(a)

Technical Specifications for the procurement of Isotope Ratio Mass Spectrometer (IRMS) & its peripheral parts

Isotope Ratio Mass Spectrometer (IRMS) and its peripheral parts with the following specifications are proposed to be procured:

1. Isotope Ratio Mass spectrometer

Basic mass spectrometer must have

- Source @ 10,000 Volts (10-kV) accelerating potential for all masses from 2-170 amu
- System should be readily configurable to allow both continuous flow sample inlet systems and dual inlet system on same mass spectrometer
- Change between dual inlet and continuous flow operations should be controlled by a single mouse click which calls up resident application specific software. The total time elapsed during changeover should be of the order of a minute. The switchover between inlet systems should be totally automatic, and there should be no requirement for loading of new software.
- Analyzer must have true stigmatic focusing for all gases
- Construction and design of ion source and vacuum system must be such that memory is eliminated. To this end , the following design features should be included
    - Weld-free monoblock source housing, machined out of single piece of metal
    - The ion source must have built in internal radiant heating of wetted surfaces in order to keep the water background at the lowest possible levels. Internal radiant heating eliminates almost all need for bakeout procedures, which can decrease the life expectancy of the vacuum sealing system.
    - Needle valve inlet for continuous flow inlet systems should be resistively heated, to eliminate surface water that builds up when inlets are disconnected.
    - The source must be pumped with a 2 stage turbomolecular pump with the highest possible compression ratio for H_2 and He.
    - The entire system construction should conform to ultrahigh vacuum (UHV) design criteria, with only electropolished stainless steel components; all gaskets to be made

  - of metal, preferably gold; and all components heatable either by resistance heating or by irradiation.
  - Bakeout of the source housing should not affect the lifetime or the functionality of the gaskets on the source housing.
  - Decay of 2 V signal of ^{13}C enriched CO_2 to <100 ppm in <2 seconds
- Source must be highly sensitive and highly linear. Specifications for sensitivity, linearity and stability must be given specifically for continuous flow mode, and demonstration of compliance to specification must be computer
  - Sensitivity SPECIFICATION: <700 molecules of CO_2 at the source/molecular ion at the collector in maximum sensitivity, and <1 ion/1200 molecules of CO_2 with maximum linearity. The measurement of sensitivity should be supported by software.
  - Linearity EXPECTATION: <0.02‰ per nanoamp ion current WITH measurement of specification must be possible under computer control from spec program using dual inlet system.
- Source must be self aligning, so that it can only be inserted in one way; there must not be any requirement for fiducial marks and there should be no mechanical tolerance for insertion in other than the correct position with the correct alignment. Procedure for removal and reinstallation of ion source must be Gas from changeover valve must enter source at ground potential, without requirement for ceramic tubing, to ensure memory free transfer of gas into the ion source.
- The gas inlet at the changeover valve must be heated, to prevent this critical spot from being a possible source of memory.
- Ion source must have externally controlled variable conductivity
- It must be possible to allow extension of the changeover valve to allow attachment of 2 or more inlet systems to the source, the capillaries for which are being pumped continuously when not in use.
- The mass spectrometer must have true differential pumping as defined by having a pressure differential between the source and the analyzer. A schematic of the mass spectrometer pumping system must be provided showing locations of pumps and vacuum gauges specified in detail for evaluation.
  - The pressure in the ion source with 0.4 ml/min He entering the ion source should be

<4x010^-6 mbar, as measured on a Penning gauge.

  - Differential pumping EXPECTATION Pressure measured in first field free drift region before the analyzer must be 1-2 orders of magnitude lower than in the ion source with He carrier gas
  - Source pumping, compression ratio EXPECTATION The pump on the ion source should be a two stage turbodrag (compound pump, combining a turbomolecular pump with a second Hollweck stage) with a compression ratio for H_2 of $1.3x10^4$ and for He of $3x10^5$.

