INDIAN INSTITUTE OF TECHNOLOGY BOMBAY
MATERIALS MANAGEMENT DIVISION
Powai, Mumbai 400076

PR No. 1000017020 (Rfx No. 6100000716)

Detailed Technical Specifications for Dynamic Mechanical Analyzer (DMA)

1. Instrument Specifications: (-150 C to 600 C or better):

1.1 **Temperature range:** -150 °C to +600 °C or better. Heating of furnace with no fan should be possible. Temperature stability should be within +/- 0.5 C of the set temperature.

1.2 Heating Rate Range: 0.1 C to 10 C/min or better, should be software programmable in stepsof 0.1 C, ramp up or down with 0.1 C or less step size. Uniformity of the temperature measured using at least 2 thermocouples at either ends of the sample grips, available as an output.

1.3 Cooling Rate: 0.1 to 10 C/min or better, should be from any starting temperature using Liquid Nitrogen cylinder, easily integrated (plug in – plug out) and programmable from software. Mention clearly the minimum and maximum pressure of the LN required for the operation.

1.4 Temperature Stability should be reached under a minute for any set temperature with ramp heating.

1.5 Minimum Force: 5 mN or less, applied and resolved for sample over the entire stiffnessrange. Maximum variation in load variation around the set value should be less than 2% or better.

1.6 Maximum Force- Static: >= +/-10 N, Dynamic: >= +/-10 N. Should allow long hold times that can be programmed. Force feedback should be available from within the software, for both ramp and cyclic loading.

1.7 Force amplitude: <= 0.1 mN under dynamic loading

1.8 Force Resolution: <= 0.3 mN under quasi-static and dynamic loading.

1.9 Displacement Resolution: <=10 nm for all loading conditions.

1.10 Displacement Range: Min <= +/- 5 µm to >= +/- 200 µm. Displacement feedback should be available from within the software, for both ramp and cyclic loading. Full range available under dynamic loading.

1.11 Minimum displacement Amplitude Range: <= 10 nm

1.12 Modulus Range for the sample: 10^3 to 10^{12} Pa

1.13 tan δ sensitivity: <=0.0001

1.14 tan δ resolution: <=0.00001

1.15 Low end frequency: 0.01 Hz or better with programmable oscillatory signal capability, not restricted to simple sinusoid.

1.16 High end frequency: at least 100 Hz, at all amplitudes and for the whole range of sample stiffness.

1.17 Force and displacement feedback bandwidth: >= 2 kHz or better. Fast transients under thermal loading and mechanical damage to be detected. Both force and displacement control should be available to pre-load and perform DMA analysis.

1.18 **Environmental Chamber** with at least 10 to 100 % relative humidity control, purge with air, nitrogen or any other inert gas with full software control for pressure and flow rate inside the chamber should be available.

1.19 **Humidity Chamber** with 1% or better relative humidity control should be a part of the instrument.

1.20 **Calibration:** On site calibration and use of customized accessories should be possible within the software to account for inertia, thermal mass, etc., allowing all modes of instrument operation. Exceptions, if any, should be clearly mentioned and justified.

1.21 **Automated Furnace:** Calibration, and independent temperature measurement should be possible, e.g., using a thermocouple output.

1.22 Other than modulus there should be no restriction on the choice of material to be used as a sample,for meeting all the specifications. Exceptions, if any, should be clearly mentioned and justified.

1.23 Should be able to run tests 24/7 with dynamic thermo-mechanical loading.

1.24 **Cooling unit**: Auto Liquid Nitrogen Cooling unit for temperature < -70 C and AirIntra- cooler for -70 C to 600 C to be supplied with the main instrument.

1.25 **Sample Holders** for Deformation Modes:

a) Single & dual cantilever,
b) 3 and 4 point bending
c) Tension
d) Shearing, Film Shear
e) Compression

1.26 **Controller:** The DMA system should have a dedicated digital controller, operated using a PC. The controller should have at least 2kHz bandwidth for sensing and feedback loop operation. The controller should allow for setting all the above mechanical, thermal, humidity parameters, and control them using a feedback loop. The controller should provide output signals for force, displacement, temperature and humidity, measured by the sensors inside the chamber.

