

TITLE: PUMP VANE

DRAWING NO. 4−PM−45−00009 REV. 01

SHT.NO. 01 NO.OF SHT. 01

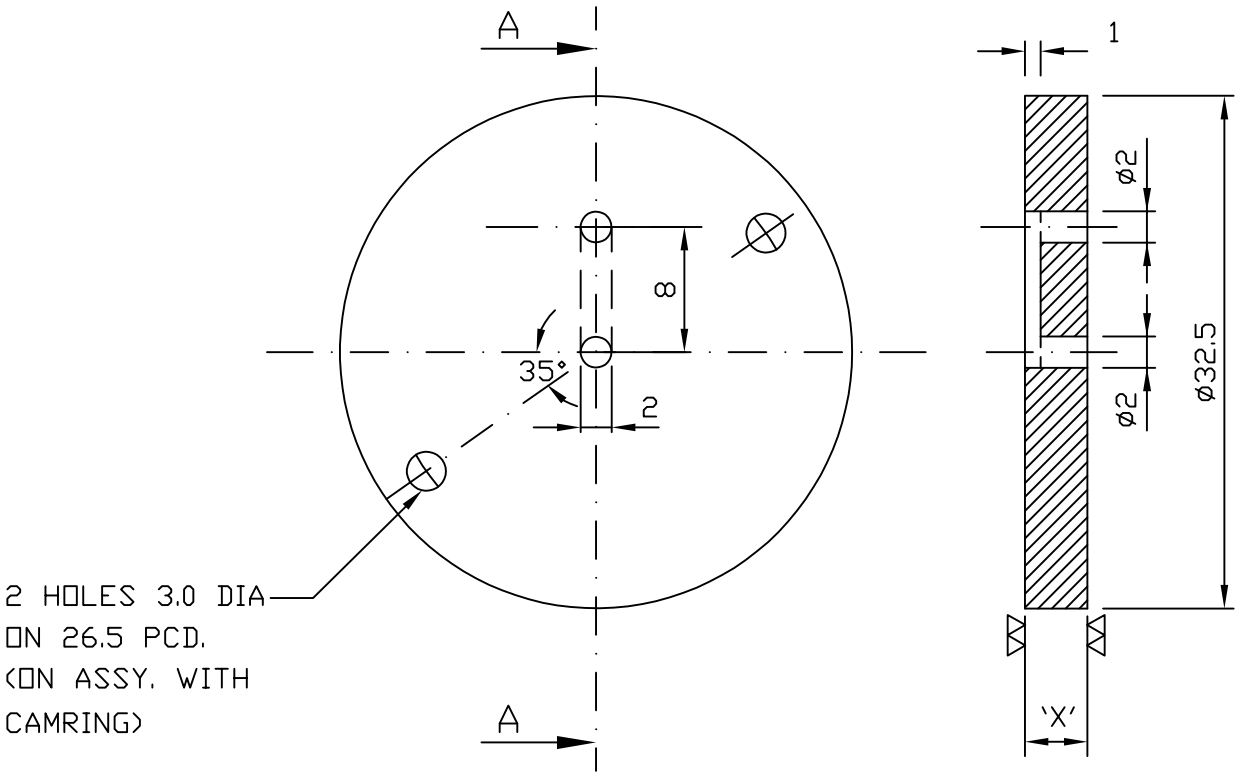
INVENTORY NO. | SIGN. & DATE | REF. DRG. NO. | COMPUTER NO.

FIRST ANGLE PROJECTION

ALL DIMENSIONS ARE IN mm.

REV.	DATE	ALTERED / CHECKED / APPROVED
01	30-03-2023	ALTERED M NAVEEN CHECKED PAVITRAN APPROVED G R RAO

ADDED NOTES



SECTION-AA

NOTE:
1. CARRY OUT ULTRASONIC TEST AS PER NDT 006 ON RAW MATERIAL
2. CARRY OUT FLUROSCENT DYE PENETRANT CHECK AS PER NDT 015 ON FINISHED PRODUCT
3. CARRY OUT THE DIMENSIONAL INSPECTION
4. MINIMUM THICKNESS 5.5mm SUGGESTED
5. THICKNESS 'X' TO BE ADJUSTED FOR PROPER ASSEMBLY ON FINAL INSPECTION OF OTHER COMPONENTS
6. REFER TO HY0230261 REV.03 FOR UNSPECIFIED TOLERANCES

Phosphor Bronze	0.0388	
BS-1400-PB-1	1	
MATL. CODE	NET.WT. (KG)	GROSS WT
MATL. SPECN.	QTY.	

