

Specification for insitu balancing facility for Hemispherical Resonator shells

Balancing of resonator constitutes two major tasks:-

- a) The removal of reaction forces at the support of the resonator at the operating mode on a fixed base
- b) Removal of splitting of resonance frequency corresponding to the functional mode.

Specific requirements

The proposed equipment should determine the following parameters and perform the above-mentioned tasks on 30mm resonators designed and realized at IISU.

- 1) Characteristic oscillation frequency and Q factor of the resonator.
- 2) Frequency splitting
- 3) Q factor mismatch
- 4) Values of 1-4 misbalance harmonics
- 5) Orientation of 1-4 misbalance harmonics.

Ion beam balancing process should include gradual removal of resonator material by low energy beam of ionized particles of working gas that is directed at definite areas of the resonator surface. Argon gas has to be used as rare gas.

Misbalance evaluation has to be made by measurement of its acoustic parameters. Thus quantity and angular orientation of mass defect of the forth form are evaluated by measurements of frequency splitting and orientation of its natural frequency. Orientation of the axes with minimum frequency corresponds to the maximum defect of the forth form.

Evaluation of the first three mass harmonics has to be made by measuring the vibration of the resonators external stem when standing wave is excited in the resonator. Special capacitive and piezo sensors are to be used to support the vibrations in the resonator shell and pick off the vibration of the stem. The readout signals are to be processed in the PC with software specially developed for that purpose.

The machine should consists of the following necessary systems. Vacuum gas system with control unit

- A) Ion source with control system
- B) Resonator rotation control system
- C) Oscillation excitation and resonator control system

A) Vacuum gas system with control unit

Vacuum chamber sizes: height – 650mm, length – 670mm, depth – 250mm (appx.).

Pumps : Clean room compatible dry pump and turbo molecular pump.

Vacuum level: less than 10^{-5} torr.

Vacuum-gas system consists of a base free from greasy exhaustion agents: mechanical rotary and turbo-molecular pumps having electrically operated valves and should have an electric controller of working gas flux through an ion source. The vacuum-gas system control unit should be integrated within the station control rack. The system has to be controlled through the keyboard and the control mode has to be manual with automatic blocking of illegal instructions.

A.0 VACCUM PUMPING SYSTEM:-

A.1 DRY PUMP:- 1 No.

M/s PFEIFFER/VARIAN/EDWARDS make Dry Vacuum Pump with approximate pumping speed of $27\text{m}^3/\text{hr}$ for nitrogen with external silencer must be provided.

A.2 TURBO MOLECULAR PUMP:- 1 No.

M/s. PFEIFFER/VARIAN/EDWARDS Make air cooled Turbo Molecular Pump with approximate pumping speed of 255 I/s for nitrogen must be provided for High Vacuum Operation. The pump should also be provided with heating jacket, splinter shield and venting valve.

A.3 HIGH VACUUM VALVE (TURBO MOLECULAR PUMP):- 1 No

M/s PFEIFFER/VARIAN/EDWARDS/VAT Make electrically operated Bellow sealed Gate Valve must be provided above the turbo molecular pump.

A.4 BACKING VALVE:-1No.

M/s PFEIFFER/VARIAN/EDWARDS/VAT make electrically operated Right Angle Valve to be provided above the turbo molecular pump.

A.5 AIR ADMITTANCE VALVE:- 1 No.

M/s PFEIFFER/VAT/VARIAN Make electrically operated Control Valve to be provided for air admittance.

A.6 VACCUM GAUGE

M/s PFEIFFER/VARIAN Make Active Pirani Transmitter and Active Cold Cathode Transmitter having a measurement range 5×10^{-11} -1000 m.bar with gauge controller.

A.7 VACCUM PLUMBING LINE:

Vacuum Plumbing Lines must be fabricated out of Stainless steel with necessary bellow adaptors. Vibration dampers must be provided in the vacuum plumbing line to arrest the vibration from the pumping system to the vacuum chamber.

Note: Along with above accessories suitable number of o-rings, gaskets, Hexogen Head set screws, Hexogen stud screws and centering rings must be provided.

