Appendix B

SCOPE OF WORK FOR FABRICATION AND SUPPLY OF RAMJET PROOF COMBUSTOR

The fabricator shall fabricate Proof ramjet motor as per the following scope of work:

1. The requirements in respect of quality assurance plan enclosed in Appendix C shall be fully met. The manufacturer shall prepare detailed manufacturing drawings taking into consideration manufacturing allowances and submit it to RPD/DOSRP, DRDL for approval prior to start of work. The dimensional requirements mentioned in the drawings shall be met by the fabricator. Necessary machining allowances for intermediate stages of fabrication shall be arrived at by the fabricator.
2. All the raw material required for realizing the combustor is to be procured and inspected by the firm. **NO FIM shall be supplied by DRDL**. All the raw material procured by the firm for use in fabrication shall accompany certificates for chemical composition, mechanical testing and ultrasonic inspection.
3. The hardware shall be supplied within 6 months from the date of placement of supply order.
4. Fabrication of any fixtures required for machining or welding is the responsibility of the firm.
5. Machining of individual component as per engineering drawing shall be carried out by the firm. Machining allowances, wherever required, shall be provided by the firm.
6. Qualification of welding and operation (WPS, PQR & welder's qualification) is required for carrying out final welding operation. Welding should be inspected as per the procedure laid down in QA plan and report to be submitted to DRDL for clearance. All weld joints shall be radiographed (wherever possible) and DP tested as per standards mentioned in QA plan.
7. Purchase of fasteners is the responsibility of the firm.
8. Procurement of O rings, seals, gaskets etc. are the responsibility of the firm.
9. The firm shall demonstrate matching and integration of all matching parts of combustor. If any problem is found, then corrective action or replacement of the component is the responsibility of the firm.
10. The firm shall submit a comprehensive inspection report containing raw material, Process inspection, 100% dimensional inspection at every stage of processing, radiographic reports, weld coupon test results, hydraulic proof pressure test procedure, certificates pertaining to bought out items like fasteners, O rings, seals etc.
11. The hardware shall be painted with enamel paint for weather proofing.
12. The hardware shall be marked with identification number, manufacturer's name and address, date of manufacture.
13. Packaging and transportation to DRDL of fabricated motor shall be done by the firm.
14. **Prospective vendor has to collect the drawings from RPD/DOSRP after the enquiry is floated. The vendor has to collect the drawings after signing NDA (Non-Disclosure agreement) and the drawings are not to be shared anywhere else.**

Appendix C

QA PLAN FOR FABRICATION AND SUPPLY OF RAMJET PROOF COMBUSTOR

1. Introduction:

RPD/DOSRP is carrying out developmental activities for solid fuel ramjet engines. Ramjet motor is an essential subsystem of this propulsion system. Number of static testing needs to be carried out in ramjet mode to verify the various performance parameters of the system. Proof ramjet combustor is required to carry out these static testing. Proof ramjet combustor is having the same internal profile as the actual combustor, however its thickness is higher and it is made up of mild steel. Hence, to improve the system reliability through testing fabrication of ramjet proof combustor has been taken up.

Scope of document:

This QA plan gives the details of applicable drawings, applicable documents, raw materials specifications, fabrication process, inspection requirements, and acceptance criteria for Fabrication and supply of ramjet proof combustor.

2. Applicable Drawings:

Read Point 14 of Appendix B

3. Applicable Documents:

ASME	ASME Boiler and pressure vessel Code Sec V, Sec VIII & Sec IX
ASTM A240/ A240M-04a	Standard Specification For Chromium and Chromium Nickel Stainless Steel Plate, Sheet and strip for Pressure Vessels for General Applications
ASTM A 516	Standard Specification for Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service
ASTM E 1417	Standard Practice for Liquid Penetrant Examination
ASTM A 370	Standard Test Methods and Definitions for Mechanical Testing of Steel Products
BS 970: 1991 (Part 3)	Specification for Wrought steel for Mechanical and allied Engineering purposes
IS 1364 (Part 2)	Hexagon head bolts, screws and nuts of product grades A and B,
1S 2004:1978	Carbon steel forgings for general engineering purposes
ISO 1106/1 -1984	Recommended practice for radiographic examination of fusion welded joints- Part 1 : Fusion welded butt joints in steel plates up to 50mm thick

