TECHNICAL SPECIFICATIONS OF METAL ADDITIVE RAPID PROTOTYPING FACILITY

The Manufacturer/Vendor shall meet the following requirements

1. The offered machine shall be capable of building wide range of materials like Stainless steels, Die steels, PH steels, Inconel alloys, Titanium alloy and Aluminium alloys.
2. Machine quoted shall be from the standard range of production of the firm and the quoted model shall be in the market minimum for the last 3 years.
3. Prototype or Developmental basis machine shall not be accepted.
4. Machine supplier should be certified as per ISO 9001 standards or equivalent. Sample factory certificate should be attached with technical bid.
5. The vendor shall produce the authorization certificate from the Original Equipment Manufacturer (OEM).

Note: Other Terms and Conditions are enclosed as **Annexure 'P'**

Machine Specifications:

The offered machine shall confirm to following specifications:

1.0 Machine type	**Laser based Metal Additive Manufacturing Machine**
2.0 Technology / Process:	
Name of process	Powder Bed Fusion Process
3.0 Build Features:	
Build Method	Layered manufacturing using metallic powder melting with high power laser.
Build Envelope	Capability to build the parts of 250 x 250 x 300 mm^3 envelope or higher.
Layer thickness	Variable thickness between 50 microns to 100 microns.
Build volume rate	Max : 15 cm^3/hour or better
Build Accuracy	Parts should be made on all three dimensions with an accuracy of ± 0.1 mm over 100 mm or better
Build Repeatability	± 0.05 mm or better on all three dimensions
Surface finish	N10 or better
Build Capability	Capability to build parts having features of - Min. wall thickness 0.30 mm and - Min. outside diameter of 0.8 mm
General build features	- Continuous unattended operation from build start to completion. - Part building on pre-build components during power failure - Real time monitoring of build process.
Incremental Positional Accuracy of Build Platform	- ± 5 µm or better
Control system	- Closed loop control system - Open Architecture and third party material compatibility.
4.0 Scan Features / Capabilities	
Scanning system with focus adjustment, temperature compensation and integrated with servo interface electronics	
Scan Speed	Max. 2 m /sec or better
Positioning Speed	Max 7 m /sec or better
5.0 Power Supply	

Power supply	Three phase 440V at 50 Hz.
Online power source monitoring.	
6.0 Laser Features / Capabilities:	
Laser focus diameter	Capable of achieving focus diameter at powder bed surface less than 200µm.
Type of Laser Source	400 watt or better, Ytterbium Fibre laser (*Water cooled)*
7.0 Build Chamber Requirements:	
Build Chamber	Stainless steel /Anodized aluminium/ Equivalent corrosion resistant metallic construction with vacuum degas and argon / nitrogen refill for maximum atmosphere purity
	Integrated Nitrogen gas generator if required
	Equipped with recirculation system and wet separators
	Shall be provided with pre heating capability of build chamber for 170deg C or more
	Collision detection system for Recoating blade if required
	Dual Stage filtration, if required
8.0 Material Capabilities:	
Materials	a) With capability to process following materials • Stainless steel (316L) or equivalent • PH steels (15-5PH, 17- 4PH) or equivalent • Titanium alloy (Ti-6Al-4V) or equivalent • Tool Steel - H13 or equivalent • Maraging steel -250 grade or equivalent • Aluminium Alloys(AA 2014, AA 6061) or equivalent b) The firm may list out the technology available for any other materials. c) **The firm must have processing technology for at least any of the above 4 materials.**

9.0 Powder Handling and Post Processing Equipment shall consist the following

- Real time sensing of quantity of powder
- Powder loading using lift trolley
- Bed separator if required
- Powder sieving machine/station
- Powder feeding module
- Industrial vacuum cleaner for powder handling
- Suitable **Heat treatment furnace** to improve mechanical Properties. The major specifications are as follows
  - **a)** It shall able to accommodate all parts produced by the offered RP machine
  - **b)** Housing Dimension suitable for accommodating parts with (250 x 250 x 300mm) volume or better
  - **c)** Max operating Temperature ≥ 1280 deg C
  - **d)** Power Rating – 15KW or better
- **Bead Blast unit** to improve the surface finish. The major specifications are as follows
  - **a)** It shall be able to accommodate all parts produced by offer RP machine
  - **b)** Closed cabinet operation, Housing Dimensions suitable for accommodating parts with (250 x 250 x 300mm) volume or better
  - **c)** Foot pedal operated Blast Gun, if required
  - **d)** Blasting pressure suitable for cleaning of products of above material (clause 8.0)
  - **e)** Blasting Media- Glass bead or equivalent suitable for cleaning of products of above material (clause 8.0)

10.0 Humidity Control System:

- Real time sensing and control of humidity if required.

