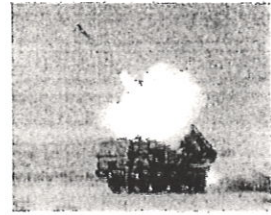


SPEC NO. ARDE / SPECN / PINAKA / RKT- 04



Issue : 01
Rev No : 0

**SPECIFICATION AND QUALITY ASSURANCE PLAN
FOR
NOZZLE ASSEMBLY (FLIGHT) - PINAKA ROCKET
(PROVISIONAL)**

TAPAN SHARMA
तपन शर्मा
LT COL
जे. कर्नल
DY CONTROLLER
उप नियंत्रक
FOR CONTROLLER
हते नियंत्रक



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G S...



19 MAY 2020

Issued by

Director, A R D E, Armament Post, Pashan, Pune
411021

Feb 2020

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List of Abbreviations:

ARDE	Armament Research & Development Establishment
ASTM	American Society of Testing Materials
IS	Indian Standard

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Suggested lot sizes

Sr No	Component	Batch/Lot Size- Min	Batch/Lot Size-Max	Remarks
1	Nozzle Assembly (Flight)	36+36+37 (109)	54+55 (109)	Qty. 1No. to be used in Burst test of Empty Propulsion unit
2	Nozzle Front	36	Multiple of 36	Max 12 heat batches to be used for lot size of 109Nosat finish stage.
3	Nozzle Rear	36	Multiple of 36	Each extrusion batch reports to be submitted
4	Ballistic Cap	36	Multiple of 36	Each extrusion batch reports to be submitted
5	Guide Stud	72	Multiple of 72	Max 06 heat batches to be used for lot size of 218Nos at finish stage.
6	Ring	54	Multiple of 54	Maximum 2 sources in one rocket lot of 108 & max 03heat batches to be used for lot size of 109Nos at finish stage.
7	'O' Ring -Ø 171.7	109	Multiple of 109	
8	'O' Ring - Ø 188.0	109	Multiple of 109	
9	'O' Ring - Ø 191.0	109	Multiple of 109	
10	'O' Ring - Ø 133.0	109	Multiple of 109	
11	Throat Insert	80	-	a. Quantity to be realized from single graphite block b. Delivery to OFC by vendor can be in maximum two batches

Note:

- For making Stabilizer assembly lot of 109 Nos. batches of 36 / 37, 54/55, 109, be made of relevant component wherever applicable. However in one stabilizer assembly lot maximum 3/2 batches of 36+36+37 / 54+55 respectively to be Utilized.
- Exceptional case:** If any component rejected during manufacturing/assembly/CP/SP the components from next batch to be used to complete the lot.
- Break in Production:** If there is stoppage in production for more than 1 year, it would be termed as Break in Production. In case of break in production, double sample size to be followed and matter will be referred to AHSP for their approval.

10.12 Component - Throat Insert

- 1 Drawing no. - 8603 02 01 10 00 001 00 PA
 2 Method of Manufacture - Machining
 3. Receiving Inspection
 3.1 Raw Material - Graphite Grade 1346 (France origin) or
 Grade ISO 63 (Japan origin) or
 Graphite Grade: Premium & Superfine of Harting
 India Pvt. Ltd.

For Raw Material Specification, Testing, acceptance criteria & other information / conditions refer **Appendix 'A4'**.

Defect Classification: Critical

- 3.2 Tests/ Checks and Acceptance Criteria for Raw Material :
Sample size: Min. 1 Cylinder. 1% Cylinders of total quantity. Min. 5 test pieces from each Cylinder to made for testing.

Sr. No.	Test / Check	Parameter	Acceptance
1	Mechanical Properties	Density, Hardness, Flexural Strength	As Per Appendix 'A4'

NOTE : Certificate for free of cracks and defects should be supply by supplier.

- 3.2.1 AHSP Intervention :As per MOD directives for input material inspection.