4. Bill Of Materials:

As given in Appendix D

5. Raw Material Specifications

Carbon steel (grade 70 as per ASTM A 516) shall be used for fabrication of ramjet proof combustor. The tests required for raw materials are given below:

5.1. Chemical Composition

Chemical composition of grade 70 carbon steel shall be as per ASTM A 516. Based on the final thicknesses of components given in the drawings, the applicable chemical composition shall be determined. The chemical composition is reproduced below:

Element	Thickness	Percent
	1/2 in. [12.5 mm] and under	0.27 (max)
	Over 1/2 in. to 2 in. [12.5 to 50 mm], incl	0.28 (max)
	1/2 in. [12.5 mm] and under	0.85-1.20
	Over 1/2 in. [12.5 mm]	0.85-1.20
Phosphorus	N/A	0.035 (max)
Sulphur	N/A	0.035 (max)
Silicon	N/A	0.15-0.40

The chemical analysis shall be carried out on a sample taken out of the batch manufactured under same condition, from same stock from one source offered at one time. Chemical analysis shall conform to ASTM A 516.

5.2. Mechanical Properties

Property	Value
Tensile strength	480-620 MPa
Yield strength	260 MPa (min)
%Elongation	17(min)

Three specimens from each lot shall be tested for tensile properties in accordance with ASTM A370 and the results shall conform to the specifications.

Identification numbers shall be verified with those mentioned in the test certificates forwarded by the raw material supplier.

Copies of raw material certificate shall be submitted to DRDL inspection authority for approval.

6. Fabrication process:

6.1. Material for Welding Trials:

Test coupon or welding trial shall be carried out for generating welding procedure specification (WPS), procedure qualification records and operator qualification personnel carrying out welding shall be approved welders as per Section IX of ASME BPVC.

6.2. Welder/welding operator qualification:

Welder shall be approved welder as per ASME B&PV code Section IX. Manufacturer shall identify only approved welders as per ASME Boiler & Pressure Vessel Code Section IX capable of understanding.

a) Welding parameters
b) Reading of drawings
c) Operation and control of welding equipment
d) Electrode details
e) Process of inspection and acceptance of welding

6.3. Fabrication methodology:

The proof Ramjet combustor is to be fabricated through the route of welding of dump mesh to the combustor shell and also the welding of flanges to the shell. The individual components shall be fabricated separately. Welding shall be carried out in a sequence, which results in minimum distortion. The fabricator is to provide suitable machining allowance on the individual components such that the assembly conforms to the final dimensions given in the drawing.

a) Various components are to be fabricated with the edges prepared for the required weld as per the engineering drawing. The individual elements should have machining allowances such that distortions are taken care of and that after final machining the motor dimensions conform to the drawings.
b) Suitable fixtures are to be used to control the distortions during welding and also to ensure that the final components conform to the dimensions given in the engineering drawing within the tolerance limits.

6.4. Process:

a) Clean the joint faces and adjacent surfaces before welding and use specially clean and packaged filler rods.
b) Removal of slag on the surface and previous weld bead between passes shall be carried out.
c) A minimum of 2 passes of TIG welding at the root followed by arc welding shall be carried out for the welds.
d) Machining of sealing surfaces to be carried out by milling to the required surface finish and groove dimensions as specified in drawing.

7. Weld Joint Inspection

7.1. Visual Inspection:

During the process of welding the following inspection shall be carried out visually:

- Treatment of tack welds
- Quality of the root pass & succeeding weld layers
- Sequence of weld passes
- Inter pass cleaning
- Root preparation prior to welding a second side [removal of slag by chipping, gouging or grinding]

After welding, the following shall be inspected visually

- Final weld appearance
- Final weld size
- Extent of welding

Cracks: Surface cracks are not acceptable in the weld surface and the heat-affected zone.

Voids and pores: Voids and pores open to the surface are not acceptable.

