Request for Proposal (RFP)
for
Fabrication and Supply
of
Pyrolytic Graphite Sheet (PGS) Thermal Strap

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1. Introduction

U.R. Rao Satellite Centre (URSC), Bangalore is a lead centre of Indian Space Research Organization (ISRO) for design, fabrication, assembly and testing of satellites in India. Thermal Systems Group (TSG) of URSC/ISRO is responsible for providing suitable thermal control system for all the satellites. Pyrolytic Graphite Sheet (PGS) thermal strap as shown in Figure 1 is emerging as an effective and efficient flexible thermal link to transfer heat from source to sink.

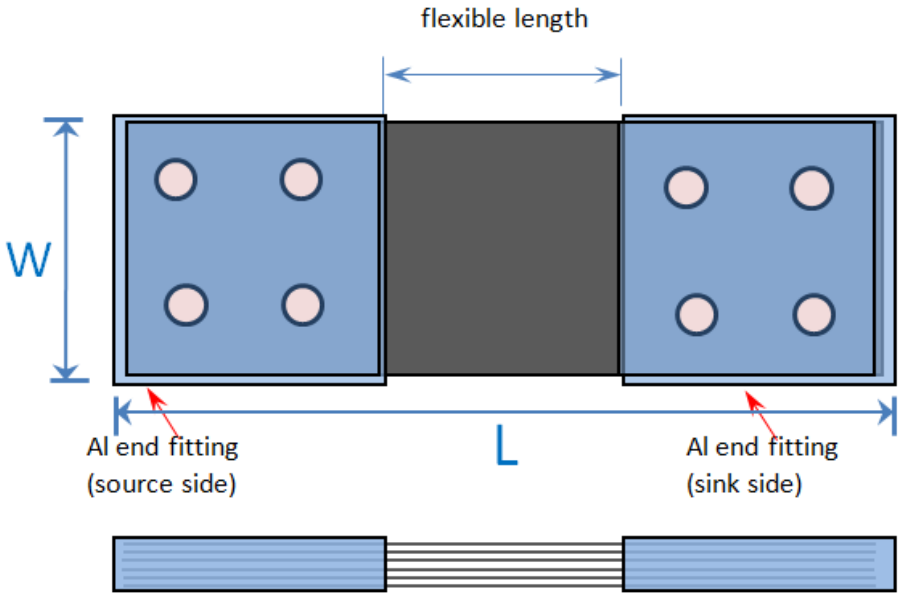

Figure 1: Schematic representation of a typical PGS thermal strap with Aluminum end fittings

Due to the growing potential use of PGS thermal strap, URSC has decided to outsource the fabrication of the straps to a suitable Indian vendor which can meet the stringent qualification requirements of URSC. This document provides all the needed input for the fabrication of the straps.

Vendors are requested to go through the document, understand the configuration, scope of work and the work order conditions before submitting quotation.

2. Typical PGS Configuration:

There are two types of PGS: (1) with end fittings and (2) without end fittings. Figure 2 shows PGS with Aluminium end fittings. The PGS sheets are bonded together with silver epoxy at the ends. The outer layers of the straps are covered with 1 mil Polyamide sheets.

Figure 2: A typical PGS strap with Aluminium end fittings

PGS *with end fittings* consist of:

a. **End fitting**: End fittings are made up of Al6061. These end fittings are made using CNC machine to fit at the heat source and heat sink location. Each end fitting consists of two parts-one base plate and top plate and within this PGS layers re sandwiched.
b. **PGS sheet layers:** PGS layers are cut into the shape to fit within the end fittings of the thermal straps.
c. **Adhesive:** The PGS layers are bonded with silver epoxy adhesive (EPO – TEK® EK2000) at the end fitting regions.
d. **Outer protective cover:** The PGS layers are wrapped with 1 mil polyamide sheet (Kapton®) on the outer sides (except end fitting surfaces), which protects from mechanical shock and tearing of PGS layers.

3. Steps involved in realisation of PGS thermal strap:

Following steps are required for the manufacturing of the strap:

a. End Fitting Design: Engineering drawing of end fittings will be provided by the URSC, and the vendor has to develop manufacturing drawing and fabrication of end fittings after approval of manufacturing drawing by URSC.

b. PGS layer preparation: Cutting operation of PGS layers to be carried out so that it can fit in the end fittings (within the dimensional tolerance).

c. Stacking of PGS layers with Silver Epoxy adhesive: The number of PGS layers is as per the design given by URSC, from time to time.

d. Baking of the PGS thermal Strap: The temperature and duration of baking will be provided by URSC, from time to time.