4.0 In-Process Inspection : N/A

5.0 Stage Inspection N/A

6.0 Final Inspection

6.1 Visual Inspection

6.1.1. Features for Visual Examination and acceptance Criteria.

Sl. No	Test	Sample Size	Defect Classification	Acceptance Criteria
1	'X' - Ray Test	100 % by QC Fy	Critical	No Cracks & Flaws acceptable.

6.1.1.1 AHSP Intervention :Surveillance point.

6.2 Dimensional inspection :As per Appendix ' B14'

6.2.1 Critical Dimensions :

Sample size- 100 % by QC Fy

Sr. No.	Dimension / Feature	Drawing Zone	Inspection Method
1	ϕ 80 + 0.1	C4	Bore gauge/ Star Micrometer

6.2.1.1 AHSP Intervention : CP- sample size 10%

6.2.2. Major Dimensions :
Sample size- 100 % by QC Fy.

Sl. No	Dimension/Feature	Drawing Zone	Inspection Method
1	L 80.0 - 0.1	A3	By Gauge
2	φ 119.9 - 0.05	C1	By Gauge.

6.2.2.1 AHSP Intervention : CP- sample size 10%

6.2.3 Minor Dimensions :
Sample size - 100 % by QC Fy

Sr. No.	Dimension / Feature	Drawing Zone	Inspection Method
1	12°	B4	By Gauge
2	17°	B2	By Gauge

6.2.3.1 AHSP Intervention : CP- sample size 10%

6.2.4 Geometrical Features :
Sample size : 10% by QC Fy

Sr. No.	Dimension / Feature	Drawing Zone	Inspection Method
1	⊙0.05 A Ref. φ 119.9	B4	Dial Gauge*
2	⊥0.025 A Ref. φ 119.9	D4	Slip Gauge & filler gauge

* If checked by dial gauge concentricity shall be half of the run- out

6.2.4.1 AHSP Intervention: Surveillance point

6.2.5 Mass Limit (as a reference): Approx. 0.740 kg. (As per density of the material)

6.3 Other Tests on Finished Items :

6.3.1 Details of Test / Checks on Finished Items and Acceptance Criteria

Sl. No	Test	Sample Size	Defect Classification	Inspection Method
1	X- Ray Test	100 % by QC Fy	Critical	X- Ray to detect Cracks & Flaws. No cracks & flaws acceptable. (Refer standard radiographic testing practice for Graphite throat Insert No. MMS/143/04, dated 22/11/04, as per Appendix 'A5

6.3.1.1 AHSP Intervention: Surveillance point

GEN. TOL. IS : 2102 (MED.)

DRG. No. SK-9043

MATL- _____

HARDNESS:- _____

FINISH- $\nabla \nabla$

MATERIAL:- GRAPHITE GRADE 1346 (FRANCE ORIGIN) OR GRADE ISO 63 (JAPAN ORIGIN) OR GRAPHITE GRADE :PREMIUM & SUPERFINE OF HARTING INDIA PVT. LTD.

GRAPHITE MATERIAL SPECIFICATION:

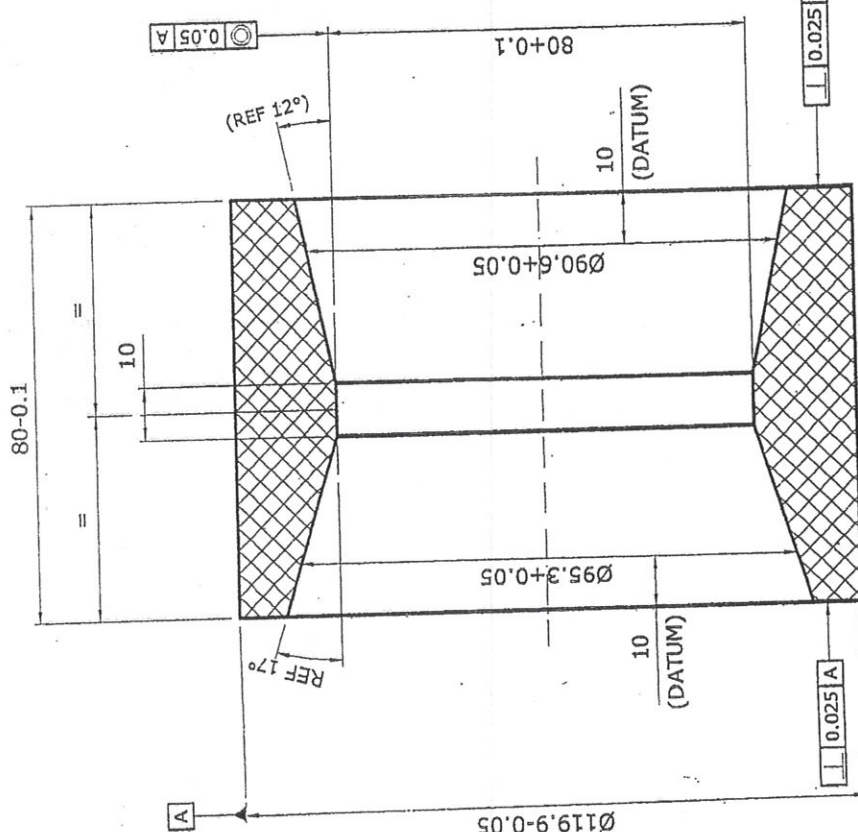
Sr No.	PARAMETER	GRADE 1346	ISO 63	HARTING	
				PREMIUM	SUPERFINE
a	BULK DENSITY (g/CC) (MIN)	1.88	1.78	1.78	1.78
b	HARDNESS(SHORE D) (MIN)	70	76	72	70
c	FLEXURAL STRENGTH(MPa) (MIN)	70	65	65	62
d	COMPRESSIVE STRENGTH (MPa) (MIN)	118	135	150	150
e	THERMAL CONDUCTIVITY (W/m K) (MIN)	90	70	67	74
f	COEFFICIENT OF THERMAL EXPANSION (10 ⁻⁶ /K) (MAX)	6	5.6*	4.95**	4.74**
g	ASH CONTENT (MAX)	0.1%	0.1%	0.1%	0.1%

* FOR 350°C TO 450°C
** UP TO 100°C

ACCEPTANCE CRITERIA:-
FOLLOWING CRITERIA FOR ACCEPTANCE OF GRAPHITE RAW MATERIAL IS LAID DOWN BASED ON THE TEST CARRIED OUT.

Sr No.	PARAMETER	MIN
1	BULK DENSITY (gm/CC)	1.88
2	HARDNESS(SHORE D)	70
3	FLEXURAL STRENGTH	45 MPa

A MINIMUM OF 5 TEST SPECIMEN SHALL BE CHECKED FOR EACH PROPERTY AND AVERAGE VALUE SHALL BE RECORDED.
MASS-0.740 Kg APPROX.



NOTES:-
1-THE FINISH THROAT INSERT SHOULD BE FREE FROM CRACKS, DEFECTS AND IT SHOULD BE CHECKED BY RADIOGRAPHY.
2-ALL SHARP EDGES AND BURRS ARE TO BE REMOVED.
3-CONTRACTOR'S IDENTIFICATION MARK TO BE STENCILED/SCREEN PRINTED.

CERTIFICATES:-
CERTIFICATE COVERING ALL ACCEPTANCE CRITERIA AND X-RAY RADIOGRAPHY TEST ARE REQUIRED TO BE SUBMITTED IN RESPECT RAW MATERIAL AND COMPONENT IN TRIPLICATE.

2015	DATE	INTL.
PREPD.	09/10	
CHD.		
JWN/DO		
DO/DO		
MASS		
MATERIAL		
AS STATED		

ORDNANCE FACTORY, KANPUR
SKETCH
FOR PROCUREMENT OF FINISH MACHINED OF THROAT INSERT, STAB.ASSY.P.R.
ASSLY.& STORE DRG. No.
DRG.NO. SK-9043
SCALE:- 1:1 SHT. 1 OF 1

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Appendix 'A4'

SPECIFICATIONS FOR GRAPHITE THROAT INSERT MATERIAL FOR PINAKA NOZZLE ASSEMBLY

1. Introduction:
 Graphite material is used for manufacturing the throat insert of Pinaka nozzle assembly. Graphite is known to have very high thermal shock resistance, good thermal conductivity and low coefficient of thermal expansion. Isotropic graphite with fine grain structure is recommended for use for Pinaka nozzle assembly.

