Pre-Qualification Requirements for

**SUPPLY, INSTALLATION, COMMISSIONING AND TRAINING OF THERMO-MECHANICAL FATIGUE (TMF) TESTING SYSTEM**

It is proposed to procure an axial-thermal mechanical fatigue test system capable of conducting high temperature low-cycle, high-cycle fatigue experiments on engineering materials, with in-phase, out-of-phase thermal and mechanical loading, complete with hardware, software and instrumentation to the following broad specifications.

Please include all components necessary for complete axial TMF test system such as high stiffness load frame; hydraulic actuators; hydraulic service manifold; hydraulic power unit; digital control electronics and software; computer based control and data acquisition system; transducers for load, strain, and displacement measurement; heating and cooling system with control electronics for thermal fatigue cycling.

All safety features for test system operation, operator safety as well as test specimen safety should be clearly indicated.

**Optional**: Inclusion of Torsional capabilities to the Axial Thermo-Mechanical Test System to allow Axial-Torsional Thermo-Mechanical Fatigue Testing. This might include actuator, associated servo-valves, controls, software and transducers. **This is based on budget availability**.

| Sl.No. | Prequalification Requirement | Compliance/Non-compliance + Remarks/point-by-point technical justification. |
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| 1 | TMF test system based on computer controlled servo-hydraulics principles to conduct tests as per applicable ASTM / equivalent test standards<br>a) +/- 100 kN dynamic capacity with at least 10% overrating for static capacity.<br>b) Maximum temperature up to 1200 deg C<br>c) Provision to conduct axial thermo-mechanical fatigue tests with in-phase (thermal and mechanical loading) and out-of-phase as per user defined test profile.<br>d) Induction heating method (or) radiant bulb heating method of gage section of test specimen with the temperature rise rate of 10 deg C/s and temperature Cooling rate of 5-10 deg C/s<br>e) Temperature stability of specimen and within three zones of heating: +/- 2 deg C.<br>f) Quick mounting and release of temperature heating system with protection for operator against electrical shock and open circuit, heat injuries.<br>g) Ability to conduct static, fatigue tests with test | |

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| | system operating frequency range: 0.001 Hz to 50 Hz (for plain RT high cycle fatigue tests). Use of twin servo-valves (Lo-Flow and Medium Flow). Specify the frequency-amplitude response for test system obtained with specimen loaded condition.<br>h) Ability to conduct user defined waveform testing under displacement, load and strain control.<br>i) Bump less mode transfer from displacement, load and strain modes.<br>j) Transducers and signal conditioners with low drift and low hysteresis as per ASTM E-74 (load cell) and ASTM E 83 (extensometer).<br>k) User programmable creep, stress-relaxation tests on the same TMF test system.<br>l) Alignment of test specimen loading axis using suitable alignment fixtures and conforming to suitable TMF test standards.<br>m) Grips and fixtures along with cooling circuitry for conducting high temperature TMF tests. Temperature outside the heating zone (near load cell or actuator end) shall not exceed 50 deg C.<br>n) Contact extensometer for conducting strain controlled experiments up to 1200 deg C. Extensometer rate for 1200 deg C with compliance to ASTM E-83 standards in terms of linearity, hysteresis, drift and noise.<br>o) Typical gage length of high temperature extensometer: **25 mm with suitable scaling blocks to either increase or decrease gage length ( 12.5 mm** or 37.5 mm) with strain range (calculated for 25 mm gage length) of **+/- 10 % or greater**<br>p) Side load protected load cell for measuring axial tension/compression loading upto +/- 100 kN with adequate over rating for infinite life fatigue operation.<br>q) Free-standing Load frame with twin columns, telescopic lift cylinders, Hydraulic assisted clamping/de-clamping and movable cross-head to accommodate test specimens of various kinds.Load frame stiffness: > **450 kN/mm.**<br>r) Spacing between two columns for specimens: > 500 mm.<br>s) Working height between actuator top and load cell: > 1000 mm.<br>t) Hydraulic power-pack with working pressure of 3000 psi, > 36 lpm discharge with suitable oil- | |

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| | water heat exchange system and chiller unit.<br>u) Digital controller with **multi-channel signal conditioning** and control unit with seamless transfer from one control mode to another.<br>v) Additional signal conditioner channels for strain bridge, thermo-couple inputs and LVDT/accelerometer to be provided apart from the typical control modes of operation (displacement, load, strain)<br>w) The controller should permit operation either in stand-alone mode with its own displays or be operated through suitable switching to computer interface. The controller should have provision to control the rate of heating/cooling of specimens and correct based on thermo-couple sensors attached to the specimen. Overshooting of high temperature is not allowed.<br>x) Controller should have high loop update rate on controls (**> 5 kHz**) and high data acquisition rate (**>5 kHz**) across all channels.<br>y) The controller should be PID type with auto-transducer sensing, electronic gain on transducer channels, and capable of auto-tuning in test control mode. A user friendly, Microsoft Windows® based **32 bit or 64 bit control software** with provision for user test design should be provided along with the system. GUI for the test system should permit monitoring of multiple windows of test parameters, which can be configured by the user. The test controller should be preferably 32 bit or 64 bit system.<br>z) Provision to tap high level output signals from signal conditioner module for data logging in external systems such as NI® cards.<br>aa) The test controller should be designed for operation in tropical conditions such as existing at Chennai (Madras), India and comply with International Standards of operation in tropical environments.<br>bb) The test system software should have supervisory/multi-level controls to ensure tamper-proof operation of system by basic operators. Software protection with password to alter test system configuration, calibration is required.<br>cc) Should there be a power failure, the protection system should ensure power to the system's controller and connected computer to ensure test stop in a controlled manner, and allow the specimen to cool down and save test data. It is desirable that the test system is transferred to load control and maintain zero load on the specimen. Restart should be smooth recognizing the previous condition of testing. | |

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| 2 | Performance curves of similar systems supplied to other vendors should be included. Typically, these refer to:<br>a) Load cycle response at different frequencies,<br>b) Temperature rise-fall response,<br>c) Temperature uniformity graphs/data<br>d) Temperature stability data with time as well as with location of the TMF test specimen (at various sections along the gage length of test specimen),<br>e) Stress vs. strain response during in-phase and out-of-phase TMF tests on axial specimens;<br>f) Load, strain signal stability response with active sensors connected to these channels along with LVDT response in actuator hydraulics ON condition for 3-6 hours. | |
| 3 | List of customers to whom such systems have been supplied worldwide over the last 10 years along with their names, contact details. | |
| 4 | **The supplier should be a reputed International Company, ISO 9000 series compliant, who undertakes responsibility for total system supply and not a parts integration vendor.** | |