A.8 ULTIMATE VACUUM AND LEAK RATE:

In clean, cold, empty, dry thoroughly de-gassed chamber an ultimate vacuum of 10^{-6} m.bar range must be achieved.

Individual Leak Rate: 1×10^{-8} mbarlit/sec

Total leak rate for the system should be less than 1×10^{-6} mbarlit/sec.

B) Ion source control system

The ion source control system should secure the argon ion flux and it has to be controlled with a board integral with the station control rack. There should not be any damage on the inside surface resonator coating during the balancing after thin film coating.

Outer diameter of ion-beam – 47 mm focused down to approx.30mm near resonator surface. The spot of the constantly removed mass from the resonator surface shall be maintained around 1sq.cm

Control range of ion-beam energy – 300-1700 eV,

Ion current at distance 50-100 mm – up to 4 mA / cm²,

C) Resonator rotation control system

The resonator rotation control system should ensure the rotation of the resonator through 360° with a position accuracy better than 4 arc min in vacuum by issuing commands from the computer. The control unit for the rotary positioner shall be incorporated in the control console and the control commands shall be issued from the computer. The detailed specifications required for the rotary positioner are given below.

Positioning accuracy	: 0.05625°
Encoder resolution	: 150arcsec
Step width of electrical motor	: 0.9°, microstep = 0.9°/16.
Lower step of electrical motor	: 3.375 arc.min
Maximum rate of travel	: 562.5°/sec
Resolution of incremental motion	: 2.5 arc.min

Type of motor used : Step motor
Details of the controller for the motor positioner stage
Type of communication : RS 232
Voltage : 24V

Power adaptors if required to be provided.

Interface software for the controller: shall be delivered as part of the delivery of the stepper motor controller.

D) Oscillation excitation and resonator control system

It should measure the resonator performance factors before and after balancing. The system should consist of resonator attachment point, a special board integral with the control rack, measuring devices and a computer. The system should control the following operating factors of the hemispherical quartz resonator before and after balancing and before and after resonator metallization.

- i. Characteristic oscillation frequency and Q factor of the resonator at different angular positions of the resonator.
- ii. Frequency splitting
- iii. Values of 1-4 misbalance harmonics
- iv. Azimuthal location of 1-4 misbalance harmonics.

The oscillations have to be excited in the resonator by electrostatic means under vacuum conditions. The max voltage to be applied to the resonator during uncoated and coated shell characterization has to be specified in the technical offer. Necessary interlocks are to be provided to ensure no arcing between the shell and electrodes by ensuring vacuum levels $<10^{-5}$ mbar during excitation and balancing. The required power supply sources and detection electronics has to be incorporated in the system. The oscillation frequency, frequency split and the Q factor of the resonator shall be determined by electrostatic means. The 1st, 2nd and 3rd unbalance harmonics has to be determined by measuring the unbalance forces on the resonator stem. The unbalance force measurement has to be done using a piezo based force sensor. Details of the piezo based force sensors are given below.

Sensitivity : 50mV/cm/sec

Frequency range : 50-12500Hz

The processing of the force measurement sensor has to be carried out in the control console and PC. Proper mechanism shall be provided for attaching the sensor to the resonator stem.

Table-1 Key technical parameters

Sl no	Parameter	Value
1	Removed masses (gm)	10^{-2} to 0.5×10^{-7}
2	Range of frequency split measurable (Hz)	0.5 to 0.0002
3	Residual mass defect on each of the first three harmonics after balancing (gm)	3×10^{-5}
4	Removal rate ($\mu\text{gm}/\text{min}$)	$1 \times 10^{-7} - 3 \times 10^{-6}$

Specific conditions.