Collector Array

- It should allow the measurement of CO_2, N_2, N_2O, SO_2, O_2, CO, and H_2 in basic configuration. Vendor to provide full schematic showing cup positions, slit widths, and resistor values.
- It must be possible to simultaneously collect up to 8 ion beams
- It must be possible to vary the value of the high ohmic resistor on any amplifier from the software
- Each amplifier should have the option of having two resistors, to allow analysis of enriched samples or to allow the channel to be used for measurement of species with different isotopic abundances
- Measurement channels must have resistors that are optimized for the natural abundance of each isotope.
- Switching between species must be fully software controlled by simple key strokes. There shall be no hardware changes required, such as changing resistors or jumpers.
- Mass resolution of >200
- It should be possible to upgrade the collector in the field, to include, but not limited to, capabilities such as
  - CO_2 isotopologues at $^m/_z$ 47-48-49 (along with documentation of installed base of such collector arrays)
  - Procedure for upgrading a collector array in the field must be specified in detail

Electronics

- To ensure registration of all data taken in continuous flow mode, the instrument must have an embedded host microprocessor

- To ensure the highest possible accuracy of all results, steps must be taken to eliminate all sources of non-linearity
        - Full and ready access to all test points and source electronics must be available, without any requirement for board extensions.
        - Amplifiers must be in sealed and evacuated housing which is actively pumped, in order to reduce dark noise from ambient alpha radiation A large dynamic range for the continuous flow IRMS system is required
- Linear amplifier range of the IRMS must be from 0 – 50 Volt, i.e. 0 – 167 nA, and this must apply to all amplifiers
- The electronics must include an automatic amplifier gain switches in the software, to allow optimization of the amplification ratios of the required isotope traces with each sample gas to be analyzed
- The accessible dynamic system range should be 1: 5000 or better

Data System for control of mass spectrometer, data acquisition, and data reduction

- Change between dual inlet and continuous flow operations should be controlled by a single mouse click which calls up resident application specific software.
    - The total time elapsed during changeover should be of the order of a minute.
    - The switchover between inlet systems should be totally automatic
    - There should be no requirement for loading of new software.
    - It must be possible to cycle between all separate inlet systems without leaving the software and without crashes or hang-ups.
    - Software must capable of fully automated peak centering in all modes of operation, including all CF modes, and it should not be required to reset tuning tables when switching applications.
    - Software must display both beam voltages and updated delta value of sample in real time.
    - It must be possible to make decision to quit or continue based on δ output on screen
    - The instrument control software must have a library of routines which automate the measurement of the quantities that are measured in the final test of an instrument, including
        - ➢ absolute sensitivity

        - relative sensitivity
        - linearity, abundance sensitivity
        - peak top stability (=magnet stability)
        - peak side stability (=high voltage power supply stability)
        - VFC converter stability
        - bellows compression ratio
        - These routines should display and compare the measured value and that value specified by the manufacturer, and printouts from these routines should be available upon request.
- 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, and full access to raw data integrity and sample identity.
- Software must contain documented routines for corrections of measured delta values for ^{17}O isotopomers of CO_2. These routines should be assembled into a single module and should be applicable to measurements made on all sample preparation devices and all inlet systems. These routines must include ability to choose between "Craig correction", Santrock and Hayes (1988) approach, or the Assimow and Brenninkmeijer (2003) approach.
- Access to easy batch reprocessing, manual peak and background definition including print-outs and data export
- Automatic data storage must be possible on any external storage device.
    - Data must be archived in a data base which allows searching of all analyses for e.g., all analyses of a specific reference material, all analyses that are to be billed to a specific account, or all analyses run by a specific operator.
    - Data must be fully customizable and allow multiple exports of evaluated data to Excel and to USGS LIMS databases.
    - Software must provide landscape printouts and data transfer based on the raw data files without any reduction of data sets.

    - The software must allow ready definition of novel inlet systems, allowing the addition of valves, traps, splits, and ovens; the software must provide complete control and automation of all interface functions during data acquisition to enable programming of novel inlet systems.

COMPUTER CONTROL

- REQUIREMENT Must have "Plug and Measure" peripheral recognition
- The following items on the IRMS and the peripheral devices must be under computer control
    - switching between two high ohmic resistors on the same amplifier
    - diagnostic routines
    - dilution of the sample and reference gases from all continuous flow peripherals, including GC, Elemental Analyzer, and Headspace sampling, including dilution of the samples from head space analysis of carbonates

2. Interfacing between Elemental Analyzer and IRMS

- The interface Interfacing of Elemental Analyzer to IRMS must have automated sample dilution, automated addition of reference gases and must be possible to dilute Sample gases by 1:100 Automatically without Manual Intervention with He prior to the transfer into the IRMS
- Be expandable to up to 3 preparation devices, to allow easy addition of future analytical capabilities.
- The accessible dynamic system range should be 1: 5000 or better
- Interface must allow coupling of devices from <1 mL/min of He to >100 mL min/He.
- He flow not to exceed 0.5 mL/minute and He consumption during operation of elemental analyzer(s) must be specified.
    - It must be possible to choose the appropriate dilution for each analyte, so that different dilutions can be used for CO_2 and N_2 during a multi-isotope analysis
    - Interface must have capability for automated introduction of at five reference gases, to allow ready expansion of analytical capabilities to include S, O and H analysis.
    - Software and hardware must permit automated Intensity matching of reference and sample peaks