TYPE OF PRODUCT OR NAME OF CUSTOMER/PROJECT: PUMP MODULE FOR LCS-ADA

BHARAT HEAVY ELECTRICALS LTD.
CORPORATE R&D, HYDERABAD

	NAME	SIGN	DATE
DRN.	M NAVEEN		21-02-2022
CKD.	D PAVITRAN		21-02-2022
APPD.	G R RAO		21-02-2022

DEPT.	SCALE	REF.TO ASSY.DRG.	ITEM NO.	NO.OF ITEM
HTF	NTS	2-PM-45-00101	4	15
CODE 45				

TITLE: THRUST PAD

DRAWING NO. 4-PM-45-00011 REV. 01

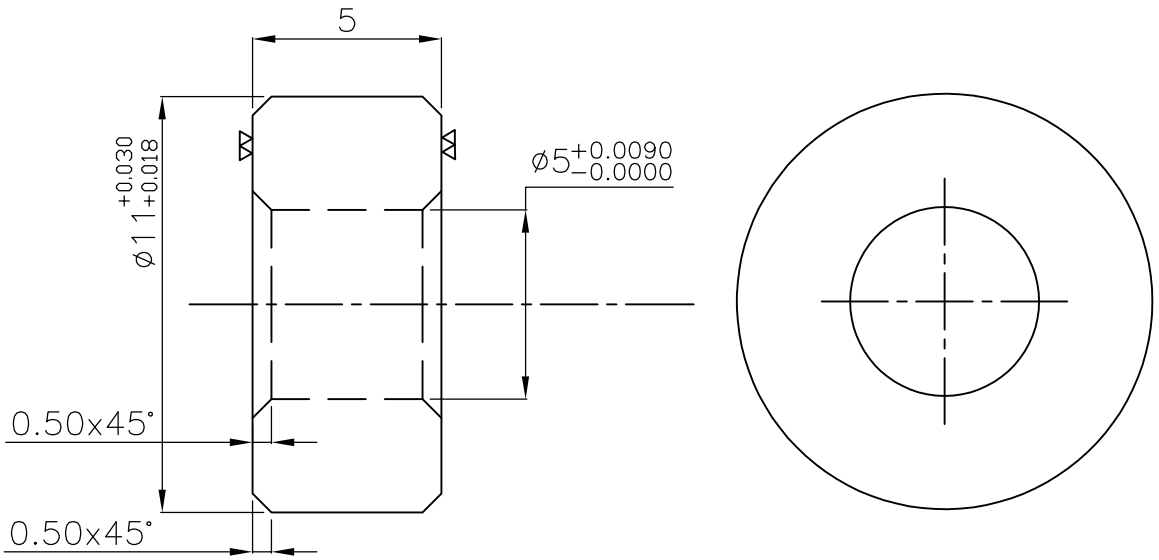
SHT.NO. 01 NO.OF SHT. 01

INVENTORY NO. | SIGN. & DATE | REF. DRG. NO. | COMPUTER NO.

FIRST ANGLE PROJECTION

ALL DIMENSIONS ARE IN mm.

REV.	DATE	ALTERED	REV.	DATE	ALTERED	REV.	DATE	ALTERED M NAVEEN
		CHECKED			CHECKED	01	30-03 -2023	CHECKED PAVITRAN
		APPROVED			APPROVED			APPROVED G R RAO
								ADDED NOTES



NOTE: 1. CARRY OUT ULTRASONIC TEST AS PER NDT 006 ON RAW MATERIAL
2. CARRY OUT FLUROSCENT DYE PENETRANT CHECK AS PER NDT 015 ON FINISHED PRODUCT
3. CARRY OUT THE DIMENSIONAL INSPECTION
4. REFER TO HY0230261 REV.03 FOR UNSPECIFIED TOLERANCES

Phosphor Bronze	0.0032	
BS−1400−PB−1	1	
MATL. CODE	NET.WT. (KG)	GROSS WT
MATL. SPECN.	QTY.	

TYPE OF PRODUCT OR NAME OF CUSTOMER/PROJECT: PUMP MODULE FOR LCS−ADA

BHARAT HEAVY ELECTRICALS LTD.
CORPORATE R&D, HYDERABAD

	NAME	SIGN	DATE
DRN.	M NAVEEN		21−02−2022
CKD.	D PAVITRAN		21−02−2022
APPD.	G R RAO		21−02−2022

DEPT. HTF		SCALE 5:1	REF.TO ASSY.DRG. 2−PM−45−00101	ITEM NO. 7	NO.OF ITEM 15
CODE 45					

TITLE: BEARING BUSH − DRIVE END

DRAWING NO. 4−PM−45−00012 REV. 01

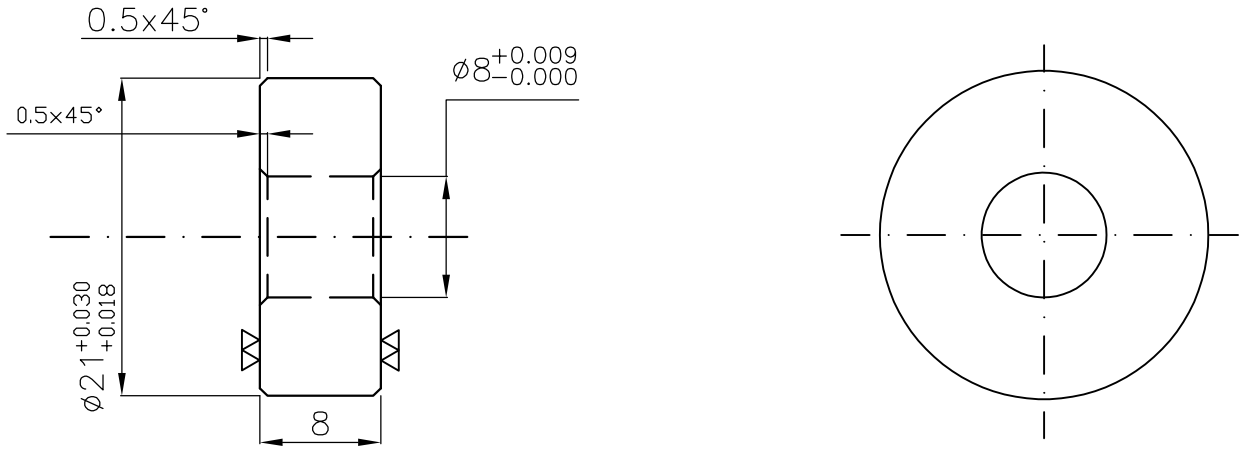
SHT.NO. 01 NO.OF SHT. 01

INVENTORY NO. | SIGN. & DATE | REF. DRG. NO. | COMPUTER NO. | THE INFORMATION ON THIS DOCUMENT IS THE PROPERTY OF BHARAT HEAVY ELECTRICALS LIMITED. IT MUST NOT BE USED DIRECTLY OR INDIRECTLY IN ANY WAY DETRIMENTAL TO THE INTEREST OF THE COMPANY.

FIRST ANGLE PROJECTION

ALL DIMENSIONS ARE IN mm.