.0 Build Support Features: • *Automatic support generation*

12.0 Software Provisions:	
Software	MS-Windows based software with user interface routines for • Shall support standard neutral formats such as IGES/STEP. Necessary Software for conversions of CAD data (in IGES / STEP format) to RP system compatible .STL format to be included. • Shall provide automatic pre-processing, slicing and generate 3D digital part files • Shall automatically generate support structures • Capability for nesting of parts • Compatible to communicate with PC / Workstation with Windows 7 / Windows XP operating system • Free license for the necessary software for the operation of the RP system to be provided. • Automatic part placement to optimise the build time • Scaling (Linear and Non-linear sizing) • Estimation of build time automatically • Analysis of built process and report generation • Full Software licenses with process parameters for all the materials as stated in clause 8. • Shall facilitate in the software to alter / develop the process parameters
	- Compatible standalone high end workstation to generate required support structure - Cables, connectors and other hardware to transfer STL data to machine

13.0 Safety & Security Features to be included along with the machine:	
Security towards machine	- Door locking security - Temperature controller in process chamber - Safety against laser beam exposure - Safety against inert gas - Monitoring system for inert gas - Monitoring system for oxygen - Monitoring system for humidity if required - Safety for anti-collision towards the built and support structure - Movement of build platform along Vertical / Laser source axis - Monitoring system for vacuum limit - Monitoring system for air pressure limit - Motion control of motors and other subsystem specific to the equipment - Non-contact powder handling and if any
Security towards personnel	- Powered air purifying respirator with High efficient particulate air cartridges and battery charger - Proper grounding of machine against static electricity - Rubber gloves –10 pairs minimum - Steel toes safety shoes of ESD standard – 4 pairs minimum - Protective clothing – 4 pairs minimum - Fire resistant hoods and clothing – 2 pairs minimum - Wet separator to prevent formation of powder clouds - Automatic oxygen monitoring - Chemical storage cabinet - Metal Powder Storage Unit - Chemical storage cabinet and trash cans

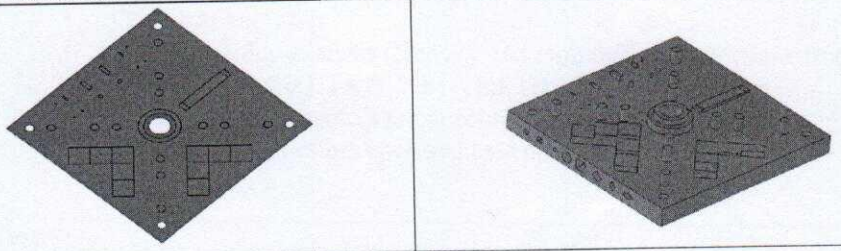
.0 Bench Marking:	
Bench marking part during Technical evaluation	- The following test artifact shall be built as bench marking part using the Stainless Steel 316L material. - The Benchmarking part as shown in Figure1 is to be built in OEM system for submission to TEC. - The built part to be supplied along with 3 nos. of sub-size tensile test specimen of 3 mm thickness as per ASTM E8 in horizontal and vertical orientations with respect to build direction without performing any post processing operation during technical evaluation. - The IGES format of the test artifact is enclosed along with tender enquiry. The drawing are enclosed as Appendix 'F' - The build part will be subjected to the following tests • Dimensional inspection as per drawing enclosed as appendix. • Chemical analysis • Metallographic analysis (Density and Homogeneity of Microstructure) • Tensile strength (UTS & Y.S) • Hardness
	

Figure1: Bechmarking part for TEC

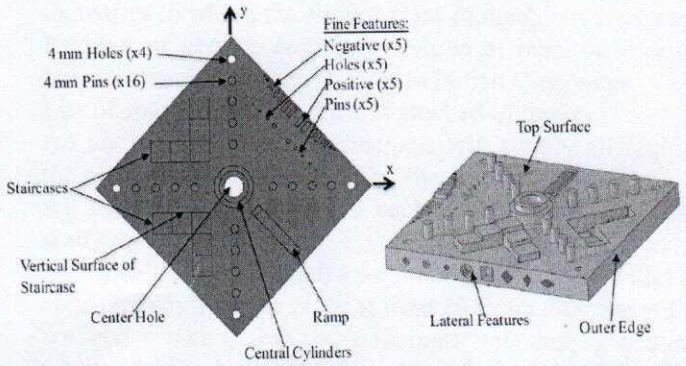
15.0 Acceptance criteria during pre-dispatch Inspection	
Pre-dispatch Inspection	• Pre-dispatch inspection and acceptance test shall be carried out in presence of DRDL representatives at Works (OEM site). • Demonstration of build process as per user specifications. • All the machine features and positional accuracy as per DRDL specifications need to be demonstrated. • List of deliverables to be identified by part name and number. • The functioning of the accessories need to be demonstrated.
Bench marking part	- The following test artifact as shown in figure 2 shall be built as bench marking part using the Stainless Steel 316L material. - The built part has to be evaluated along with 3 nos. of sub-size tensile test specimen of 3 mm thickness as per ASTM E8 in horizontal and vertical orientations with respect to build direction without any post processing operation and to be demonstrated during pre-dispatch inspection at Works (OEM site) and final demonstration at DRDL. - The IGES format of the test artifact is enclosed along with tender enquiry. The drawing are enclosed as Appendix 'F'
	