Mismatch: Mismatch shall not exceed 5% of thickness.

Rework: More than one rework is not permitted on weld joint.

7.2. Fluorescent penetrant inspection:

All welds shall be fluorescent penetrate inspected in accordance with SAE AMS 2647 / ASTM E165 to locate imperfections open to the surface. No defects are permitted. 8 microns wide and 50 microns deep crack shall be detected by the method adopted.

7.3. Radiographic Inspection:

Butt welds are to be radiograph in accordance with ASME Boiler & Pressure Vessel Code Section V. Sensitivity of the radiograph shall be less than 2%.

Cracks, undercuts: Not acceptable

Porosity, voids and inclusions: Weld discontinuities such as porosity, voids & inclusions shall conform to acceptance standards in ASME Boiler & Pressure Vessel Code Section VIII, Division 2, Article 1-5. However the maximum pore size shall not exceed 1.5mm in size. Radiography shall be conducted and certified by a qualified minimum ISNT level II inspector.

8. List of fasteners:

EN 24(as per BS 970(Part 3)) fasteners of 10.9 **class** are to be used for the all fastened joints.

The procurement of these fasteners is in the scope of the vendor.

Size	Quantity required	Comment
M16 x 2	48	Along with nut plain washer

All the fasteners shall be **"UNBRAKO"** make and shall be supplied in sealed packets as supplied by manufacturer. Procurement of loose fasteners is NOT permitted. The firm shall also make available all the relevant inspection certificates with respect to fasteners as provided by manufacturer. At least 10% of fasteners shall be tested for mechanical properties from each batch / box.

9. Dimensional Inspection:

The individual assemblies and final dimensions should conform to the values within allowable tolerances as per the Drawings. The amount of distortion shall be determined and shall be less than 0.5mm. Ovality shall be within 0.5mm.

10. Proof pressure testing

The Ramjet Proof Motor shall be assembled with nozzle end and head end blank (to be manufactured by the vendor for purposes of proof pressure testing) with the specified seals and O-rings and hydro tested to a pressure of 10 ksc for duration of 180 sec. The fasteners used for fastening the blanks shall be bought by the firm (UNBRAKO make only).

Only distilled water shall be used for hydro test and water shall be free from particles.

Hydro test shall be carried out in the presence of DRDL inspection authority. No leakage from weld joints, parent material or fastened joints is acceptable.

Only brass gaskets shall be used for hydro test and low pressure leak test during the final assembly.

11. Corrosion Protection

Red oxide paint shall be applied on all the exposed surfaces of the hardware. Zinc rich epoxide paint shall be used for this purpose. No part shall be left uncovered from the protective layer.

12. Marking

The combustor shall be marked by engraving/ painting on the face of flange opposite to seal face with the following information:

- Serial No.:
- Date of fabrication:
- Date of Hydro test:
- Manufacturer's insignia
- Material of construction

13. QA Matrix:

DRDL inspection authority shall witness/ review the reports as per the given QA matrix:

Raw material			
1.	Chemical composition	R	
2.	Mechanical properties	R	
Weld Joint			
3.	Visual inspection report	W	
4.	Fluorescent DP test	W	
5.	Radiographic inspection	R	Pre Proof Pressure test
6.	Radiographic inspection	R	Post Proof Pressure test
Fasteners			
7.	MPT test	W	
Final			
8.	Dimensional inspection	W	
9.	Proof Pressure Test	W	

R: Review Reports W: Witness

Appendix D

LIST OF DELIVERABLES

S No	Nomenclature	Quantity
1.	Ramjet Combustor Assembly	03 sets

Bill of material for 1 set of Ramjet Combustor Assembly is given in the table below.

Sl. No.	Nomenclature	Quantity / Set
1	Dump Combustor Welded Assembly	01
2	Ramjet Combustor Welded Assembly	01
3	Ramjet Nozzle Welded Assembly	01
4	Baffle Plate Left	01
5	Baffle Plate Right	01
6	Baffle Pins	02
7	M16x2 Flange Nut	24
8	M16x2 Flange Bolt	24
9	M16 Plain Washer	24