- Reference gas consumption must be <200 µL/minute in routine operation
- It must be possible to change reference gas intensity by a factor of ten in <1 second
- Interface must have “gas saver mode” for all reference gases, in which there is zero consumption of reference gas when it is not required in the analytical program
- Reference gas intensity must be variable over an intensity range of 2-30 V (CO_2, N_2)

3. GC-IRMS

Isotope analysis of chromatographically resolved peaks (CSIA)

- It must be possible to undertake fully automated high precision isotopic analysis of C, N, O, and H at natural abundance from individual GC peaks.
- The GC must be a state of the art and commercially available capillary GC. Discontinued GC models will not be accepted.
- IRMS software must allow control to upload GC methods, autosampler & injector. It must allow different GC methods for each vial in the autosampler from the software in an automated sequence without manual intervention.
- The systems must support auto-dilution of individual compounds or ranges (e.g. CH4 in natural gas, C12 to C34 fatty acids, C13 to C40 alkanes etc.).
- The system must support Auto-Ranging of reference gas peaks. Capillary GC should have Leak check function, automatic column characterization & must allow multidimensional chromatography. Capabilities must be described.
- Injectors that must be available as optional or upgradable items include Optional PTV inlet, large volume, on column injection & loop injection.
- All possible steps to eliminate post-GC peak tailing must be documented, and should include
    - Elimination of any requirement for makeup gas
    - Matching of diameters of capillary GC column and micro-reactors
    - Elimination of cold spots, including at end of GC column and use of liquid nitrogen for water removal
- In normal operation, it should be possible to achieve baseline resolution at the 5% level of pristane and phytane from the closely eluting C17 and C18 n-alkanes

- Under standard GC conditions, the overall split ratio from the GC column head to IRMS must not exceed a ratio 1:5.
- COMBUSTION- The GC combustion interface must contain a single high temperature combustion reactor for combustion of C to CO_2 and N to N_2
    - It must be possible to attain Temp up to 1100 °C.
    - The reactor must have easy fit connections.
    - Interface must include reactor for C (conversion to CO_2) and reduction reactor for N (conversion to N).
- It must be able to run ^{15}N and ^{13}C analyses without hardware modifications.
- Regeneration of the reactor must be automated.
- Precision SPECIFICATIONS (1) ^{13}C: 0.8 nmol of C on column: <0.2‰, 1 sigma
- The reactor must be capable of sustained operating at T>1100° C over periods of weeks without significant degradation in performance, as determined by precision, accuracy, and yield.
- Methane EXPECTATIONS
    - Combustion must be demonstrated to be quantitative to >99.5%
    - Change in value over a decade in sample size should be <0.1‰/V vi) Analysis of ^{13}C in CO_2 in breath: it must be possible to set up an auto-sampler that allows sampling of serum vials (Exetainer or Vacutainer) for analysis of ^{13}C in breath CO_2 on the GC-C interface
- HIGH TEMPERATURE THERMOCHEMICAL DECOMPOSITION
    - It must be possible to configure the GC interface for thermochemical decomposition of organic material unit to allow determination of D/H on individual GC peaks.
    - The reactor must sustain T >1500°C and the system must quantitatively produce H_2 from organic H, as demonstrated by analysis of methane.
    - REACTOR LIFETIME: The reactor must be capable of sustained operating over periods of weeks without significant degradation in performance, as determined by precision, accuracy, and yield.
    - Change in value over a half a decade in sample size should be <0.5‰/V.
    - Sensitivity EXPECTATION: It should be possible to get a well-defined peak of significant height for 30 ng H_2 in the compound being decomposed. Vendor must

supply spectrum showing peak height for peak containing 30 nmol H_2-equivalent on column.