Figure2: Bechmarking part for Pre-dispatch Inspection

ilding of Test Parts	- The test parts as mentioned below shall be built using the specified material for acceptance along with 3 nos. of sub-size tensile test specimen of 3 mm thickness as per ASTM E8 in horizontal and vertical orientations with respect to build direction. • Test Part 1 (Stainless Steel SS 316L); Dwg No. DRDL/Sketch/TP1 • Test Part 2 (15-5 PH Steel); Dwg No. DRDL/Sketch/TP2 • Test Part 3 (17-4 PH Steel); Dwg No. DRDL/Sketch/TP3 - Drawings of Test Parts are enclosed as Appendix 'F. IGES model is uploaded along with tender. - To calibrate the accuracy of the machine, test artifact is to be built and submitted to the user as reference specimen. - Dimensional accuracy and surface finish of the bench marking components and test parts to be inspected and reported with reference to CAD data.
Evaluation of Benchmarking and test parts	- The Benchmarking part and Test parts shall be subjected to the following tests and reports to be generated in the presence of DRDL representatives at Works (OEM site). • Dimensional inspection as per drawing • Chemical analysis • Metallographic analysis (Density and Homogeneity of Microstructure) • Tensile strength (UTS & Y.S) – for Tensile Test specimen • Hardness - for Tensile Test specimen • Acceptance values are enclosed as Appendix 'E'.
16.0 Installation and Commissioning:	
	- Manufacturer shall carry out installation and commissioning of the facility including other sub-systems, supportive equipment, and monitoring equipment for the operation of the machine. - License for processing of the material mentioned shall be installed. - Full demonstration of the facility and the performance of the equipment to the specification and acceptance criteria.
17.0 Warranty:	
For equipment	The complete equipment along with accessories, spares if any must be warranted for free repairs and replacements for a period of 36 months from the date of installation and commission at DRDL
For Software	- Software updates shall be provided freely for a period of 36 months from the date of installation. - Perpetual licenses for software shall be provided for all materials mentioned above.
18.0 Service Requirements:	
To be provided by vendor	The following details and services shall be provided - List of service centres in India / Abroad. - The vendor should enclose the documentary evidence of a list of institutions or industries to whom the similar class of machines were supplied. - Number of service engineers trained at manufacturer's site and available in India to provide service support to Indian Customers. - List of spares and consumables stocked in India. - An undertaking that the principals will supply all required spares and service the equipment for 10 years after the warranty period. - All the software updates to be installed as soon as it is released during the warranty period. - Technical support for software updates, mechanical and electrical maintenance, consumables and spares for at least 10 years after the warranty period. - An under taking that the principals will supply a complete set of manuals (operational and maintenance with necessary details) – 3 sets

19.0 Training details:	

Details about training	- Training shall be provided for Five (5) personnel at Works (OEM site) before the despatch of machine for 15 working days in the following aspects.
	  - Two engineers shall be trained in the *Operation of the machine, material changing procedures, Programming, transfer of data, setup preparation, operation of other machine accessories and safety procedures.*
	  - Two engineers shall be trained in the areas related to, *mechanical & electrical maintenance, calibration of machine, machine configuration and maintenance software management.*
	  - One engineer shall be trained in the topics of *Development of process parameters, optimisation of parameter, selection of support build structure and orientation.*
	- Post Installation training for minimum 15 days to be provided at DRDL on the operation and maintenance of the machine.

20.0 Spares and Consumables:	
	- Vendor shall quote under a distinct head all the standard spares for two years of post-warranty period operation. - 50 kgs each metal powder [Stainless steel (316L), 15-5 PH and 17-4-PH] shall be supplied along with the machine. - 100Kgs of blasting medium ranging from 250 microns to 600 microns of average size to be supplied along with machine. - The standard consumables for three years shall be supplied along with machine. - Hence L1 shall be decided by considering the cost of basic machine, cost of offered metal powder and blasting medium only. The cost of standard spares and consumables necessary for 3 years of trouble free operation of Machine shall not be considered to arrive L1 offer.

Abhishek Kumar
Sc 'D', Member Secratary

V. K Jain
Sc 'D', External Expert RCI

R. Ashok Pavan Kumar
Sc 'E', Internal expert

01/12/2016
N. Srinivasa Rao
Sc 'E', External Expert, DMRL

Ashish Kumar
Sc 'E', External Expert, ASL

A. Venkat Ramana
Sc 'E', External Expert, DMRL

Bikramjit Podder
Sc 'F', DRDL

P Shravan Kumar
Sc 'F', DRDL (Rep R& QA)

Dr. Shivapal Singh
Sc 'F', Chairman

Appendix C

ACCEPTANCE TEST PLAN

METAL ADDITIVE RAPID PROTOTYPING FACILITY

1. Installation and commissioning of the machine to be done by the supplier at DRDL and proving out of the machine and demonstration of all the features is to be carried out by the firm at DRDL.

2. The firm shall demonstrate the capability of the machine in processing of Stainless Steel (316L) and PH steels (15-5 and 17-4) as given in specification.

3. The benchmarking test artifact with material SS 316L be built and submitted along with process parameters for evaluation in order to prove out the capability of the machine as given in Clause 15 of Appendix 'B'.

4. Three sub-size tensile test specimens of Materials SS 316L, 15-5PH and 17-4 PH steel as per ASTM E8/E8M of 3 mm thickness are to be made in Horizontal as well as Vertical orientations and to be submitted for testing at user premises. The corresponding drawings and acceptance values have been enclosed as Appendix 'E' and Appendix 'F'.

5. The firm shall demonstrate the build capability for test parts specified by user and to be submitted for Dimensional and Geometrical Inspection.

6. The firm shall provide training to five (5) personnel at Works (OEM site) before the despatch of machine for 15 working days as specified in 'clause 19' of Specifications and to the concerned engineers and operators for minimum of 15 days on operation and maintenance of the machine at DRDL after installation and commissioning.