REV.	DATE	ALTERED	REV.	DATE	ALTERED	REV.	DATE	ALTERED M NAVEEN
		CHECKED			CHECKED	01	30-03 -2023	CHECKED PAVITRAN
		APPROVED			APPROVED			APPROVED G R RAO
								ADDED NOTES



NOTE: 1. CARRY OUT ULTRASONIC TEST AS PER NDT 006 ON RAW MATERIAL
2. CARRY OUT FLUROSCENT DYE PENETRANT CHECK AS PER NDT 015 ON FINISHED PRODUCT
3. CARRY OUT THE DIMENSIONAL INSPECTION
4. REFER TO HY0230261 REV.03 FOR UNSPECIFIED TOLERANCES

Phosphor Bronze	0.02	
BS−1400−PB−1	1	
MATL. CODE	NET.WT. (KG)	GROSS WT
MATL. SPECN.	QTY.	

TYPE OF PRODUCT OR NAME OF CUSTOMER/PROJECT: PUMP MODULE FOR LCS−ADA

BHARAT HEAVY ELECTRICALS LTD.
CORPORATE R&D, HYDERABAD

	NAME	SIGN	DATE
DRN.	M NAVEEN		21−02−2022
CKD.	D PAVITRAN		21−02−2022
APPD.	G R RAO		21−02−2022

DEPT. HTF		SCALE		REF.TO ASSY.DRG.	ITEM NO.	NO.OF ITEM
CODE 45		2:1		2−PM−45−00101	6	15

TITLE: BEARING BUSH − END COVER PLATE

DRAWING NO. 4−PM−45−00013 REV. 01

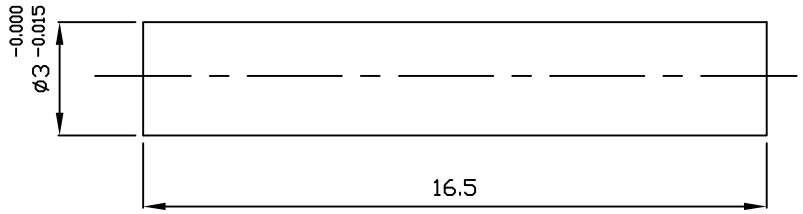
SHT.NO. 01 NO.OF SHT. 01

INVENTORY NO. | SIGN. & DATE | REF. DRG. NO. | COMPUTER NO.

FIRST ANGLE PROJECTION

ALL DIMENSIONS ARE IN mm.

REV.	DATE	ALTERED	REV.	DATE	ALTERED	REV.	DATE	ALTERED M NAVEEN
		CHECKED			CHECKED	01	30-03-2023	CHECKED PAVITRAN
		APPROVED			APPROVED			APPROVED G R RAO
								ADDED NOTES



NOTE: 1. CARRY OUT ULTRASONIC TEST AS PER NDT 006 ON RAW MATERIAL
2. CARRY OUT FLUROSCENT DYE PENETRANT CHECK AS PER NDT 015 ON FINISHED PRODUCT
3. CARRY OUT THE DIMENSIONAL INSPECTION
4. REFER TO HY0230261 REV.03 FOR UNSPECIFIED TOLERANCES
5. LOCATING PIN FOR CASING SUCTION, THRUST PAD AND CAM RING

Titanium Ti-6Al-4V (Grade 5)	0.00052	
AMS 4928	02	
MATL. CODE	NET.WT. (KG)	GROSS WT
MATL. SPECN.	QTY.	

TYPE OF PRODUCT OR NAME OF CUSTOMER/PROJECT: PUMP MODULE FOR LCS-ADA

BHARAT HEAVY ELECTRICALS LTD.
CORPORATE R&D, HYDERABAD

	NAME	SIGN	DATE
DRN.	M NAVEEN		28-02-2022
CKD.	D PAVITRAN		28-02-2022
APPD.	G R RAO		28-02-2022

DEPT.	SCALE	REF.TO ASSY.DRG.	ITEM NO.	NO.OF ITEM
HTF	5:1	2-PM-45-00101	10	15
CODE 45				

TITLE	DRAWING NO.	REV.
PIN	4-PM-45-00014	01
	SHT.NO. 01	NO.OF SHT. 01

COMPUTER NO. | REF. DRG. NO. | SIGN. & DATE | INVENTORY NO.

LIST OF APPLICABLE STANDARDS ON LIMITS, FITS AND TOLERANCES

1.0 SCOPE:

The standard covers the list of applicable standards on Limits, Fits and Tolerances. These standards are applicable unless or otherwise specified.

2.0 LIST OF APPLICABLE STANDARDS:

SL. NO.	STANDARD NO.		TITLE
1.	AA0230201	-	Limits and Fits (Tolerance grade, Position and Class).
2.	AA0230202	-	Limits and sizes for commercial bolts and nuts.
3.	AA0230204	-	Guide for selection of Fits.
4.	AA0230206	-	Standard limits for Shafts (upto 500 mm).
5.	AA0230207	-	Standard limits for Shafts (above 500 mm and upto 3150 mm).
6.	AA0230208	-	Allowable deviations for dimensions without specified tolerances (linear and angular).
7.	AA0230402	-	Permissible deviations for untoleranced dimensions of castings.
8.	AA0230403	-	Tolerancing system ISO Metric Screw Threads
9.	AA0621101	-	Tolerances and Machining allowances for Flame cutting.
10.	AA0621104	-	General tolerances for welding constructions for length and angles.
11.	AA0621105	-	General tolerances for welded structures – form and position.

NOTE:

1) AA 023 02 08

Medium class of deviation is applicable, if the same is not mentioned on the drgs./specs.

2) AA 023 04 02

Tolerance class 5 is applicable, if the same is not mentioned on the drgs./specs.

3) AA 062 11 04

Accuracy class A is applicable if the same is not mentioned on the drgs.

4) AA 062 11 05

Accuracy class E is applicable, if the same is not applicable on drgs.

1. SCOPE

This Nondestructive Testing Standard covers the procedures and requirements applicable to liquid penetrant methods of inspection for detecting flaws open to surface.

2. INTENDED USE

This penetrant inspection method is applicable for all parts made of non-porous materials in machined or unmachined condition and the method is effective on cast wrought, welded, brazed and sheet metal formed components including inservice components.

This NDTS supersedes NDTS 002, 003, 011, and 013.