1.1 Method of manufacture of graphite:
 The graphite material should be manufactured by isostatic pressing followed by graphitization. It should have fine grain structure (average particle size < 8 μm) with isotropic properties. The graphite material is available in form of rectangular blocks.

2. Approved OEMs for graphite material:
 The following OEMs are approved for graphite material.

- a. Le-Carbone, France (# MERSEN)
- b. Toyo Tanso, Japan
- c. Harting, UK

3. Graphite material specifications:

Sr. No.	Parameter	Le Carbone (Grade 1346) #	Toyo Tanso (ISO 63)	Harting		Test method
				Premium	Superfine	
a.	Bulk Density (g/cc) (min)	1.88	1.78	1.78	1.78	ASTM C 559 / ASTM D 792 / DIN 51918-A
b.	Hardness (Shore D) (min)	70	76	72	70	ASTM D 2240
c.	Flexural strength (MPa) (min)	70	65	65	62	ASTM D 790 / DIN 51902-A
d.	Compressive strength (MPa) (min)	118	135	150	150	ASTM C 695 / DIN 51910-A
e.	Thermal conductivity (W/m K) (min)	90	70	67	74	ASTM E 1225
f.	Coefficient of thermal expansion (10 ⁻⁶ /K) (max)	6	5.6*	4.95**	4.74**	ASTM E 1461 / DIN 51909
g.	Ash content (max)	0.1%	0.1%	0.1%	0.1%	ASTM C 561 / DIN 51903

* for 350° C to 450° C
 ** up to 100° C

The name of the firm M/s Le Carbone has been changed to M/s MERSEN and also new grades of graphite have been introduced by the new company discontinuing the older one. However the earlier material i.e. Grade 1346 is still available in the market. The newer grade i.e. ELLOR+50 have comparable properties to earlier grade i.e. Grade 1346 and can be considered for Pinaka throat insert application.

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Appendix 'A4'

SPECIFICATIONS FOR GRAPHITE THROAT INSERT MATERIAL FOR
PINAKA NOZZLE ASSEMBLY

1. Introduction:

Graphite material is used for manufacturing the throat insert of Pinaka nozzle assembly. Graphite is known to have very high thermal shock resistance, good thermal conductivity and low coefficient of thermal expansion. Isotropic graphite with fine grain structure is recommended for use for Pinaka nozzle assembly.

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				Premium	Superfine	
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d.	Compressive strength (MPa) (min)	118	135	150	150	ASTM C 695 / DIN 51910-A
e.	Thermal conductivity (W/m K) (min)	90	70	67	74	ASTM E 1225
f.	Coefficient of thermal expansion ($10^{-6}/\text{K}$) (max)	6	5.6*	4.95**	4.74**	ASTM E 1461 / DIN 51909
g.	Ash content (max)	0.1%	0.1%	0.1%	0.1%	ASTM C 561 / DIN 51903

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The name of the firm M/s Le Carbone has been changed to M/s MERSEN and also new grades of graphite have been introduced by the new company discontinuing the older one. However the earlier material i.e. Grade 1346 is still available in the market. The newer grade i.e. ELLOR+50 have comparable properties to earlier grade i.e. Grade 1346 and can be considered for Pinaka throat insert application.

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xii) On receipt of graphite tube inspection of packing & damage of tubes.

b. Raw material form: The supplier shall submit the graphite material for inspection only in form of rectangular blocks. The standard block sizes for various OEMs are indicated below. The sizes indicated below are for reference purpose.