7. The firm shall ensure the safety norms as specified in the specifications.

8. The firm shall supply 3 sets of hard copy of operation/programming and maintenance manual.

R. Ashok

(R. ASHOK PONRAM)
Sc-'E', QAO/DOE

Abhishek Kumar

Abhishek Kumar
Sc 'D'

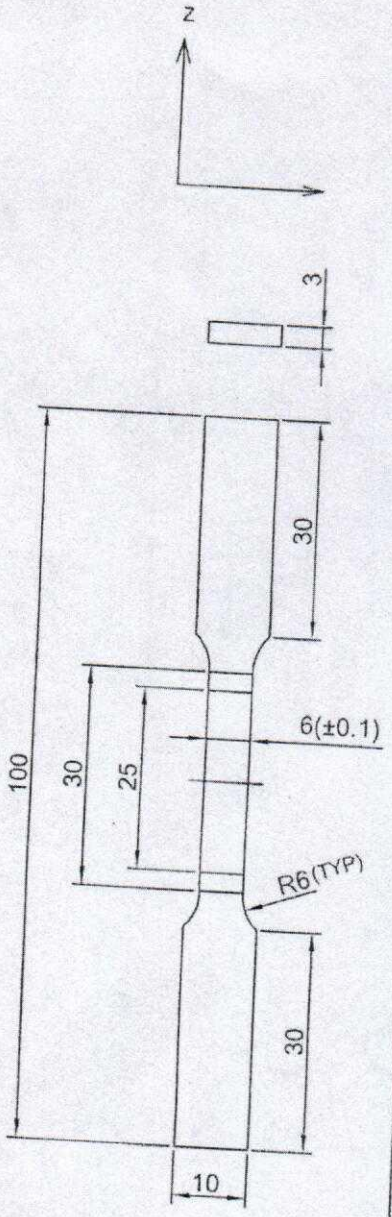
ANNEXURE-P

OTHER TERMS & CONDITIONS

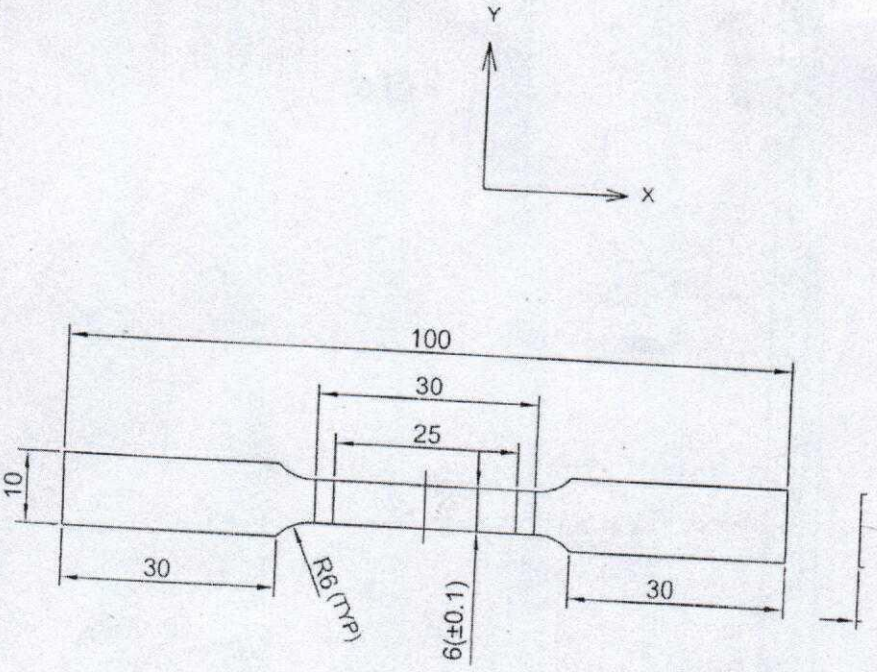
1. The supplier must quote in the tabular from indicating compliance of features of the equipment being quoted with those given in the specifications. If any feature does not comply, the same has to be clearly mentioned with relevant details for further consideration. Without such clarifications, it will be assumed that the quoted model does not have the required features as in the specifications – and the quotation will be liable for rejection.
2. DRDL reserves the right to determine which deviations are deemed substantial based on the current and the future requirements. If there are better features in the quoted equipment, than what are indicated in the specifications, they may be clearly explained.
3. The firm must adhere to quote in the sequence as mentioned in our specifications **only.**
4. The supplier may provide technical brochures and application notes adequately explaining and confirming the availability of the features in the equipment being quoted. The supplier must provide guarantee (in writing) that the specification being quoted for shall be demonstrated to conformity with the values quoted in quotation at the user's laboratory.
5. The firm should clearly highlight the specifications not meeting the DRDL specifications.