4. Materials and Equipments Required:

I. Industrial Oven for baking of PGS Thermal Strap

- ✓ Maximum temperature: ≥ 300˚C
- ✓ Heating Volume: 40 to 50 litres
- ✓ Maximum Power: 2500 W to 3500 W

II. C-Clamps for pressurising End fittings during baking

III. Surgical blades of SURGEON make of type 11 to cut PGS sheets as per the internal dimension of the end fittings.

IV. CNC Machine for machining of end fittings. This activity can also be outsourced.

V. Aluminium alloy (Al6061) material for preparation of end fittings as specified in annexure – 2.

VI. Pyrolytic Graphite Sheets of various thicknesses like 40 µm , 75 µm , 100 µm, etc. as specified in annexure-1.

VII. Silver epoxy adhesive (EPO – TEK® EK2000)

VIII. 1 mil thick polyamide film (Kapton ®)

5. Scope of Work:

Vendor has to provide 100 numbers of PGS Straps within the duration of 2 years against the supply of drawings by URSC and the time frame can be extended to one more year if need arises.

Typical dimension of PGS thermal Strap is as follows:

- Total **Length (L)** of PGS thermal strap will vary from **50 mm to 200 mm**
- **Width (W)** will vary from **10 mm to 100mm**
- Number of **PGS layers** in the thermal strap will vary from **20** layers to **200** layers.
- End fitting dimensions

  Length: 20 to 100 mm

  Width: 20 to 100 mm

  Height: 5 to 15 mm

6. Responsibility definition:

I. Responsibility of URSC

a) Release of work order to vendor with Engineering drawings for each batch of PGS straps.

b) Provide necessary test procedures, work instructions, checklists and guidelines.

c) Periodic review

d) Space qualification tests on all batches of PGS Thermal straps prior to final acceptance.

II. Responsibility of vendor

a) Preparation of manufacturing drawings, fabrication and supply of PGS Thermal Straps

b) Vendor shall establish required infrastructure at vendor premises for this fabrication.

c) Prepare, maintain and supply necessary log books, reports, documentation, etc. of all activities / processes.

d) Data analysis, report generation and submission to URSC.

e) Provide Quality assurance and Warranty Certificate to URSC

f) All the raw materials and processes need to be qualified by URSC before they are used for the fabrication of the PGS straps.

g) Pack each strap inside in a sealed PVC cover which is free from moisture and with hard casing.

h) Transportation (to &from ISITE / URSC) of PGS Thermal straps for testing, corrections, repair, final delivery, etc., whenever necessary

Vendor Responsibilities in a Nut-shell

i. Fabricate the PGS thermal strap end fittings as per the drawing provided by the URSC and provide the QA certificate of the end fittings and PGS material before fabrication of the strap.
ii. Procure PGS sheets and silver epoxy materials as per URSC specifications provided in this document. Vendor to provide material conformance certificates at the time of delivery.
iii. Cut the PGS sheets within the dimensional tolerances, as per the drawing provided by the URSC.
iv. Fabrication of complete PGS thermal straps as per the procedure mentioned in this document.
v. Pack each strap inside the sealed PVC cover which is free from moisture and with hard casing, as instructed by URSC.
vi. Deliver the PGS thermal straps at TSG office at MSA, ISITE-ISRO, Marathalli, Bangalore.

7. Quality assurance and reliability requirements	
7.1.	The vendor shall provide assurance for maintaining the overall quality.

7.2.	The vendor shall be responsible for verifying all the specification requirements in accordance with the product assurance and reliability specifications. The vendor shall also be responsible for compliance with all the technical specifications. Following methods shall be used to carry out verifications: A. Analysis B. Demonstration C. Inspection D. Test
7.3.	Any specific test performed by URSC, instead of the vendor / subcontractor, shall not relieve vendor from the responsibility of compliance with all the technical requirements. The subcontractor quality shall also be controlled so as to meet the specification requirements if any.
7.4.	The qualification and acceptance tests shall be carried out in accordance with the test procedures approved by URSC. All test procedures and test plans shall be mutually agreed upon by vendor and URSC during Manufacturing Readiness Review (MRR).
7.5.	**PROCESS IDENTIFICATION DOCUMENT** Vendor shall submit for approval, the Process Identification Document (PID) describing the steps necessary to meet the requirements. In order to optimize cost, quality and schedules, these steps should utilize the existing procedures, which have been established over the years as a result of in-house programs at URSC. In case of variations in details and sequence, to comply with the requirements, the same may be proposed. The PID should include, though not necessarily limited to, the following: a. A detailed specification showing component parameters and other data to fully describe the PGS Thermal straps, its components and the allied materials proposed to be supplied.