- i. Toyo Tanso (ISO 63): 230 x 540 x 1000 mm
- ii. Harting (Premium & Superfine): 165 x 315 x 635 mm
(6.5" x 12.5" x 25")
- iii. Le Carbone (Grade 1346): 305 x 610 x 1800 mm

The samples required for physical, mechanical and thermal testing would be drawn from these rectangular blocks by the inspection agency. The inspection agency would inspect the size of the graphite block and generate a report.

c. Marking: The following information shall be marked on each block.

- i. Material, trade name and identification
- ii. Lot number and graphite block number
- iii. Date of manufacture

d. Visual inspection: All the graphite blocks would be visually examined. The graphite shall be uniform in appearance and free from foreign materials, cracks or voids.

e. Lot Size: The lot size would be number of rectangular graphite blocks required for manufacturing more than 80 Nos. of graphite throat inserts.

4.2 Inspection of physical properties: Testing of physical properties should be carried out at ARAI, Pune.

a. Bulk Density:

- i. The bulk density of five samples* drawn from each graphite block would be tested.
- ii. The bulk density of the graphite should be minimum 1.78 g/cc.
- iii. Defect classification: Critical

4.3 Inspection of mechanical properties: Testing of mechanical properties is to be carried out at ARAI, Pune.

a. Hardness (Shore D):

- i. Hardness of five samples* drawn from each graphite block would be tested.
- ii. After manufacturing graphite cylinders, the hardness of all the graphite cylinders should be measured at NABL accredited laboratory.
- iii. The hardness of the graphite should be minimum 70 Shore D.
- iv. Defect classification: Critical

b. Flexural Strength:

- i. The flexural strength of five samples* drawn from each graphite block would be tested.
- ii. The flexural strength of the graphite should be minimum 45 MPa (3 point support method).
- iii. Defect classification: Critical

c. Compressive Strength:

- i. The compressive strength of five samples drawn from each graphite block would be tested.
- ii. The compressive strength of the graphite should be minimum 105 MPa

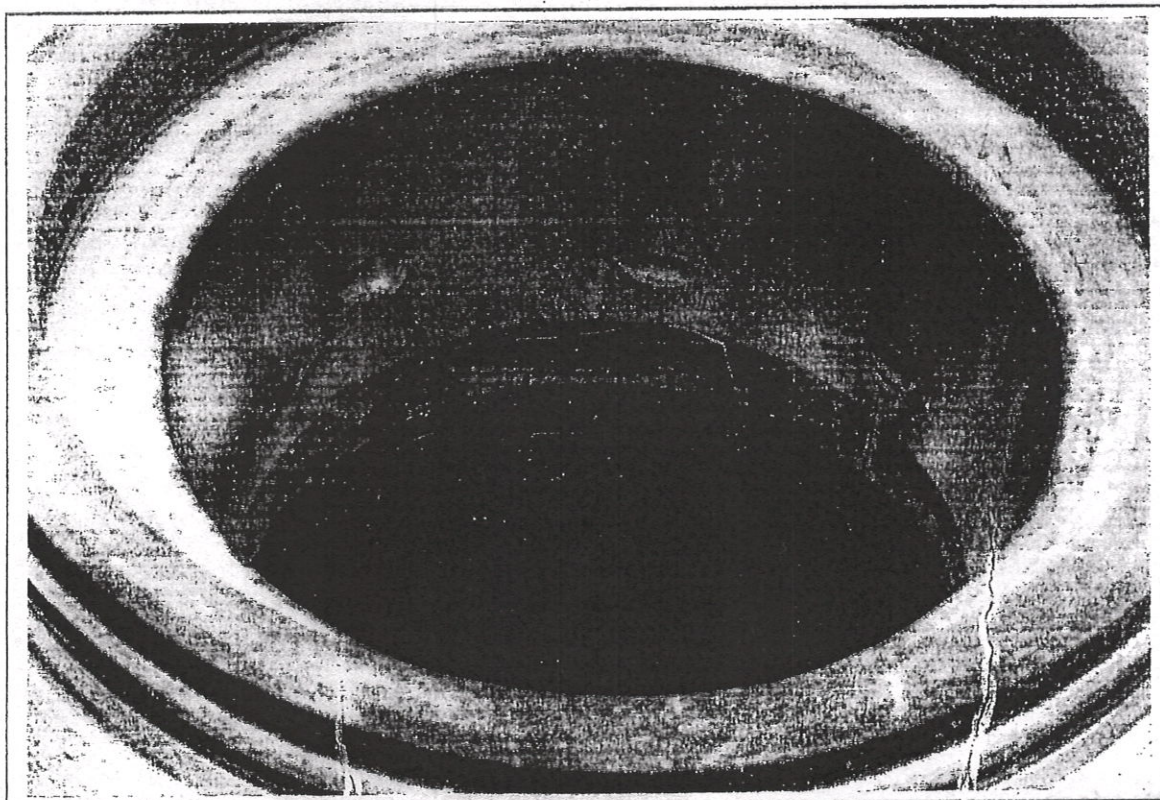
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(after firing) should be done only after allowing the propulsion system to cool down to room temperature for @ 1-2 hrs.

