

Technical specifications of EA-GC-CF-IRMS (Elemental Analyzer-Gas Chromatography-continuous flow- Isotope Ratio Mass Spectrometer):

Parameter	Specifications
Mass range (amu)	1-146 or higher
Mass resolution (m/ Δ m)	≥ 190 for C, N, O, S and ≥ 20 for H/D with 10% valley separation
Mass dispersion (mm)	≥ 350 for CNOS and ≥ 150 for H/D
Ion beam acceleration	≥ 5 kV
Sensitivity (Absolute)	At least one in 850 molecules (0.04 nmol/s/5nA or better)
Ion source linearity	$\leq 0.03\%$ per nA ion current
Abundance sensitivity	< 3 ppm
Number of faraday cups	At least 7 numbers measured masses are: CO ₂ : 44, 45, 46; N ₂ : 28, 29; O ₂ : 32, 33, 34; SO ₂ : 64, 66; CO: 28, 30; H ₂ : 2, 3
Faraday Amplifier dynamic range	Amplifiers should linear dynamic range of ≥ 47 V (0-167 nA). It should allow high SNR on small ion beams with high precision on small sample size. It should be software controlled.
H ₃ ⁺ factor	Contribution ≤ 10 ppm/nA and stability < 0.04 ppm/nA/hr
Vacuum system	$< 2 \times 10^{-8}$ mbar
Internal precision (1 σ)% (continuous flow)	$\delta^{13}\text{C}$ (CO ₂): ≤ 0.06 ; $\delta^{18}\text{O}$ (CO ₂): ≤ 0.08 ; $\delta^{15}\text{N}$ (N ₂): ≤ 0.06 ; $\delta^{18}\text{O}$ (CO): ≤ 0.15 ; $\delta^{34}\text{S}$ (SO ₂): ≤ 0.10 ; δ^2 (H ₂): ≤ 0.40
Configuration	Continuous flow (CF) mode
Interface (Continuous flow)	<ul style="list-style-type: none"> • It should allow the simultaneous attachment of 2 flow peripherals at least, such as elemental analyzer (EA) and Gas chromatograph (GC); should be expandable up to three peripherals • The interface connecting input peripherals to IRMS must have system for automated sample dilution, addition of reference gases and dilution of sample gases with He.

	<ul style="list-style-type: none"> • It should have simultaneous connection and management of minimum 6 gases (N₂, CO₂, SO₂, H₂, CO, and He). Heated regulator should be provided for SO₂ to avoid corrosion, memory, and isotopic fractionation. • Automatic stand by position to reduce reference gas consumption to zero and carrier gas (He) consumption should be <2 ml/min • It must have two open-split gas transfers (one for sample and one from the reference gas) both should have independent capillaries leading to the ion source to eliminate the cross-over.
Elemental analyzer (EA)	<ul style="list-style-type: none"> • System should have dual furnace [(one for combustion (~1100°C) and one for reduction (~ 650 °C)] with separate temperature control for C, N and S isotopes. • Should have complete pyrolysis (~1450 °C) set-up and accessories for O and H isotope analysis. • It also includes a water trap, GC column, thermal conductivity detector and other necessary parts for the installation of EA. • It must have an automatic switching device exists between CNS and OH modes controlled by software. EA must consists isolink CNOSH. • Autosampler (≥30 samples) for the Elemental Analyzer should be provided. • Elemental Analyzer should be capable of operating as a standalone unit for CNS elemental analysis. It must be possible to directly elemental ratios and elemental composition of weight %. • Precision: The external precision (1σ)% should be $\delta^{13}\text{C}$ (CO₂) ≤0.10 ‰, sample size 125 μg C; $\delta^{15}\text{N}$ (N₂) ≤0.15 ‰, sample size 49 μg N; $\delta^{34}\text{S}$ (SO₂) 0.20 ‰, sample size 60 μg S; δD (H₂) ≤3 ‰, solid sample size 25 μg H; $\delta^{18}\text{O}$ (CO) ≤0.4 ‰, solid sample size 50 μg O
Gas Chromatography (GC)	<ul style="list-style-type: none"> • GC should be capable of operating as a standalone unit for quantitative measurements of individual C and D/H compounds (mass concentrations). • GC should include a split/splitless injector; capillary columns (60m x 0.25mm x 0.25μm film thickness); GC Oven with temperature controlled programmable (40-300°C); Detector (FID); auto samplers (≥20 samples); should have USB and LAN ports; GC syringes; interactive display for peak editing. GC is directly connected by the GC isolink. • IRMS software must allow control to upload GC method, autosampler and injector; it must allow different GC methods for each analysis (combustion and pyrolysis modes) from the software in an automated sequence without manual intervention