- 1) Q factor change measurements should be made with the accuracy better than 3%.
- 2) The accessories for the resonators supplied by IISU as well as those required for Medicon resonators has to be provided along with the supply of the machine.
- 3) IISU will supply resonators (dwg no. ISG/AIS/IISU) for tuning of electronics control systems. The resonators currently being produced at IISU are of 3 million Q factor and 0.5Hz frequency split. The same will be provided for adjustments of electronics control systems.
- 4) Factory Acceptance Test

The FAT shall be carried out as per the table below. The original test reports shall be supplied to IISU. IISU Engineers shall have the option to participate at manufacturer's site, during Factory acceptance tests (FAT) of the machine before dispatch to purchaser's site as per the specifications below. Tooling also shall be provided to IISU as part of the delivery. **The dispatch clearance of the machine will be based on the successful completion of the FAT components as detailed in Table-2**

Table-2

Sl no	Input resonator parameters		Balanced resonator parameters		
	Q factor (millions)	Frequency split (Hz)	Frequency split	Residual mass defect (micrograms)	Remarks
1*	7	0.5	0.0003	30	
2	3	0.5	0.005	30	

*→if IISU is not able to provide resonators of 7 million Q factor, the same has to be demonstrated on the resonators realized by the party.

FAT includes sl no.1+sl no.2

5) Demonstration at the time of Installation

The machine should be installed at our site by experienced and factory trained engineers from machine manufacturer and demonstrates the accuracies, performance and machine functional features by trial balancing after installation. The supplier shall demonstrate the capability of the machine as per Table-1 and Table -2 at the time of installation and commissioning at IISU. The installation is considered as completed after finishing 2 IISU resonators.

6) Hands on training on machines

The supplier shall provide hands on training on machines with respect to operations, general maintenance, balancing procedure etc at IISU for a period of minimum 10 working days.

7) Final acceptance

Machines will be finally accepted at IISU after successful installation and training as well as demonstration of FAT component at our site.

The supply of the micro balance machine should consists of the following

- a) Vacuum-gas module
- b) Plant control rack
- c) Resonator control rack
- d) PC and associate software, including source code for balancing, control and measurement program.
- e) Program description.
- f) Spare parts for trouble free operation of the machine has to be supplied by the party. The necessary attachments and forcer/pick off for both FAT-1 and FAT-2 has to be provided by the party. Details of specific items for which spares are mandatory are mentioned as a separate list below.
- g) Detailed operation manual in **English language** with following details
 - Technical description of the station and basic operating requirements
 - Resonator parameter control methods, including coefficient for interconversion from microgram into mV
 - Resonator ion balancing methods
 - Electric schemes, wiring diagrams and drawings required for station setting and maintenance.
 - Source programs
 - Requirements of room including requirements of isolated foundation, accuracy of equipment horizontal positioning etc.
- h) Detailed maintenance manual in English language.
- i) Applicable documents on safety aspect.
- j) All tools, jigs and fixtures for installation, commissioning, maintenance and operation.

- k) Machine assemblies/subassemblies, Electrical/ Electronics/ Pneumatic/ coolant/hydraulic circuit diagrams etc. to be supplied along with the machine in duplicate.
- l) Documents related to acceptance tests of the machine.

List of items for which spares are required other than essentials

Sl no	Item	Qty	remarks
1	Resonator attachment	3 nos. each	Suiting both IISU and Medicon resonators
2	Piezo sensors	5 nos.	
3	Forcer/ Pick off electrodes	3 nos. each	Suiting both IISU and Medicon resonators

GENERAL:

- a) Complete technical specifications along with leaflets for each bought out items should be included with the quotation.
- b) The system should operate on main supply voltage of 220V, 1 ϕ , 50Hz or 440V, 3 ϕ , 50Hz, which is available at IISU.
- c) The complete fabrication drawing for the system should be sent to indenter for approval before commencing the fabrication.
- d) The system should be tested to the required level and the performance specifications are to be met during the FAT.
- e) The performance specifications must be met during installation and commissioning at IISU.
- f) The required accessories must be quoted separately for minimum period of three-year trouble-free operation.
- g) The party should provide PC with necessary operating system and monitor for the control of the system.

WARRANTY

Warranty of all the total system is to be provided for one year from the date of installation. Warranty certificate from OEM must be provided for bought out items.

AMC

The party shall quote for non-comprehensive AMC for 3 years after the warranty period. The AMC shall include at least one maintenance visit and unlimited break down visits. IISU reserves the right to enter into AMC with the party soon after the Warranty expires.