	b. A detailed flow chart, showing all processing steps involved in the realization of the PGS Thermal straps. A list of QA check points during manufacture shall be included. c. A product flow chart, including the tests under the scope of vendor. d. Manufacturing drawing of the PGS Thermal straps, which complies with the specifications and reflects the hardware configuration when delivered.
7.6.	The vendor shall submit Declared Materials List (DML) for realizing the PGS Thermal straps. All materials to be used in the manufacture of PGS Thermal straps shall be traceable to the input lot whose characteristics shall have been measured, checked for uniformity and recorded during inspection. All material inspection reports shall be made available to URSC, whenever required.
7.7.	Manufacture of PGS Thermal straps shall be carried out in accordance with certified equipment / processes established and qualified for spacecraft. In-process quality assurance shall include the inspections / tests / measurements like physical dimensions, dimensional tolerances, mass, material composition, etc. for each PGS Thermal straps.
7.8.	**Production Control** Vendor shall have complete traceability and lot-control over the complete production flow, beginning from raw material to final product. The lot-control shall include information and traceability to the raw material, processing information, date of processing, operators and equipment used for realizing the PGS thermal straps. URSC reserve the right to station a resident engineer at the vendor facility during the period of the contract to monitor the PGS thermal straps manufacturing, if necessary.

7.9.	A logbook of all the procedures, in-process checks and test conditions and results shall be maintained for each PGS thermal straps. The logbook shall also include recent certifications of all equipment used. All logbooks/ records shall be accessible to URSC representatives.
7.10.	Human resources shall have suitable training and only qualified / certified persons shall carry out the activities.
7.11.	**Non-Conformance Management:** Any non-conformance encountered during the phases of realization of PGS thermal straps shall be reported within 24 hours to URSC for formal clearance and approval.
7.12.	URSC reserves the right to witness the qualification/acceptance tests and to review the progress of the work at various milestones of the programme. If any test is to be carried out at a place other than the vendor's premises, the vendor shall make the appropriate arrangements for the participation of the URSC nominees.
8.	**8. Product documentation** Design document shall contain • Design overview • Interfaces i) User manual and Certificate of compliance (MIL standard or similar) ii) Test reports • Qualification Test Results • Soft copy of all documents / reports / data, etc. with relevant information shall be submitted at least one week prior to the review date through e-mail. Subsequently, hardcopy of the End Item Data package (EIDP) shall be submitted to URSC

9. Patents and Copyrights

- The Intellectual Property Rights such as Patents, Copyrights, Documentations relating to Qualification testing and other quality procedures or any other details related to this activity that are provided by URSC shall remain the property of URSC.
- However, if any special methods or procedure or processes are evolved on mutual interactions, the same may be owned jointly by both URSC and vendor.

10. Work Order Conditions

a. The selected vendor has to establish shop floor for the fabrication of PGS thermal straps, preferably at Bangalore.

b. First few PGS straps will be fabricated under the supervision of URSC Engineers.

c. Work Order will be released separately in batches for each satellite and vendor has to supply the straps within 15 days from the date of work order release.

d. Supplier has to provide the material properties certificate of all the materials used before supply of each batch of PGS straps.

e. All the materials used for PGS Straps need to be procured after obtaining approvals from URSC.

f. Every batch (Batch size will vary from 1 to 20 No.s) of PGS strap will be subjected to inspection at URSC and after final acceptance by URSC payment will be released for each batch

g. **Warranty:** The PGS Thermal Straps shall have minimum warranty for 5 years from the date of acceptance.

11. Inspection Stages

1. First inspection (**MIP-1**) will be carried out after the fabrication of end fittings for each batch at vendor's premises. During this inspection URSC Engineer will check the conformity of the product with the Engineering drawing. After clearance from URSC, vendor can carry out further operation for realisation of the straps
2. Second inspection (**MIP-2**) will check the quality of PGS straps bonding, flexibility of the strap and other manufacturing defects at vendor's premises.
3. Third inspection (**MIP-3**) will be carried out after the delivery of the straps to the URSC. In this stage thermal conductance of the straps will be measured and it need to be within ± 20 % of the design value.

12. Tendering process

- RFP requests in the form of two-part tender viz; Part-1 [Technical and Commercial terms (without pricing information)] and Part-2 [Price Bid], both through e-procurement mode only.
- Being a two-Part Tender, Part-1 will be scrutinized first by URSC and then the techno- commercially qualified vendors shall be eligible for the Part-2.
- As a part of Technical Competence Audit, if required, URSC team shall have the right to visit vendor's premises, to verify and assess the capabilities in terms of Technical Competency, Infrastructure Capacity, Quality Management Systems, Human Resource Management, and Financial Strength, etc. as stated in their proposals.
- On completion of Technical and Commercial terms evaluation, Price Bids of techno-commercially suitable vendors will be opened.
- The lowest price bid will be selected from among qualified techno-commercial Bids.

- The contract signing date or Purchase Order (PO) release date will be taken as T0 for commencement of contract period.