3. SELECTION OF TEST METHODS

Guidelines for selection of suitable method of penetrant inspection are given in ANNEXURE - 1

4. PROCESS OPERATION

Suitable method of penetrant inspection and the stages at which inspection is ot be carried out shall be specified in the relevant Drawings / Process cards / Test sheets. If the method of penetrant inspection is not furnished, follow the guide lines given in ANNEXURE -1.

Penetrant inspection shall be carried out prior to any surface treatment, that will smear metal, close surface openings or leave unremovable residues within defects, such as: anodizing, peening, plating, painting, sand blasting, abrasive cleaning, buffing, honing, spinning etc.

Penetrant inspection of certain in-service components without removal of surface coating due to operational constraints shall be at the discretion of Quality Control Authority. However, efficiency of defect detection will be affected in such process

5. PROCESS DETAILS

5.1 PRE-CLEANING OF PARTS

Parts to be penetrant inspected shall be clean, dry and free of grease, oil, grinding compounds, rust, scale, acids or alkalies, fluxes, smeared metals, burrs, paint and other foreign materials that may hinder penetration, mask defects or result in irrelevant indications.

5.1.1 Part surface with heavy scaling and adherent sand and other hard foreign matters shall be subjected to mechanical cleaning as per HPS.108.

5.1.2 Parts subjected to mechanical cleaning shall be followed by chemical

cleaning as per HPS.101.

.1.3 Machined surfaces and raw forgings of aluminium, magnesium and Titanium alloys should not be subjected to mechanical cleaning.

.1.4 Chemical etching may not be necessary for light alloy forgings.

.1.5 Painted surface shall be cleaned to remove paint as per HPS.102.

.1.6 All parts cleaned by chemical etching, parts subjected to paint removal and parts with smooth surface (e.g. Investment castings, aluminium and magnesium alloy forgings) shall be subjected to trichloroethylene vapour degreasing as per HPS.109.

.1.7 Titanium and Titanium alloys shall not be subjected to chlorinated solvent cleaning. Refer HPS.101 for degreasing of Titanium and Titanium alloys.

.1.8 Titanium alloys containing 5% aluminium and 2.5% tin must be stress relieved before degreasing.

.1.9 Parts degreased shall be allowed to cool to 40°C or less before the next operation.

.1.10 Stress relieving and de-embrittlement of steel parts shall be carried out as per HPS.403, as applicable.

.1.11 Local areas of parts or assembled parts that have been solvent cleaned (e.g. spot checks of overhaul components) must be thoroughly air dried for 20 minutes before application of penetrant.

.2 INSPECTION PROCESS FOR DETECTION OF THROUGH AND THROUGH DEFECTS IN SHEET METAL FORMED AND WELDED PRODUCTS.

.2.1 Immediately after operation 5.1.9 apply non-aqueous wet developer on the outer surface of the component and then apply penetrant on the opposite inner side of the component by spraying, brushing or flowing.

.2.2 Check after 5 minutes for seepage of penetrant on the developer coated side in day light or artificial daylight in the case of visible dye and under black light in a dark enclosure in case of fluorescent penetrant.

.2.3 If no indication of through and through defects is observed clean the developer coated surface by swabbing with degreasing solvent and thoroughly dry the surface at room temperature.

.2.4 Proceed with operation 5.3 immediately if the time period between operation 5.2.1 and 5.2.3 does not exceed 30 minutes. If the period exceeds 30 minutes degrease the component as per 5.1.4 before proceeding with operation 5.3.

.3 PENETRANT APPLICATION

.3.1 Apply penetrant by immersing the part in the penetrant. For large and intricate parts apply penetrant by spraying, brushing or flowing.

.3.2 Keep the part on a drain tray until the excess dye drains off and at the same time ensure that the surface of the component is wet. Penetrant shall be

reapplied as necessary to prevent drying of the penetrant on the part.

5.3.3 The minimum dwell time (the time period between the contact of penetrant with the part surface until removal of excess penetrant) for aluminium, magnesium and bronze products shall be 10 minutes except for detection of fatigue cracks

5.3.4 The minimum dwell time for steel, titanium and high temperature alloys shall be 20 minutes except for detection of fatigue cracks.

5.3.5 The minimum dwell time for detection of fatigue cracks shall be 30 minutes. However, the maximum dwell time should not exceed 60 minutes.

5.3.6 The above dwell times are applicable for temperatures between 16°C and 38°C.

5.3.7 Above 38°C, the dwell time shall be half the recommended times mentioned vide 5.3.3. to 5.3.4. Temperature above 46°C is not permitted.

5.3.8 The dwell time for temperatures between 2°C and 15°C shall be double the recommended time vide, 5.3.3 and 5.3.4

5.4 PENETRANT REMOVAL

5.4.1 Water washable penetrant

5.4.1.1 Remove excess penetrant by either immersion in agitated water or by spraying. The jet pressure shall be 2 bars. Water temperature shall be maintained between 15°C and 30°C. The nozzle spray gun shall be held inclined at least 300 mm. away from the component. Rinsing time shall not exceed 3 minutes.

5.4.1.2 In case of fluorescent penetrant, ensure removal of excess penetrant by observing under black light. Total absence of background fluorescence may indicate overwashing.

5.4.2 Post Emulsified Penetrant

5.4.2.1 In case of lipophilic emulsifier, dip the part in the emulsifier and allow to drain off. Use minimum emulsification time to avoid removal of penetrant from the defects. Subsequently subject the parts to agitated water wash or spray rinse. Ensure satisfactory removal of penetrant - emulsifier mixture by observing under black light. Emulsification time is critical and shall be determined experimentally. Maximum emulsification time shall not exceed 2-3 minutes.

5.4.2.2 In case of hydrophilic emulsifiers, subject the parts to agitated water wash or spray rinse to remove obvious excess penetrant from the part surface.

5.4.2.3 Immerse the part in emulsifier and drain out the excess. Determine the emulsification time experimentally. Emulsification time depends upon the concentration of the emulsifier. Normally, the concentration will be in the range of 5 to 20% by volume.

5.4.2.4 Allow to drain off and subject the part to spray wash and ensure satisfactory removal of pentrant-emulsifier mixture under black light. The maximum emulsifier time shall not exceed 3 minutes.