Appendix C

Nomenclature	Stainless Steel 17-4PH	Stainless 316L	Stainless Steel 15-5 PH	Maraging Steel
Applicable Standards				
Material Composition	Cr : 15 - 17.5% Ni : 3 - 5% Cu : 3 – 5 % Mn: max. 1% Si: max. 1% Mo: max. 0.5% Nb : 0.15 – 0.45% C: max. 0.07%	Cr: 17 – 19% Ni: 13 – 15% Mo: 2.25 – 3% C: 0.030% Mn: max. 2% Cu: max. 0.50% P: max. 0.025% S: max. 0.010% Si: max. 0.75% N: max. 0.10%	Cr : 14 - 15.5% Ni : 3.5 – 5.5% Cu : 2.5 – 4.5 % Mn: max. 1% Si: max. 1% Mo: max. 0.5% Nb : 0.15 – 0.45% C: max. 0.07%	Ni : 17 – 19% Co : 8.5 – 9.5 % Mo: 4.5 – 5.2% Ti: 0.6 – 0.8% Al : 0.05 – 0.15% Cr:Cu: 0.5% C: 0.03% Mn, Si : 0.1% P, S : 0.01%
Relative Density	Approx. 100%	Approx. 100%	Approx. 100%	Approx. 100%
Density	7.8 g/cm^2	Min. 7.9 g/cm^2	7.8 g/cm^3	8.0 – 8.1 g/cm^3
Mechanical Properties				
Ultimate tensile strength -in horizontal direction (XY) -in Vertical direction (Z)	min 850 MPa (123 ksi) min 850 MPa	640 ± 50 MPa 540 ± 55 MPa	1150 ± 50 MPa 1050 ± 50 MPa	1100 ± 100 MPa 1100 ± 100 MPa
Yield Strength, -in horizontal direction (XY) -in Vertical direction (Z)	Lower yield strength, min 530 MPa min 530 MPa	Upper yield strength, min 595 MPa min 595 MPa	530 ± 60 MPa 470 ± 90 MPa	1050 ± 50 MPa 1000 ± 50 MPa	1050 ± 100 MPa 1000 ± 100 MPa
Elongation at break -in horizontal direction (XY) -in vertical direction (Z)	min 25% min 25%	40 ± 15% 50 ± 20%	16% ± 4% 17% ± 4%	10 ± 4% 10 ± 4%
Hardness -as built (Approx)	230 ± 20HV1	85HRB	30 – 35 HRC	33 – 37 HRC