13. Submission of Offer

Offer shall be submitted by the vendor/s in two parts as below:

Part 1: TECHNO-COMMERCIAL (without price details)

This shall include the following:

- Compliance matrix for all the requirements / specifications with explanatory notes, wherever applicable
- All the relevant documents as mentioned in this document
- Payment terms and Performance Bank Guarantee (PBG)
- Price bid details by masking the price part.

Part 2: PRICE BID

- Price bid shall contain
  - Average fixed price of each PGS thermal straps.

- Purchase order will be released on a shortlisted vendor with technically suitable lowest budgetary quote.

14. Compliance Matrix:

Sl. No.	Description	Compliance [YES / NO]
1	Specification of PGS Material as per Annexure -1	
2	Use of Silver epoxy adhesive (EPO – TEK® EK2000)	
3	Wrapping of free length of PGS with 1 mil thick polyamide film (Kapton ®)	
4	Making of the end fitting as per the Engineering drawing released by URSC	
5	Payment for each batch of PGS straps will be released after they are accepted at URSC, post delivery	
6	Vendor has to supply the PGS Thermal straps within 15 days of work order release, for each batch.	

Annexure-1

Table 1: Specifications of PGS Material Roll (Raw Material)

Thickness for different Types	40 µm to 100 µm
Approx width in mm	≥ 200 mm
Roll Length	≥ 25 m
Density (kg/m^3)	~2000 kg/m^3
Working temperature, (°C)	-150 to +250
In-plane Thermal conductivity @ Room Temperature, (W/mK)	≥ 1100 W/mK for all thickness between 40 µm to 100 µm
Across plane Thermal conductivity @ RT, (W/mK)	≥ 10 W/mK
In-plane Coefficient of linear thermal expansion (1/K)	≤ 9.3x10-7 (1/K)
Across plane Coefficient of linear thermal expansion (1/K)	≤ 3.2x10-5 (1/K)
Electrical conductivity (S/cm)	≥10000 S/cm
Extensional strength (MPa)	≥ 20 MPa
Withstand Temperature (°C)	≥ 400 deg C
Bending(angle 180,R5) (Number of cycles for strap bending with 5 mm radius and 180˚angle)	≥10000 cycles

Annexure-2

Table 2: Specifications for end fitting material

Technical Specification for Aluminium Alloy 6061 Plates

<table>
<tr><th>S.No</th><th>Description</th><th>Specification</th></tr>
<tr><td>1.</td><td>Product Form</td><td>Plates</td></tr>
<tr><td>2.</td><td>Applicable Standard</td><td>ASTM B 209/ AMS 4027</td></tr>
<tr><td>3.</td><td>Temper condition</td><td>Plates in T651 Condition</td></tr>
<tr><td>4.</td><td>Chemical Composition</td><td>
<table>
<tr><th rowspan="2">Element</th><th colspan="2">% by weight</th></tr>
<tr><th>Minimum</th><th>Maximum</th></tr>
<tr><td>Magnesium</td><td>0.8</td><td>1.2</td></tr>
<tr><td>Silicon</td><td>0.4</td><td>0.8</td></tr>
<tr><td>Copper</td><td>0.15</td><td>0.4</td></tr>
<tr><td>Chromium</td><td>0.04</td><td>0.35</td></tr>
<tr><td>Iron</td><td>-</td><td>0.3</td></tr>
<tr><td>Zinc</td><td>-</td><td>0.25</td></tr>
<tr><td>Manganese</td><td>-</td><td>0.15</td></tr>
<tr><td>Titanium</td><td>-</td><td>0.15</td></tr>
<tr><td>Other impurities, each</td><td>-</td><td>0.05</td></tr>
<tr><td>Other impurities, total</td><td>-</td><td>0.15</td></tr>
<tr><td>Mg:Si ratio</td><td>1.6</td><td>1.8</td></tr>
<tr><td>Aluminium</td><td colspan="2">Remainder</td></tr>
</table>
</td></tr>
<tr><td>5.</td><td>Mechanical Properties</td><td>
<table>
<tr><th rowspan="2">Temper</th><th colspan="2">Nominal Thickness mm</th><th rowspan="2">Tensile Strength MPa (min.)</th><th rowspan="2">Yield Strength at 0.2% offset MPa (min.)</th><th rowspan="2">Elongation in 50 mm or 4D % (min.)</th></tr>
<tr><th>Over</th><th>Incl.</th></tr>
<tr><td rowspan="5">T6 / T651</td><td>0.5</td><td>13</td><td>290</td><td>241</td><td>10</td></tr>
<tr><td>13</td><td>25</td><td>290</td><td>241</td><td>9</td></tr>
<tr><td>25</td><td>51</td><td>290</td><td>241</td><td>8</td></tr>
<tr><td>51</td><td>102</td><td>290</td><td>241</td><td>6</td></tr>
<tr><td>102</td><td>152</td><td>276</td><td>241</td><td>6</td></tr>
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