Solvent Removable Penetrant

5.4.3.1 Remove excess penetrant by wiping the surface with clean dry rags, followed by clean rags moistened with penetrant remover to remove remainder of excess penetrant and throughly dry the surface.

5.5 DRYING

5.5.1 For water washable and post-emulsifiable methods, parts shall be dried in a hot-air-circulating oven. The drying temperature shall not exceed 90°C, and the drying time will be 3 to 8 minutes depending on the size of the parts. Parts shall not be dried in direct sunlight or in a contaminating environment. Alternatively, force dry with clean air from an airline or compressed air (1.5) bar) at ambient temperature for a minimum period of 3 minutes and not exceeding 8 minutes. Ensure that the air from the airline is free from humidity and greasy material. The absence of moisture and grease is ensured by spraying the air on a filter paper and observing the same.

5.6 APPLICATION OF DEVELOPER

5.6.1 For red dye penetrant method, apply non-aqueous wet developer by means of a spray gun at 1.2 to 1.5 bar. Keep the liquid reservoir agitated to maintain even suspension of powdered particles. Apply a light, uniform coating by spraying with a very fine nozzle and constant movement of the spray. Two or three light coats are preferred to a single heavy coat.

5.6.2 For fluorescent penetrant method, dry developer shall be applied as soon as possible after drying, in such a manner as to ensure complete coverage. Developer shall be applied by powder storm cabinet method or immersion in dry powder or by electrostatic spraying. Remove excess developer by gentle tapping or blowing with dry low pressure air.

5.6.3 The developing time shall be not less than 10 minutes and not more than 2 hours after the application of developer.

5.7 INSPECTION OF PARTS

5.7.1 Parts subjected to red dye penetrant method shall be inspected in day light with, if necessary, an artificial white light of minimum intensity of 500 lux at a distance of 1 meter aided by magnifying glass (x5). [80 watts fluorescent tube at 1 meter or a 100 watts tungsten filament lamp at 0.2 meter distance gives 500 lux.]. For detection of very fine cracks, an intensity of 600-1000 lux may be required.

5.7.2 Parts subjected to fluorescent penetrant method shall be inspected in a dark enclosure under black light aided by magnifying glass (x5). The minimum black light intensity shall be 1000 microwatts per centimeter square at the inspection surface.

5.7.3 Parts showing indications which are not interpretable satisfactorily should be reprocessed. Indications may be evaluated by wiping with a cotton swab moistened with trichloroethane or acetone gently, with or without the aid of developer, for observing the size, shape and location of bleed-out. (Note : Do not allow the solvent to flow on the part surface).

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5.8 REMOVAL OF DEVELOPER

5.8.1 The developer film shall be removed either with a jet of water followed by air drying or by blowing off under air blast followed by cleaning with dry cloth.

5.9 GENERAL PRECAUTIONS

5.9.1 Some of the solutions used in this process are extremely inflammable and every precaution should be taken to avoid fire hazard.

5.9.2 Adequate ventilation should be provided when solvents, removers, and non-aqueous wet developer are used and when penetrant is applied by spraying.

5.9.3 Any possibility of onset of corrosion should be avoided during or after the process.

5.9.4 Various process units should be so positioned as to avoid contamination. Tanks should be provided with lids while not in use.

5.9.5 Fluorescent penetrant inspection for aluminium and magnesium alloy castings/forgings should not be carried out if they were subjected to visible dye penetrant inspection earlier.

5.9.6 Fluorescent penetrant inspection after visible dye penetrant inspection for steel forgings, extruded and rolled bars, can, under special circumstances, be carried out in which case the parts shall be thoroughly cleaned by immersing them in boiling trichloroethylene for 10-15 minutes prior to application of fluorescent penetrant.

5.10 INTERPRETATION OF RESULTS AND ACCEPTANCE/REJECTION CRITERIA

5.10.1 Interpretation of results and acceptance/rejection criteria shall be as per ANNEXURE-3.

5.11 SALVAGING

5.11.1 Areas containing unacceptable defects may be removed and reworked as permissible and such areas shall be etched as per HPS.101, and subjected to reinspection by appropriate penetrant method as per this NDTS.

5.12 TECHNICAL REQUIREMENTS

5.12.1 Only approved penetrant materials shall be used. Approved penetrant materials are listed vide, ANNEXURE-2.

5.12.2 The fluorescent inspection area or booth shall be free of fluorescent material contamination.

5.12.3 A minimum of 5 minutes shall be allowed for black light warm up after switching on. Inspectors are required to dark-adapt for 5 minutes each time they enter the darkened enclosure from white light. Inspectors should not see the black light directly.

5.12.4 The black light intensity at the inspection area shall be a minimum of 1000 micro watts per centimeter square and the ambient light not to exceed 2 foot candles.

5.12.4.1 White light emission from U.V. lamp shall not exceed 2 foot candles when

measured with Spectronix DSE 100X light meter.

5.13 CONTROL CHECK

Particulars	Daily	Weekly	Monthly	Yearly / H.Y	Action by
Performance check	x				Inspector
Water content in WWFP			x		Laboratory
Penetrant washability for PEFP.	x				Inspector
Flourescent Penetrant Brightness			x		Laboratory
Dry developer		x			Inspector
Water temperature and pressure	x				Inspector
U.V. Light intensity			x		Inspector
Etchant Strength		x			Laboratory
Trichlorothylene			x		Laboratory

5.13.1 Details of Control/Maintenance checks are given vide, ANNEXURE 4.

6.0 REFERENCE :

MIL-I-25135

MIL-STD-6866

MIL -STD-1907

BS 4489

M 35
DIN 54152

ANNEXURE - 1

Guideline for selection of Penetrant Inspection Method		
Method		**Applicability**
Red Dye Penetrant		Raw castings - rough surface (Note: Not applicable for parts that are to be subsequently subject to Fluorescent penetrant test. Not to be used on Titanium and Titanium alloys)
Fluorescent Penetrant		
- Water washable		Raw castings with smooth surface, investment castings, raw forgings, parts having threads, blind holes slots etc.; machined castings or forgings, welded, brazed and formed components
- Post Emulsifiable	i)	Highly critical machined components (eg. compressor turbine rotating components.
	ii)	When high sensitivity for very fine defects and shallow defects are desired
	iii)	Titanium and Titanium alloys Austenitic Stainless steels and Nickel alloys
Solvent Removable Visible Dye (Aerosol)		Insitu Inspection of localized areas where use of water is prohibited/ not feasible