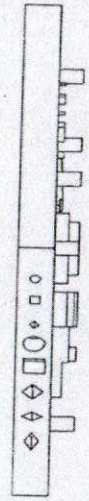
Vertical Test Specimen

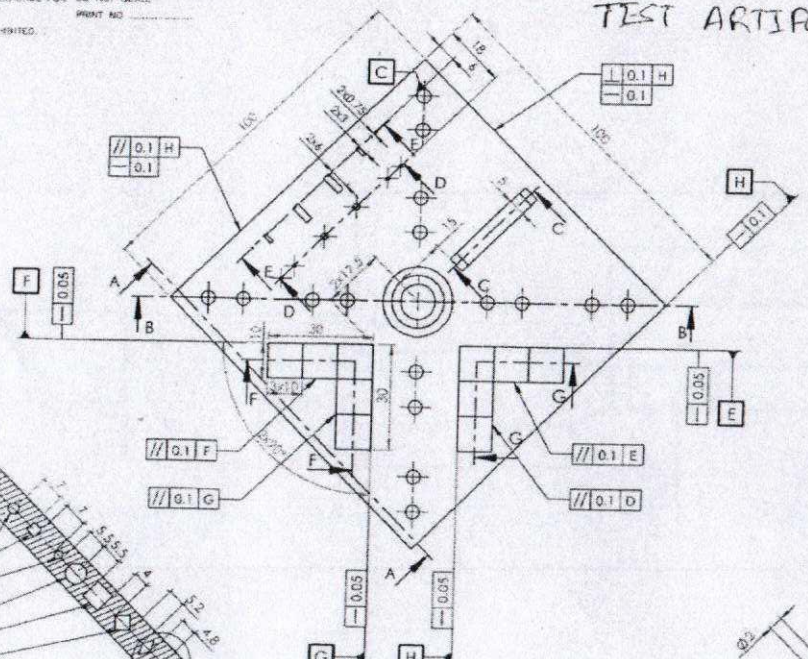


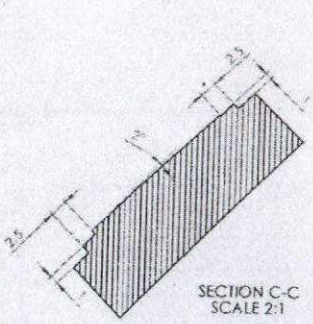
Test specimen as per standard ASTME8

Abhishek Kumar

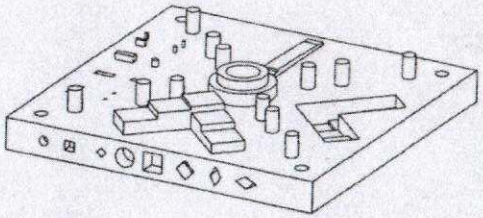
TEST ARTIFACT FOR TECHNICAL EVALUATION



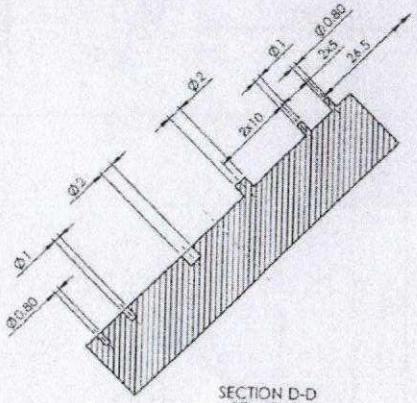




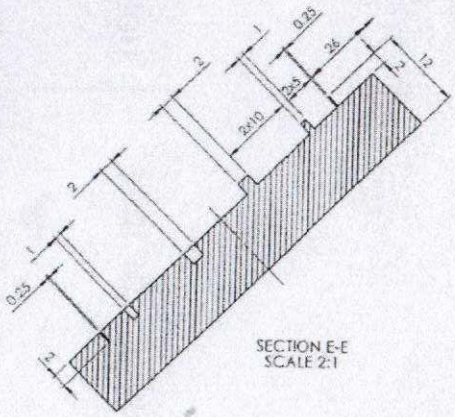
SECTION C-C
SCALE 2:1



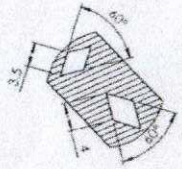
SECTION A-A



SECTION D-D
SCALE 2:1

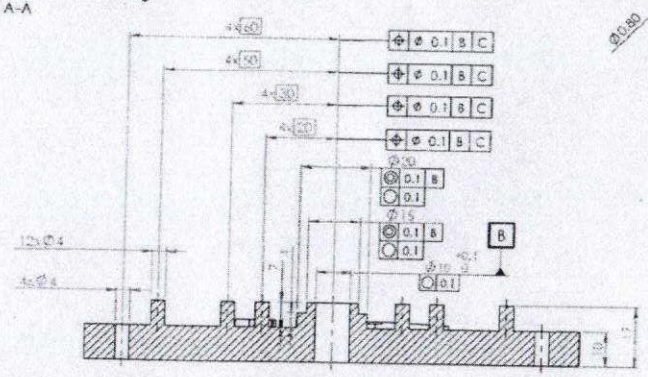


SECTION E-E
SCALE 2:1

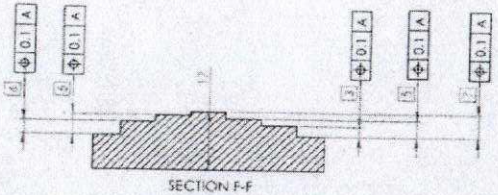


Uniform depth 5 mm.

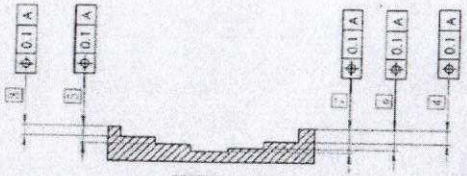
DETAIL A
SCALE 2 : 1



SECTION B-B



SECTION F-F



SECTION G-G

NOTE:

Mat: - SS316L

Ref: NIST - TEST ARTIFACT-2012.

Page 2/4

PART No.	DESCRIPTION	DRG.No./SPEC. No.	MATL	QTY	REMARKS
DEVIATIONS FOR UNTOLERANCED DIMENSIONS TO CONFORM TO SPEC. IS : 2102 – MEDIUM			DRAWN TO SPEC. IS:696 & DROL NOTE SHT. 1&2		
DIMENSIONS ARE IN mm		SCALE 1:1			
	DATE	NAME	MATL : AS PER TECHNICAL SPECIFICATIONS		RCMA (M)
DRAWN					
CHECKED					APPD (DGN)
MASS : .	COMPUTER FILE NAME : .		FINISH :		APPD (DRG)

TEST-ARTIFACT FOR TECHNICAL EVALUATION

PART LIST No.

ASSY DRG NO.