- g. X-ray radiography of the fired nozzle (throat insert) should be carried out at OF, Itarsi.
- h. The acceptance criteria for the static firing test is as follows:

Sr. No.	Parameter	Acceptance criteria	Defect classification
1.	Erosion (mm) [to be measured at throat diameter 80+0.1mm].	Difference in the throat diameters measured before firing and after firing should not be more than 0.2 mm	Critical
2.	Cracks in throat insert	<ul style="list-style-type: none"> No cracks should be observed in X-ray radiography. There should not be scooping of material more than 1 mm deep from localised areas. 	<ul style="list-style-type: none"> Cracks in X-ray radiography – critical Scooping of material more than 1 mm deep from localised areas – critical.

- i. Non-conformity of the erosion limit and cracks/scooping will lead to rejection of entire lot of graphite blocks. (Sample photograph of localized scooping and visual cracks on graphite throat insert seen after firing is shown below).

LOCALIZED SCOOPING AND CRACKS IN GRAPHITE THROAT INSERT

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Appendix 'A5'
(Sht.1 of 7 Shts)

APPENDIX-A7

STANDARD
RADIOGRAPHIC
TESTING PRACTICE
FOR
GRAPHITE THROAT INSERT
FOR
ROCKET PINAKA

ARMAMENT RESEARCH AND DEVELOPMENT ESTABLISHMENT,
PASHAN, PUNE 21

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Appendix 'A5'
(Sht 3 of 7 Shts)

APPENDIX - A7 Sht 3

$$\text{Sensitivity} = \frac{\text{Smallest dia hole visible}}{\text{Effective thickness}} \times 100 = \frac{0.4\text{mm}}{29.9\text{mm}} \times 100 = 1.337\%$$

3 Procedure

Radiography testing of graphite throat inserts is carried out using optimised parameters as per the procedure given below.

a) Exposure set-up

- 1 Keep four nos. of Graphite throat inserts on a radiographic film of size 30 x 40cms, in 'X' position as shown in the figure and give the exposure.
- 2 Keep same graphite throat inserts on other film in 'Y' position, which is perpendicular to 'X' position and give the exposure.
- 3 Check radiation level during exposure by dose rate meter for radiation safety.

b) Developing - Immerse the exposed film in agitated developing bath for 3 min, at 20° C

c) Stop bath - Immerse the developed film in agitated stop bath for 1 min, at 20° C

d) Fixer - Immerse the developed film in agitated fixer bath for 3 min, at 20° C

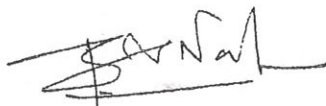
e) Washing - Wash the film for 30 min under normal running tap water

f) Drying - Dry the film in hot air blowing oven set at 40° C

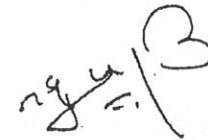
g) Interpretation of radiographs - Critically view the radiograph for presence of defects such as cracks, porosity, voids, foreign material, etc.