H3+ correction, magnitude SPECIFICATION: <10 ppm/nA H_2

H3+ correction, stability EXPECTATION: <0.1 ppm drift in 8 hours

- Determination of H3+ factor must be automated
  - The mass analyzer will be capable of resolving m/z=2 (1 H_2) and 3 (DH) and m/z=3 (DH and 3He) and 4 (4He)
  - Baseline separation of m/z=DH will be achieved from the collisionally induced low energy "energy loss tail" of the 4He beam with standard capillary GC He flow rates.
  - Resolution: A chromatogram of m/z=2 (H_2) vs. time shall show resolution sufficient to separate pristane and phytane (C17 and C18 branched alkanes) from the adjacent C17 and C18 n-alkanes, with separation efficiency better than 5% valley on both pairs of peaks. This EXPECTATION must be supported with data.
  - It must be possible to configure the system for measurement of $^{18}O/^{16}O$ (1) Reactor for conversion of O to CO must be O-free, to avoid O-exchange between reactor O and sample O
- $\delta^{13}C$, $\delta^{15}N$ and δD Analysis i) It must be possible analyze $\delta^{13}C$, $\delta^{15}N$ and δD within one sequence
- Switching between Oxidation and Pyrolysis reactors must be automated
- It must be possible to automatically regenerate both reactors

HEAD SPACE ANALYSIS

- It must be possible to analyze 30 bar-µl of breath for ^{13}C of CO_2 with a precision of 0.2‰
- It must be possible to measure the ^{13}C of CO_2 in atmospheric air (360 ppm) without any pre-concentration: EXPECTATION: <100 µl air by syringe injection, 10 repeated injections from same sample, with a reproducibility of <0.2‰.
- It must be possible to measure ^{13}C of ethanol from the headspace over an alcoholic beverage with a precision of <0.3 per mil
- REFERENCE INJECTION- The interface must have a reference gas injection positions, for addition of distinct and unambiguous pulses of reference gas from an external reservoirs, and this reference gas inlet must be under computer control. Software must support designation of peak as reference gas and allow calculation of unknown peaks

relative to designated peak.

- Reference injection SPECIFICATION, CO_2: When the CO_2 supply used with the reference injection module is also used to supply CO_2 to the main, or analyte, carrier stream and peaks delivered from each pathway are compared isotopically, the average values (n>10, ^{13}C and ^{18}O) should not differ from zero by more than three standard deviations of the mean.

SOFTWARE

- It must be possible to display the trace of an optional FID or a MS detector together with either the trace of the calculated isotope ratio or the trace of the major beam.
- Software must include automated routines for background correction as well as allow for fully user selectable background.
- Software must allow for separate measurement of each peak for isotopic species, to allow for time migration of peak centroids for proper subtraction of background. It must be possible to demonstrate that time migration is used and used properly to evaluated the chromatograms for CO_2, N_2, CO and H_2.
- Software must include rigorously verified routine for H3+ correction during measurement of H_2.
- IRMS software must allow control to upload GC methods, auto-sampler & injector. It must allow different GC methods for each vial in the auto-sampler from the software in an automated sequence without manual intervention.

4. ELEMENTAL ANALYSER

Isotopic and elemental analysis of bulk materials:

- All sample preparation devices must conform to the 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
- Adsorption and desorption of analytes are not to be used.
- Separation of analyte species is to be achieved by passage through Isothermal GC Column.
- C and N analysis must be done in a single continuous flow analysis of a single

combustion, by analysis of CO_2, N_2 created by combustion of C to CO_2, N to N_2.

- the TCD output of CO_2 and N_2 sample size must be ready for the IRMS software and used to calculate and control the amount of dilution that is required in order to maintain CO_2 and N_2 sample sizes within pre-defined ranges.
- It must be possible to directly calculate isotope ratios for $^{13}C/^{12}C$ and $^{15}N/^{14}N$, elemental ratios of C/N, and elemental composition of wt% C and N
- N_2 and CO_2 must be measured sequentially as it elutes from the GC column of the Elemental analyzer without a magnet jump
- Precision, ^{13}C and ^{15}N, normal samples SPECIFICATION <0.15‰ for $\delta^{13}C$ and $\delta^{15}N$ from single analysis (>50 ug C and N) with precision of 1% or better for elemental analysis
- Precision, ^{13}C and ^{15}N, small samples SPECIFICATION 0.2‰ for 5 μg C; 0.4‰ for 10 μg N
- The instrumental setup, EA-IRMS, must demonstrate capability of precisely and accurately analyzing samples in the size range <10 ug C or N and in the size range <1 μg C or N.
- The software should have a fail-safe mode that will stop the EA operation if the mass spectrometer source is not on.