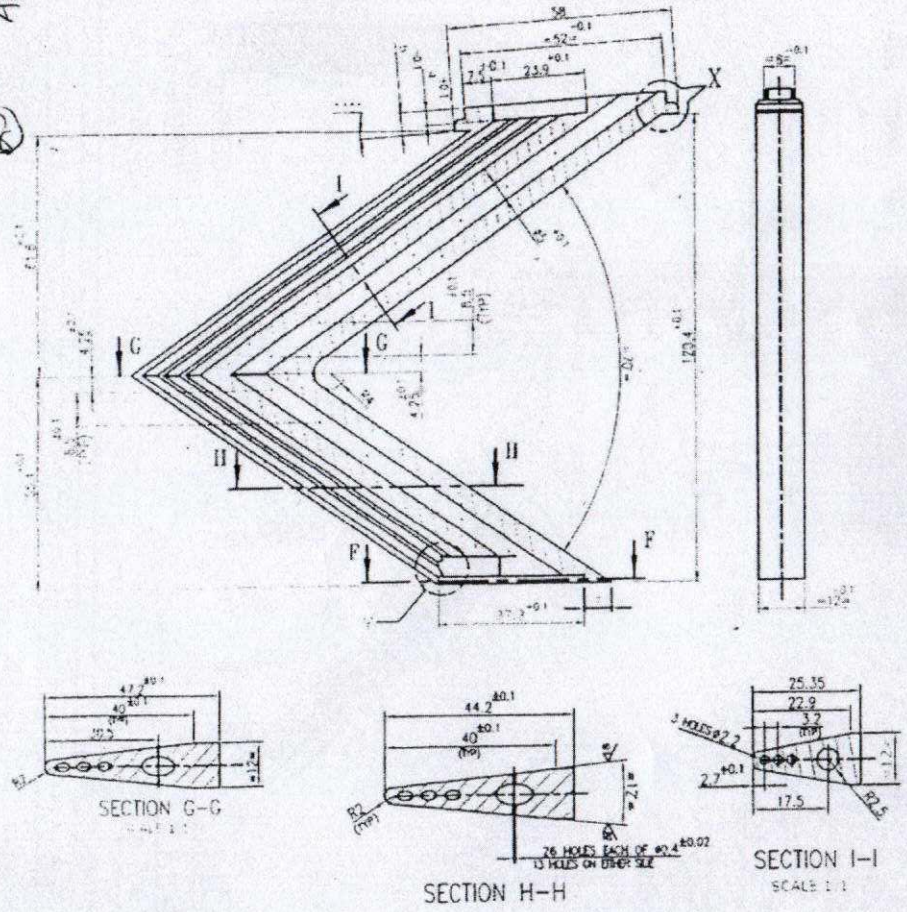
DEFENCE RESEARCH & DEVELOPMENT LABORATORY HYDERABAD

DRG NO : SKETCH/01

R.No	DATE	AUTHORITY	ZONE	BRIEF RECORD	DATED INITIALS

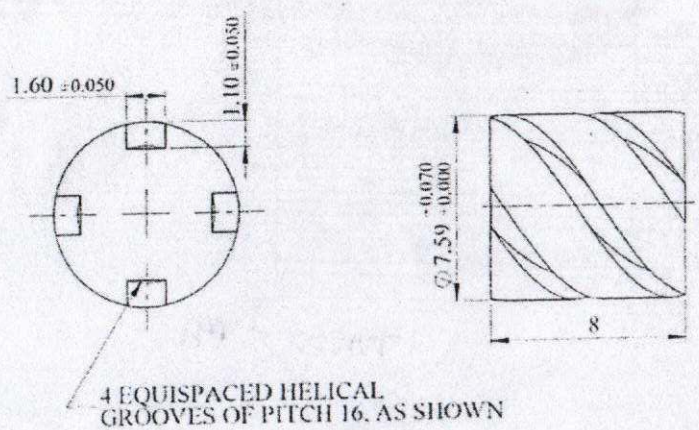
Appendix 'F'

(25)