ANNEXURE - 2

Approved Penetrant System		
Penetrant System	**Trade Name**	**Applicability**
Visible Red Dye (with penetrant-Remover)	Indrox 996 P3 996 P2 9 PR1 9D2/9D6 Orion 19 P 19 PR 19 D	Light alloy castings
Visible Red Dye Aerosol)	Indrox 996 P 9PR551 9D6	In situ Spot checks.
Visible Red Dye (water washable)	Indrox 907 9D2/9D6	Light Alloy castings.
Fluorescent Penetrant (water washable)		
Low Sensitivity	Ardrox 970P1 P22 P131D	-do-
	Zyglo ZL 15B ZP4/4A/4B	-do-
Medium/Standard Sentivity	Indrox 970 P4 9D3 Ardorx 970 P4 970 P23/P24 971/972 9D4A	Precision steel castings, Sheet metal fabrications and welding.
Fluorrescent· Penetrant. (Water washable)		
High Sensitivity	ZL 16/17C ZP 4A/4B ZL 17D/54A/60C 66A ZP 4/4A/4 Indrox 970 P10 9D3	

Approved Penetrant System		
Penetrant System	**Trade Name**	**Applicability**
Fluorescent Penetrant. (Post emulsifiable) Standard / High Sensitivity	Indrox 985 P1 9PR4/PR 9D3	Turbine motors Compressor Blades. Turbine discs, Rotating shafts, machined forgings, Titanium and Titanium alloys
	Androx 985 P1 9PR12 9D3	
	Ardrox/ 985P2 Indrox P12 P13 9PR12 9D3	
	Zyglo ZL 2C 2D 27A ZR10A ZP4A/4B	
	ZL 22C 22D ZR 10B ZP 4A/4B	
	Indrox 970P17 9PR4 9D6	

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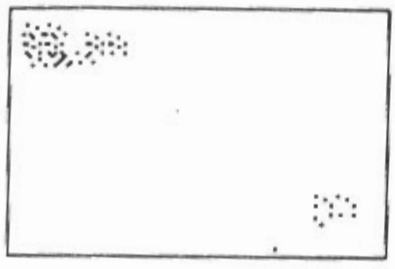
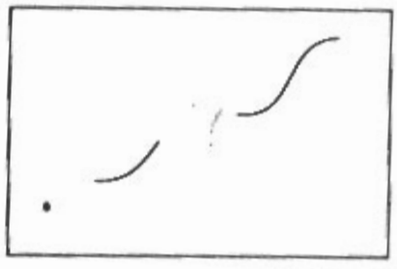
ANNEXURE - 3

INTERPRETATION OF RESULTS (GENERAL GUIDELINE)

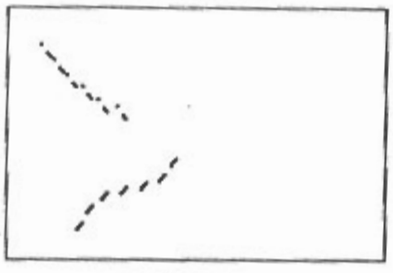
Following are some of the defect indications revealed by Penetrant Inspection:



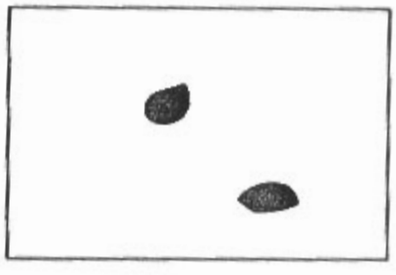
Type - I
Scattered/Cluster of dots.
Generally blisters or pits.



Type - II
Solid line. Generally cracks,laps and folds. Depth indicated by the degree of spread of indication.



Type - III
Dotted line. Generally tight cracks, laps and folds.



Type - IV
Large blobs, Generally voids of any type.

2. DEFINITIONS

2.1 **Isolated defects** : Isolated defect means that the distance between any two such defects will not be less than ten times the size of the largest defect

2.2 **Line defects** : Line defect means that the defects fall within a band of 3.00 mm width.

2.3 **Linear defects** : Defects whose length to width ratio is 3 and above.

3. ACCEPTANCE/REJECTION CRITERIA :

3.1 FORGINGS/EXTRUDED PRODUCTS:

3.1.1 Forging cracks, flashline discontinuities; and heat-treat cracks are not acceptable.

3.1.2 Open surface blisters and pits of line type are not acceptable

3.1.3 Isolated defects however small, giving indications of through and through type defect are not acceptable.

3.1.4 Seams, Laps and Folds are acceptable within the following limits:

	High stressed Zone	Medium stressed Zone	Low/Un-stressed zone
Unmachined surface	* 12..5 mm	*25 mm	* 37.5 mm.
Machined surface	0	0	* 6.0 mm

* Distance between any two successive defects shall be more than 12.5 mm. in linear direction and 6mm in parallel direction.

3.2 Castings :

3.2.1 Casting cracks, cold shuts, misruns, heat-treat cracks are not acceptable.

3.2.2 Defects however small, giving through and through indications, are not acceptable.

3.2.3 Inter-linked porosity, shrinkage, pits giving crack-like linear indications are not acceptable.

3.2.4 Individual and clustered imperfections in areas other than edges or fillet radii are permitted as per guidelines given in Table-I and Table-II.