HIGH TEMPERATURE DECOMPOSITION

- It must be possible to configure to undertake high temperature thermo-chemical decomposition of organic material.
- The decomposition reaction must be quantitative EXPECTATION: reaction T of >1450°C; the oven must be able to support sustained operation at these temperatures. Installed base of reactors, to allow discussion with existing users in order to document performance and life time, must be provided with the bid response.
- Reaction temperatures must be sufficient that methane is not a byproduct of the decomposition; methane must be completely decomposed. This is imperative because reactions involving CH_4 in the ion source lead to H3+, and the normal H3+ correction schemes do not work. EXPECTATION: the decomposition of organic material to CO must be quantitative; vendor must submit evidence showing the complete absence of CH_4.

- The elemental analyzer must have been in fail safe controls, to shut off the high temperature reactor in case of loss of He carrier gas flow or increase in pressure due to a leak.
- The interface and mass spectrometer must support the analysis of CO for the measurement of ^{18}O and ^{16}O respectively.
- The interface and mass spectrometer must support the analysis of H2 for the measurement of D/H.
- The elemental analyzer interface+mass spectrometer must allow the measurement of both O and H on CO and H_2 from individual sample decompositions, either from water or from solids. The measurement of H_2 and CO must be sequential and continuous so that one sample can be characterized for both isotopes in a single sample.
- H3+ correction, magnitude SPECIFICATION: <10 ppm/nA H_2.
- H3+ correction, stability EXPECTATION: <0.1 ppm drift in 8 hours
- Pyrolysis reactor should allow analysis of organic material for O (and under limited conditions, C and N), as well as a wide variety of inorganic oxides. Documentation of publications showing successful analysis of these materials must be included with bid. Oxides should include nitrate (for N and O), sulfate (O), phosphate (O).
- Precision: for >200 µg benzoic acid (>50 µg O) <0.4‰
- Precision: for >500 µg benzoic acid (>25 µg H), <3 ‰
- Memory: sequential analysis of samples different by more than 20‰ in ^{18}O shall show no memory effect at the 0.1‰ level, and there shall be no increase in background during the measurement of the sequence.
- Linearity: sequential analysis over a size range from 50 to 500 µg benzoic acid shall show no discernible trend in ^{18}O.
- Sequential combustion and C-reduction i) System shall be able to operate the combustion elemental analyzer and the high temperature C-reduction elemental analyzer in one sequence.
- There must be unattended switch between methods and both devices.

5. GAS BENCH

Analysis of Water for Hydrogen isotope by Reduction

- D/H shall be performed by direct reduction of water to H_2 in fully Automated Mode.
- Sample size shall be in the range of 1-5 microliters of water.
- SPECIFICATION: <0.5‰ for D/H for injection of 1 microliter H_2O. Normalized results must be accurate (No stretch correction should be required)

Water Analysis System For Analysis of H_2O for ^{18}O and D.

- The system must be built around a general purpose programmable autosampler capable of sampling both aqueous samples for direct transfer of water and headspace samples.
- $^{18}O/^{16}O$ of water shall be done with by equilibration. Automated Flushing of the reaction vial by He in <5 minutes. The software shall control cessation of the He flow at the end of flushing, to conserve the He.
- Headspace CO_2 shall be flushed with He and sampling done via a loop; and it should be possible to make repetitive (N>10 loop) injections during the course of a single analysis.
- The loop shall initiate a GC run which separates the CO_2 from other gas species (e.g. H_2O, O_2, N_2, Ar) to ensure complete cleanup.
- SPECIFICATION: <0.08‰ for $^{18}O/^{16}O$
- Normalized results must be accurate (No stretch correction should be required)

Carbonate Analysis By Individual Acid Bath using Continuous Flow

- Automated Phosphorolysis shall be performed in individual vials in a tray contained in a thermostated constant temperature block.
- Automated Flushing of the reaction vial by He in <5 minutes. The software shall control cessation of the He flow at the end of flushing, to conserve Helium from the external Reservoir.
- If the initial sample is out of range, the software should control initiation of automated He dilution of the signal to bring subsequent peaks from the repetitive loop injection to within range; this dilution must be shown to be non-fractionating.
- Headspace CO_2 shall be flushed with He and sampling done via a loop, this sampling must be done under complete computer control, and it should be possible to make repetitive (N>10 loop injections during the course of a single analysis.
- The loop shall initiated a GC run which separates the CO_2 from other gas species (e.g. H_2O, O_2, N_2, Ar)

- INSTALLATION SPECIFICATION: <0.1‰ for $^{18}O/^{16}O$ and <0.1‰ for $^{13}C/^{12}C$ for 100 µg $CaCO_3$
- SPECIFICATION Size range for carbonates should be from 50-1000 µg