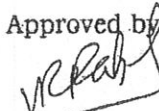
f) Preparation of report - Sentence the observed results as per the requirement of drawing / Quality Acceptance Plan (QAP).

Note - The demonstration of above radiographic practice, was given by Shri VV Gangote, TO'B' at Ordnance Factory, Ambazari on 13th & 14th June 2004.


(BS NALE) TO'A'

Prepared by


(VV GANGOTE) TO'B'

Approved by


(VR PATIL) Sc. 'E'

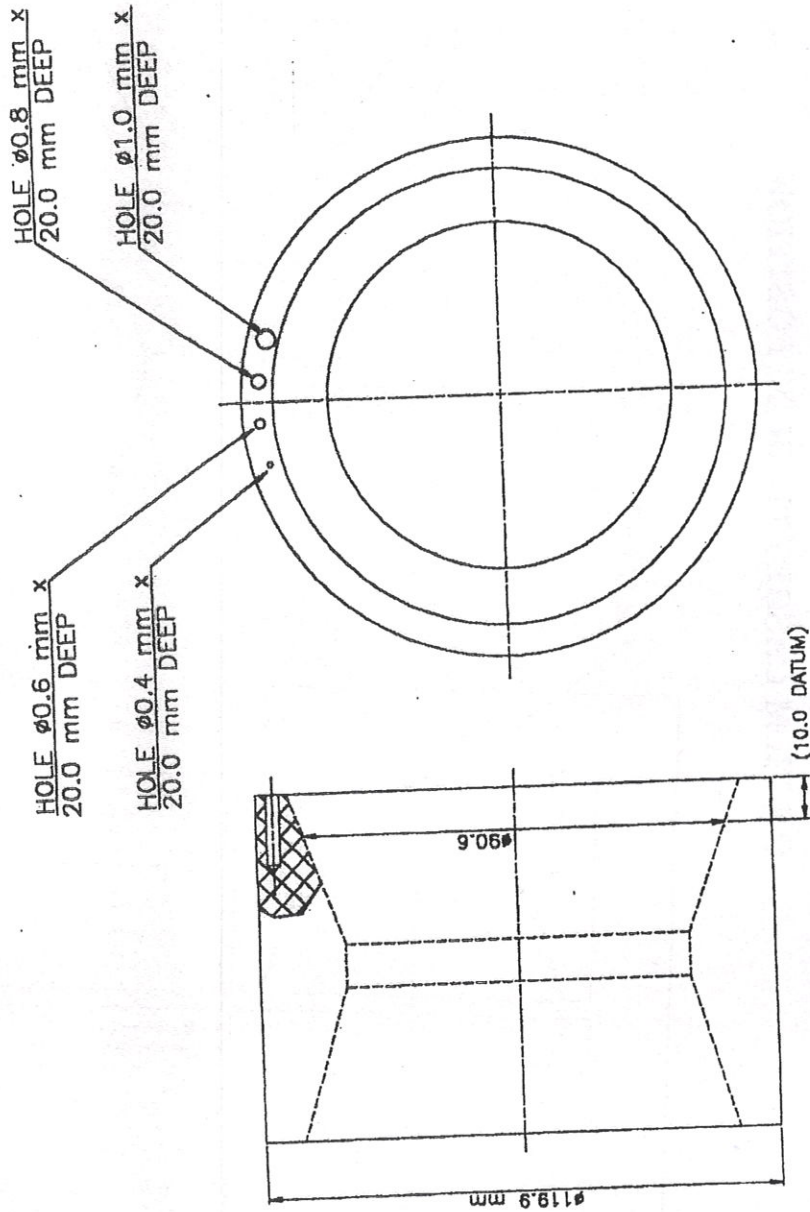
DH (MMS) ARDE, PUNE

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Appendix 'A5'
(Sht 5 of 7 Shts)