1.27 **Personal Computer** with the following Specifications or better:Intel i7 or better CPU, Windows10 or later OS, at least 16GB RAM, at least 256 GB SATA NVMe Solid State Drive for all programs and data collection from the instrument, SATA or better 2TB HDD for local

data storage, dedicated graphics Card with 4GB memory, at least27-inch LED Screen, wireless Keyboard and Mouse (Branded).

1.28 **UPS system:** Appropriate standard make UPS (and isolation transformer) with at least one hour back up for the uninterrupted and smooth functioning of the entire system. The power requirement for proper functioning of the system along with all accessories should also be provided by the vendor.

1.29 All the tools required for analysis should be a part of the supply.

2. Consumables and Accessories: (Vendor must provide cost for each item; all such items quoted for should be compatible with the respective main instrument mentioned under item 1 above):

2.1 Standard samples for Calibration should be provided, e.g., annealed andstress free PMMA tension, compression and bending samples.

2.2 Gases: Regulator for DMA system i.e., Nitrogen, dry air and humid air gascylinder/humidifier with multi-stage regulators.

2.3 Vibration Isolation Table to accommodate the instrument and all accessories, with passive damping, enabling the highest resolution achievable in force and displacement, on any kind of floor.

2.4 Immersion bath for in situ DMA testing of samples, in various solvents and liquids.

2.5 Humidity generator for in situ DMA testing of samples

2.6 UV equipment for in situ curing and testing, along with related safety equipment.

2.7 Dielectric Analyzer (DEA) for in situ testing

2.8 Sample imaging: Capability to image the sample during experiment through an optical window under all loading conditions, with integrated software for image capture at >= 30 fps and > 2 Mega pixel resolution.

3. Software:

3.1 Windows 10 based DMA analysis software pre-installed on a PC, toperform the following functions on the instrument:

3.2 Controlled heating, cooling, force/displacement feedback, humidity, etc., including all optional features that may be accessible with the addition of hardware accessories in the future, especially those listed under item 2 above. The software updates and improvements should be provided for at least 10 years, free of cost.

3.3 All calibration procedures and routines should be built into the software and quickly available through the user interface. All calibration results should be displayed and compared against benchmark results.

3.4 The software should show all for input, control and display of all test parameters, curves showing force, displacement, temperature, frequency, humidity, time, etc., on different axes. It should be possible to continuously monitor the applied loads and outputs, including processed data (e.g., storage modulus, loss modulus, tan delta, etc.), live during the experiments in the form of numerical values as well as plots/charts on the screen (e.g., as a function of time, temperature, frequency).

3.5 The data should be stored continuously on the computer in at least csv or ascii format, retrievable at the end of the experiment and later for further processing.

3.6 There should be a software-controlled emergency stop, to freeze the hardware, in case of an emergency, including issues with the sample or the instrument.

4. Warranty:

4.1 The supplied system should have a minimum of 5 years on-site comprehensive
warranty. The warranty should include all parts of quoted system and its options and accessories.

4.2 Supply of spares and service should be guaranteed for 10 years from the date of installation.

5. The following technical requirements should be strictly met and the necessary document has to be enclosed along with the technical bid

5.1 Maintenance network: Mention address of the institutions where the systems are in working conditions. Mention the maintenance network in India for the instrument.

5.2 The vendor should have installed the quoted machine in India and a documentary evidence of the same and evidence of satisfactory working & after sale support to be submitted along with tender document.

5.3 All specifications should be demonstrated through verifiable results against each specification submitted with the technical bid. All such results presented should be demonstrated on the instrument at the time of installation.

5.4 Technical bid should include all the necessary electrical, mechanical, civil and environmental requirements for the instruments to be installed and operated.

5.5 Availability of applications/service Engineer to handle instrument problems immediately.

5.6 All manuals (service & operational) should be given as hard copies and/or soft copies on CDs or on USB drives.

5.7 Complete product catalogues describing all the required basic items should be produced.

5.8 Installation: An OEM trained engineer should install, on site, including all the electrical and mechanical systems, and accessories. This should be part of the quote.

5.9 Onsite Training by competent Application Scientist for 1 week on applications and capabilities of the System and all the components. This should be part of the quote.

5.10 Upgradation of software should be given free of cost as and when the new extension versions are released by the manufacturer/vendor at no additional cost during the period of warranty.

5.11. A compliance certificate duly signed by the OEM against all the specifications, with a yes or no for each specification, as listed under items 1, 2 and 3 above.

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