3.2.5 TABLE - I

3.2.5.1 Individual Imperfections

Thickness (mm)	High Stressed Zone			Medium Stressed Zone			Low Stressed Zone		
	x	xx	xxx	x	xx	xxx	x	xx	xxx
<4	0	0	0	0.5	1.5	2	0.5	1.5	3
>-4<10	0	0	0	0.5	1.5	2	1.0	3.0	4
>10-<25	2.0	6.0	2	2.0	6.0	4	3.0	9.0	6
>25	3.0	9.0	2	3.0	9.0	4	5.0	15.0	6

x - Maximum dia permissible in mm
xx - Minimum separation between defects in mm.
xxx - Maximum number permissible over a square decimetre

3.2.6 TABLE - II

3.2.6.1 CLUSTER IMPERFECTIONS

High Stressed Zone			Medium Stressed Zone			Low stressed Zone		
x	xx	xxx	x	xx	xxx	x	xx	xxx
5.0	20.0	3	5.0	15.0	4	5.0	15.0	5
>5-<15	25.0	2	>5-<15	20.0	3	>5-<15	15.0	5
>15-<25	50.0	1	>15-<25	50.0	2	>15-<25	50.0	3

x - Maximum dia of cluster in mm
xx - Minimum seperation between clusters in mm
xxx - Maximum number of clusters per sq.decimeter

3.2.6.2 Penetrant indications of microshrinkage in magnesium alloys is not a cause

for rejection provided such defect is not of through and through nature. Their acceptance shall be based on radiographic acceptance standard of the concerned area. However, if the area is inaccessible for radiography, acceptance or rejection as the case may shall be as per the guidelines given in TABLE-II.

3.3 Precision Steel Castings

3.3.1

Permissible defects	High Stressed Zone	Medium Stressed zone	Low Stressed zone
Isolated :			
Max.dia (mm.)	0.50	0.75	1.00
Min. Separation (mm)	15.00	15.00	15.00
Max.no.of defects per 50 mm. dia.	2	3	4
Dendritic Shrinkage:			
Max. dia. (mm)	2.00	4.0	6.00
Min. Separation (mm)	15.00	15.00	15.00
Max. no. of defects per 50 mm.dia	2	3	4

3.4 Fusion Welding/Brazing

3.4.1 Cracks and crack like indications are not acceptable .

3.4.2 Through and through indications are not acceptable.

3.4.3 Aligned porosity whose length to width ratio is more than 3 is not acceptable.

3.4.4 Non linear isolated defects of diameter not greater than 20% of the thickness of weld and not closer than the distance equivalent to weld thickness are acceptable

Note:

a) Thickness of weld is the combined thickness of weld and parent metal.

b) Two isolated defects separated by less than the diameter of the adjacent smaller defect should be treated as a single defect.

3.5 Resistance Welding (Titanium, Titanium base, Nickel bae, Non-magnetic ferrous alloys for sheet thickness less than 5 mm.

3.5.1 Seam and Stich welding

3.5.1.1 Star cracks of maximum diameter 40% of the weld track width contained within the weld track acceptable provided 10% of the weld track width on each side along the weld track is free from crack.

3.5.1.2 Separation between two successive acceptable star cracks should not be less than 25 mm.

3.5.1.3 Not more than two acceptable star cracks are permitted over a running length of 500 mm or part thereof.

3.5.1.4 Isolated transverse cracks up to a maximum of 40% width of weld track contained within the weld track are acceptable provided 10% of the weld track width on each side along the weld track is free from crack.

3.5.1.5 Separation between two successive acceptable transverse cracks should not be less than three times the largest defect.

3.5.1.6 Not more than 2 acceptable transverse cracks are permitted over a running length of 500 mm or part there of.

Note : Not more than one each of acceptable star and transverse crack is permitted over a running length of 500 mm or part thereof and the distance between a star and a transverse crack shall not be less than 25 mm.

3.5.2 Spot weld

3.5.2.1 Star shaped crack having a major dimension equal to or less than 40% of spot diameter in the centre of the spot weld is acceptable.

3.5.2.2 There should be atleast one defect free spot weld between two spot weld with acceptable defects.

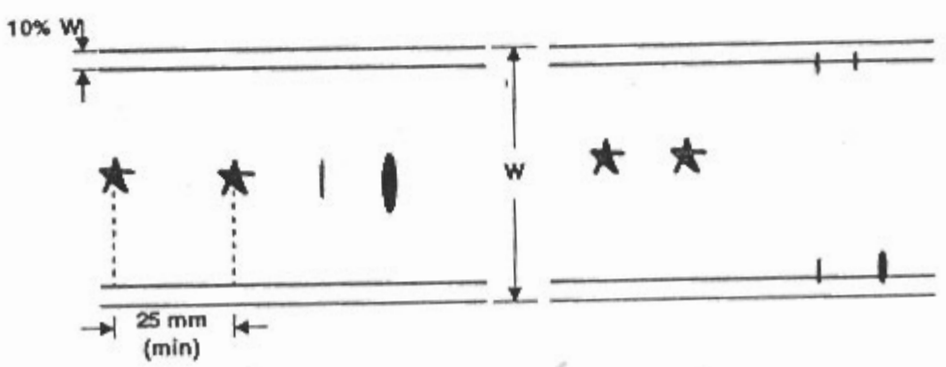
3.5.2.3 Not more than 5% of the total spot welds inspected are permitted with acceptable defects.

3.6 Sheet Metal components:

3.6.1 Cracks, crack like indications and linear imperfections are not acceptable.

3.6.2 Through and Through defects, however small are not acceptable.

3.6.3 Non-linear isolated imperfections of dia not greater than 20% of the thickness and not closer than the distance equivalent to the sheet thickness are acceptable.



Acceptable star cracks and transverse cracks.

Rejectable star cracks and transverse cracks.

ANNEXURE - 4

1. CONTROL/MAINTENANCE CHECK

1.1 PERFORMANCE CHECK

1.1.1 The performance of the plant shall be checked at the commoncement of each shift using a test piece containing known defects.

1.1.2 The test piece shall be subjected to dye penetrant examination as per the normal process. The number, size, shape and intensity of defect indications on test piece shall be compared with the permanent record. If the indications are not comparable, it would indicate that the plant is not functioning properly and needs rectification.