APPENDIX - A5/S1



STANDARD TEST SAMPLE OF GRAPHITE THROAT INSERT

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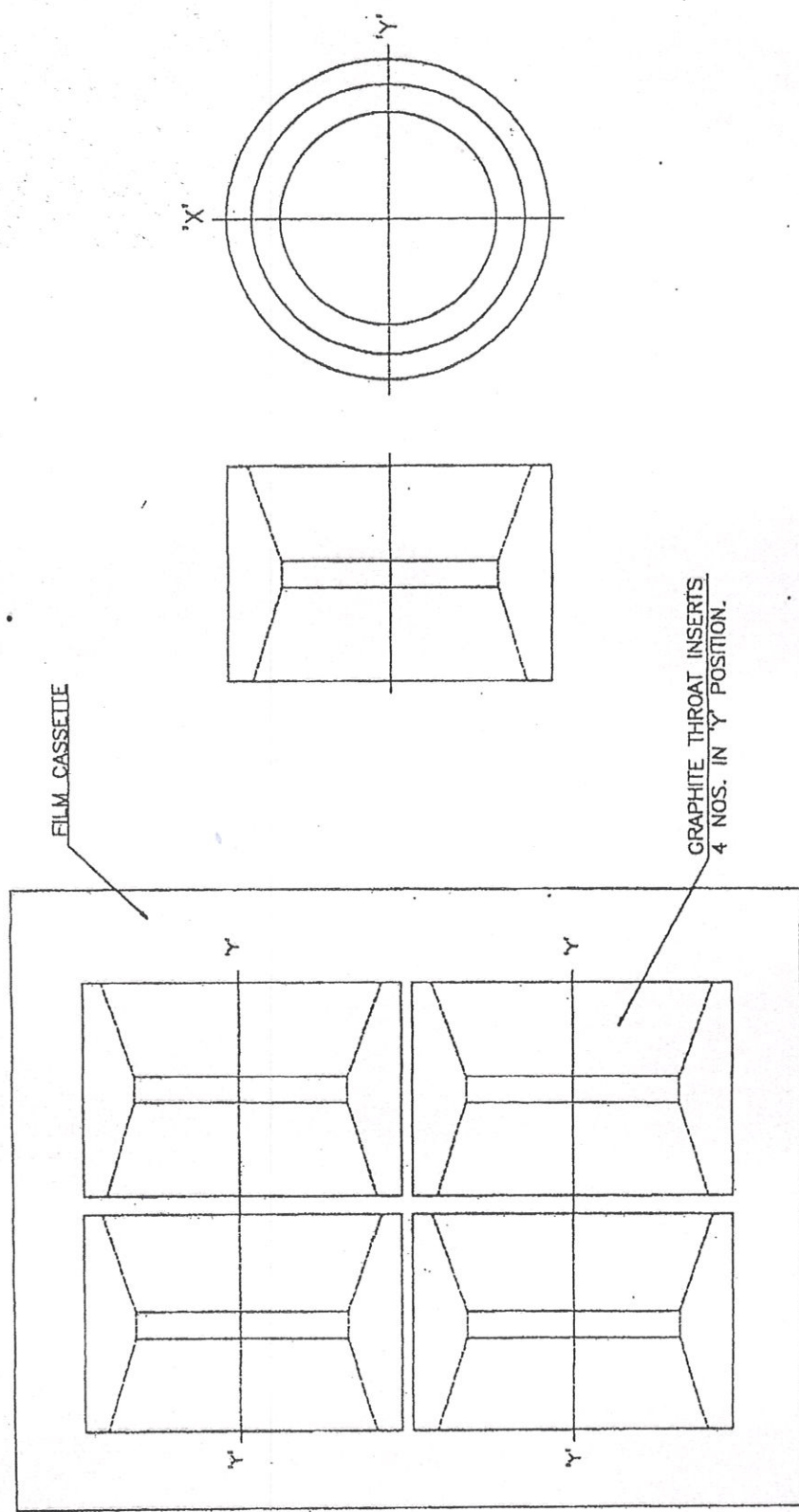
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Appendix 'A5'
(Sht 7 of 7 Shts)

APPENDIX-A7 Sht 7

**PLACEMENT OF GRAPHITE THROAT INSERTS
ON FILM CASSETTE IN 'Y' POSITION**



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