	<ul style="list-style-type: none"> GC must be consistent with principles of continuous flow, which require unchecked and unrestricted flow of sample entrained in He carrier gas, from the point of sample introduction, through conversion to the analyte, to ionization of the analyte in the mass spectrometer. <p>Precision: The external precision (1σ)‰ should be: $\delta^{13}\text{C}$ (CO_2) 0.18 ‰ for 10 ngC (on column); $\delta^{15}\text{N}$ (N_2) 0.5 ‰ for 42 ngC; $\delta^{18}\text{O}$ (CO) 0.8 ‰ for 80 ngO; $\delta^2(\text{H}_2)$ 2.5 ‰ for 30ng H</p>
Data System and Software	<ul style="list-style-type: none"> Software must be provided the control of entire IRMS system, and it must be used for obtaining, processing and reporting the data. It must be possible to automatically check all valves of system. Software must display both ion beam voltages and updated delta value of sample in real time. Parameters such as stability and linearity must be monitored and determined automatically during acquisition of samples Software must allow full access to all raw data and processed data, full access to ion correction algorithms and intermediate data
Additional Requirements	<p>Spares and Consumables:</p> <ul style="list-style-type: none"> Consumables and spare parts should be provided for minimum 300 measurements of C, N, O, S, and H isotope ratios along with IRMS system. <p>Additional consumables:</p> <ul style="list-style-type: none"> Consumables for 5000 measurements of C, N and S isotopic ratios analysis- this includes quartz reactor tubes, oxidation catalysts (Cr_2O_3), reduction catalyst (copper grains), silvered cobaltous oxide to trap SO_2 and halogens, unhydrone for water-trap, quartz wool, O-rings for quartz reactors, sample holders, and tin capsules and related consumables. Consumables for 2000 OH Analyses in EA- this includes Glassy carbon chips, silver wool, graphite crucibles, quartz wool, O-rings, Aluminum ferrules, stainless steel nuts, silver capsules and related consumables. Consumables for 2000 $\delta^{13}\text{C}$ (compound specific) analyses in GC. this includes tubes/connectors for FID, glass liners, septums, GC syringes, and sample trays Additional spare parts: <ul style="list-style-type: none"> Quartz reaction tubes (n=4) for EA; and GC columns (n=2) Spare parts and consumables for IRMS for minimum three years of operation. All diagnostic and mechanical tools required for installation/servicing/repair should be provided by the vendor.

- IRMS system should have interactive display along with possibility to print the chromatograms and isotope ratio peaks of compounds
 - Upgradation of all software installed along with the complete system, should be provided free of cost, as and when it is released. This support should be provided for 10 years beyond the standard warranty period.
 - Manuals: Soft copies of Operation and Service Manuals for all modules including Third party manuals if any, must be provided with the System. Must provide at least 3 publications in referred journals supporting all modes of operation and all types of measurements requested.
 - Vendor should provide complete user list (including email id and phone numbers) of their IRMS systems installed within India. The technical specifications demonstrated elsewhere has to be provided. The vendor should be maintaining minimum 2 instruments on current date (copy of AMC contract to be attached along with the tender).
 - Hard or soft copies of all electronic circuit diagrams of IRMS system (including peripherals) is preferred.
 - Complete onsite installation, demonstration, calibration and performance test as per specification. Vendor to include the list of tests that will be carried out during Installation and Acceptance.
 - Vendor should also provide a standard reference materials/gases.
- Pre-installation requirements and Site specifications: All the Pre-installation requirements have to be mentioned clearly like Instruments' and peripherals' Footprint area, floor space for instruments and peripherals, working space around the instruments and peripherals, Power requirements, UPS configuration, Air conditioning, Gas vent, working bench area for source cleaning, humidity control, dehumidifier, thermo hygrometer, any other specific operating environment – cleanliness level, etc.
- Warranty: should provide minimum 1 year of warranty of the IRMS system including all input peripherals from the date of Installation and Acceptance of performance test. A separate price quote of non-comprehensive AMC for 5 years should provide after the warranty period (It should contains the number of preventive calls and breakdown calls per year).
 - The complete system should be supplied & supported by single vendor (multiple vendors are not accepted).
 - Vendor shall ensure thorough installation, demonstration & relevant application training at the time of installation.
 - Training: Meticulous training for minimum 3 persons for complete operation and maintenance of the IRMS system should be provided on site by factory trained and certified Specialist for minimum 4 days.

	<ul style="list-style-type: none">• Vendor must have an India-based service organization, for which detailed documentation is required, including full disclosure of names, locations, training, and years of experience. Availability of telephone support, including telephone numbers and email addresses, must be detailed. Information must allow contact to be made during bid evaluation, in order to evaluate the length of time and quality of response to technical and procedure questions.• It is essential to provide a pre-demonstration of the installation of IRMS system interfaced with input peripherals (EA-GC-CF-IRMS), followed by isotope ratio measurements of a few particulate matter samples, either online or offline.
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