1.1.2.1. Test pieces

1.1.2.2 Preparation of typical test pieces is described below. Anyone of these may be used for performance check of the penetrant dye and developer system. However, for Fluorescent penetrant, only chrome plated test piece shall be used.

1.1.2.3 The test pieces are processed through standard penetrant developer system and photographed to presserve the indications for future comparison.

1.1.2.4 Aluminium test piece

1.1.2.5 Take a 75 x 50 x 12 mm piece of duralumin. Heat the test piece to a temperrature above 550^{o} over a burner, the heat being applied to the centre of the test piece. When the requisite temperature is reached, the piece is immediately quenched in cold water. This process is repeated on both sides of the specimen until formation of cracks is ensured. The piece is then moderately heated to drive off water.

1.1.2.6 Chrome plated test piece

1.1.2.7 The test piece is made by chrome plating a suitable piece of steel or brass on one side. The thickness of plating is approximately 1.0 mm. The test piece is then stressed on the side opposite to plating with a suitable hardness indentor, until cracks appear.

1.1.3. Any component having known defects of which the number, size and position has been previously recorded, may also be used as a test piece.

1.1.4 After test, test piece shall be thoroughly cleaned to remove all traces of penetrant and developer. The cleaning procedure shall be: (a) Washing the test piece thoroughly in water; (b) Drying with air blast; (c) immersing in hot liquid trichloroethylene for a minimum period of 15 minutes; and (d) cooling.

1.1.5 The cleaned test piece shall be stored in a sealed container in a clean mixture of 50% acetone (AR quality) and 50% trichloroethylene (inhibited) until required for next check.

1.2 DYE COLOUR INTENSITY

1.2.1 This test shall be carried out only, in case of accidental dilution of the penetrant with foreign solvents, eg: trichloroethylene or Kerosene or in case

of dilution in excess of 10% v/v of dye solvent replenisher.

1.2.1.1 Method 1

Take 1 ml. each of the standard dye (Standard dye is the dye when fresh bath was prepared) and the dye under test in 100 ml. volumetric flask seperately and identify them properly. Dilute both with colourless kerosene and bring to 100 ml. mark. Shake well after stoppering the flasks. Transfer 1 ml. of each of the dyes in a nessler tube properly identified. Then dilute the dyes with kerosene, until the colours compare against a Whatman filter paper background. When the colours compare, notedown the reading V1 of standard dye and V2 of the dye under test. Then the percentage intensity is expressed as:

$$\frac{V2}{V1} \times 100$$

1.2.1.2 Method 2

Take 10 ml. each of the standard penetrant and the penetrant under test in 100 ml volumetric flask seperately, properly identified. Dilute both with colourless kerosene to the 100 ml. mark. Shake the flask well. Transfer a known quantityof the standard penetrant in a test tube and measure the intensity of the light transmitted through it, with the help of a Spectro photometer and note down the reading T1. Take same quantity of penetrant under test and obtain the transmitted intensity reading T2. Similarly, take transmitted intensity T for test tube containing kerosene used for dilution.

Then, % colour intensity $= \frac{T2 - T}{T1 - T} \times 100$

1.2.2. Acceptance criteria

1.2.2.1 If the colour intensity of the dye under test is 80% or less, then the dye shall be rejected. If large quantity of dye is involved, manufacturers of the dye may be consulted for reclaiming the rejected dye.

1.3 Water content in water washable fluorescent penetrant:

1.3.1 Water content of water washable fluorescent penetrant shall not exceed 5% by volume when tested in accordance with ASTM D 95.

1.4 Penetrant washability for post Emulsifiable Fluorescent Penetrant:

1.4.1 Take 150 x 100 x 5 mm Stainless Steel sheet and subject it to sand blasting to obtain a surface roughness of 2.5 microns (approx.). Carry out penetrant test as per standard procedure and note down the emulsification time. After developing and during inspection under black light, only indentations caused by sand blasting should be visible, but without any fluorescent background. If fluorescent background is noticed, emulsification time shall be increased by 30 seconds each time till fluorescence background is eliminated. Then the time determined shall be recorded for the day's work to maintain consistency of test cycle.

1.5 FLUORESCENT PENETRANT BRIGHTNESS

1.5.1 a) Fluorescent Penetrant brightness shall be checked once in a month against an unused fluorescent penetrant (Standard). For this purpose a filter paper shall be soaked in the penetrant undertest and another

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results obtained on the test piece.

1.7.2 Dry developer:

1.7.2.1 The developer powder shall be checked once in a week to ensure that it is dry, light and fluffy. Coagulated or lumpy powder shall be rejected. Further, the developer powder shall be seen under ultraviolet light to ensure that the powder is free from penetrant contamination. Contaminated developer shall be discarded.

1.8 ETCHANT STRENGTH CHECK

1.8.1 Strength of the etchant should be checked every fortnight by titration method by laboratory personnel and the result sent to the operator. The reduced strength should be made up accordingly by the operator concerned.

1.9 TRICHLOROETHYLENE CHECK

1.9.1 A sample from condensed vapour and sump from tricholoethylene vapour degreasing plant shall be sent to laboratory once in a month. Tests shall be carried out as per LTP 480.

1.10 TANK CLEANLINESS

1.10.1 All tanks shall be kept clean to prevent corrosion and contamination. This prevents the onset of a corrosive element in the liquids and restricts the build-up of impurities which could contaminate components lowered on to the bottom of the tank. Tank levels shall be checked daily.

1.10.2 When cleaning out tanks, the contents shall first be allowed to settle for atleast 3 hours.

1.10.3 The uncontaminated portion of the process fluid shall be transferred to clean drums kept for this purpose by either using a pump whose suction point is above the contaminated level, or by draining from a similar point. The impurities left on the tank floor and the aedjancent layer of fluid shall be washed out.

1.10.4 The tank shall be flushed with a small quantity of fluid, previously transferred from the tank to the drum and again emptied. The uncontaminated fluids shall now be replaced and the complete range of control checks instituted.

1.10.5 The level of tank shall be checked daily.