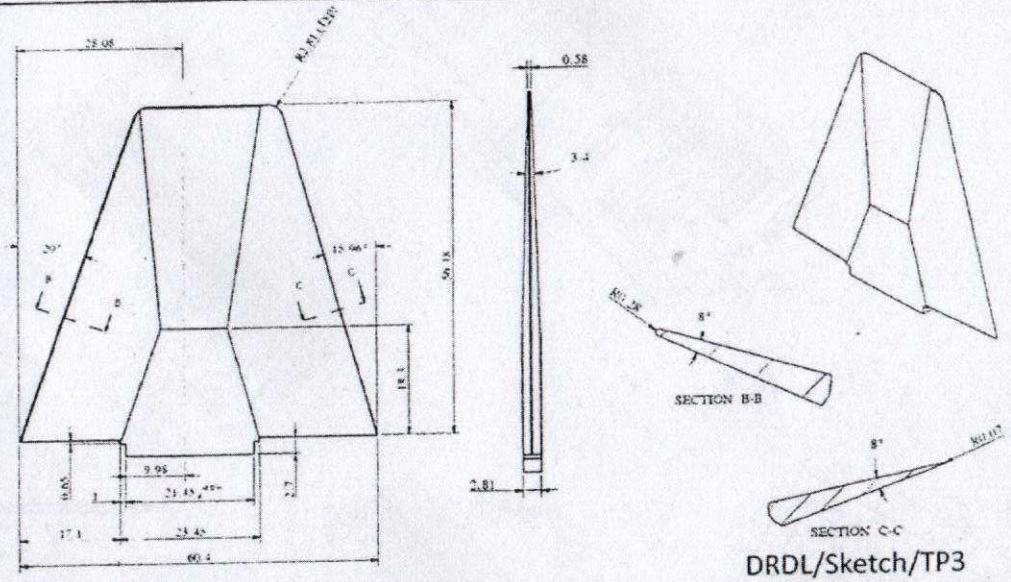
Material- SS316L

DRDL/Sketch/TP1



Material- 15-5 PH

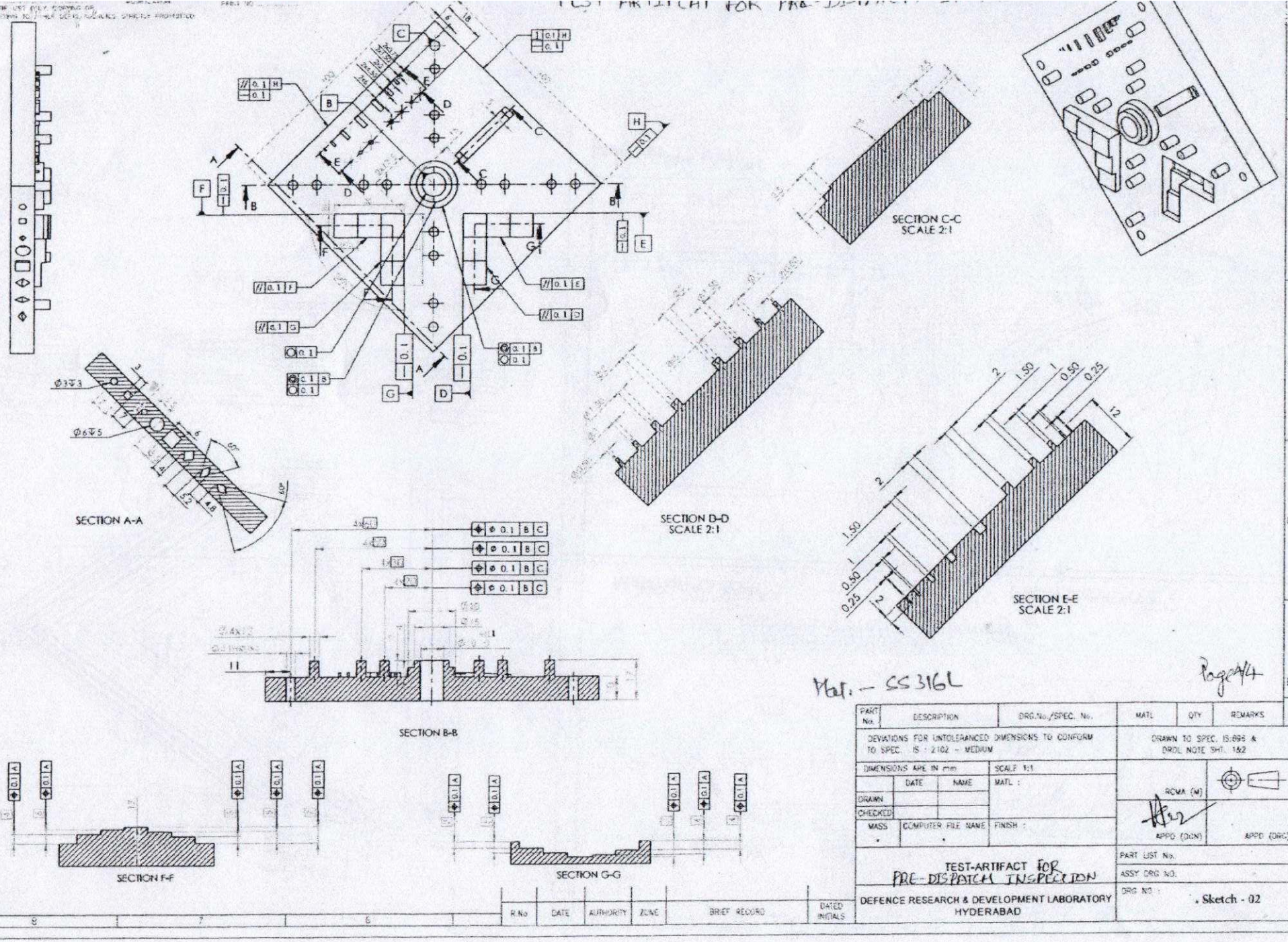
DRDL/Sketch/TP2



Material- 17-4 PH

DRDL/Sketch/TP3

Abhishek Kumar



Mat:- SS316L

Page 4/4

PART No.	DESCRIPTION	DRG.No./SPEC. No.	MATL	QTY	REMARKS
DEVIATIONS FOR UNTOLERANCED DIMENSIONS TO CONFORM TO SPEC. IS : 2102 - MEDIUM			DRAWN TO SPEC. IS:696 & DRDL NOTE SHT. 1&2		
DIMENSIONS ARE IN mm			SCALE 1:1		
	DATE	NAME	MATL :		
DRAWN					
CHECKED					
MASS	COMPUTER FILE NAME		FINISH :		

RCMA (M)

APPD (DGN) APPD (DRG)

TEST-ARTIFACT FOR PRE-DISPATCH INSPECTION

DEFENCE RESEARCH & DEVELOPMENT LABORATORY HYDERABAD

PART LIST No.

ASSY DRG NO.

DRG NO : Sketch - 02

R.No	DATE	AUTHORITY	ZONE	BRIEF RECORD	DATED INITIALS

Appendix 'G'

List of Consumables for Rapid prototyping facility

1. Metal powders
   - I. SS 316L : 50 Kgs
   - II. 15-5 PH Steel : 50 Kgs
   - III. 17-4 PH Steel : 50 Kgs
2. Recoater Blades : 2 Nos
3. Build Plates : 3 Build plates for each material as listed above
4. Filters : Required Quantity (Nos) for 6000 Hours of operation of the machine.
5. Blasting Medium : 100 kgs (250-600 microns size)

Abhishek Kumar
Sc 'D' TED
DOE, DRDL

NOTE

17-02-2017

Sub: Procedure to download CAD models in IGES Format

Ref: Tender No- 32/07P/14/0726, Dated: 26-02-2015, (Metal Additive Rapid Prototyping Facility)

The 3D CAD Models as mentioned in the specifications are being uploaded along with Specifications. The procedure to download the Models is as follows

1. The 5 CAD models in IGES format are upload as Winrar file named as 'CAD MODELS'
2. The participating vendor needs to download them and open in any CAD software.

In case of any difficulty in downloading the CAD models, you can contact the undersigned on mail and mobile.

Abhishek Kumar, Sc 'D'
Email: meet2abhishek@gmail.com
Mobile: 40-24583792/9618880080

Abhishek Kumar
Sc 'D'
DOE/DRDL

TO

CMM-I