(b)

Technical Specifications for the procurement of Gas Chromatography-Mass Spectrometer (GC-MS) with Flame Ionization Detector (FID) and Accelerated Solvent Extractor (ASE)

1. GC-Single Quadrupole Mass Spectrometer with FID

Ion Source

- Must be able to remove all source parts that require periodic cleaning, including the repeller, ion volume and lens stack, without venting mass spectrometer.
- It should have ability to interchange dedicated EI, PCI and NCI sources without venting mass spectrometer.
- It should have Integrated, dual filament assembly with improved filament lifetime
- Both the filaments should be used in either EI or CI mode.
- The GC transferline temperature should be programmable up to 350 °C
- The system should have curved ion guide to reduce excited neutral background to single counts per scan without requiring signal thresholding, background subtraction or smoothing.

Quadrupole Mass Analyzer

- Mass Range: 1.2 –1100 amu
- Resolution: Unit mass resolution
- The Main quadrupole rods should be non-coated, homogeneous, molybdenum, and cleanable.

Detection System

- It should utilize new generation discrete dynode electron multiplier integrated with linear-log electrometer with maximum linear output

Vacuum System

- It should have high-capacity (>300 L/s) turbo molecular pump with air-cooled high vacuum pump, with control and safety interlocks integrated into the system.
- It should have Standard 3.0 m^3/min rotary-vane pump.

Instrument Control

- It should have scan modes like full scan, SIM, and alternating full scan/SIM.

- It should have ability to alternate between full scan MS and SIM target analysis on successive scans.

Chemical Ionization (optional)

- It should have ability to perform Positive Chemical Ionization (PCI) and Negative Chemical Ionization (NCI).

Installation Specifications

- Using helium as carrier gas:

EI full scan specs: 1 µL injection of 1 pg/µL OFN while scanning from 50-300 u gives for mass 272 an RMS S/N ≥ 600:1

PCI full scan specs: 1 µL injection of 100 pg/µL benzophenone while scanning from 80 – 230 u gives for mass 183 an RMS S/N ≥ 300:1

NCI full scan specs: 2 µL injection of 100 fg/µL OFN while scanning from 50 – 300 u gives for mass 272 an RMS S/N ≥ 600:1

GC Control

- The GC must feature an external color touch screen to provide easy accessibility to the GC and immediate interactions with it.
- A dedicated automated routine should allow a assisted leak check procedure
- A dedicated automated routine should allow automatic evaluation and storing the column pneumatic resistance.

Oven:

- The column oven should have an operating range of -99°C to 450°C using the optional sub ambient oven accessory (with liquid nitrogen or liquid CO2 as coolant).
- Heat-up time from 50°C to 450°C should be within 4 minutes
- Cool-down time from 450°C to 50°C should be within less than 4 minutes

Pneumatic controls

- Electronic pneumatic controls should be integral part of injector and detector modules No extra tubing and wires should be needed to operate electrical valves, and deliver carrier, detector and make-up gases to injectors and detectors.The digital carrier gas controller should allow operating in constant and programmed flow and pressure modes.

Split/splitless injector

- The Split/Splitless injector should be user-installable within few minutes, and without any special tool.

- The injector should be able to operate with capillary, wide bore and packed columns
- Maximum Temperature: 400 °C
- Split Ratio: up to 12500:1
- Pressure Range: 0-1000 kPa (0-145 PSI)
- Total Flow Setting:
    - Control of split flow in 1 mL/min from 0 to 1250 mL/min
    - Purge flow from 0 to 50 mL/min

Detectors

- Should be available as Instant Connect, user-exchangeable modules: the instrument design must allow the user for an easy interchangeability of the detectors in less than two minutes without special tools
- The GC must have complete integrated control of all parameters (no external control module) for the following detectors: FID, TCD, NPD, ECD. The GC must be able to house and operate with three detectors simultaneously, including a mass spectrometers on the same oven

Flame Ionization Detector

- Capillary column optimized compatible with 1/8" and 1/16" packed column
- Flameout detection and automatic re-ignition
- MDL: <1.8 pg C/s
- Sensitivity: >0.03 Coulombs/gC
- Linear Dynamic Range: >107 (±10%)
- Maximum Temperature: 450 °C in steps of 0.1 °C
- Data Acquisition Rate: up to 300 Hz.
- ECD
- Radioactive Source: 370 MBq equal to 10 mCi, 63Ni
- MDL: <6 fg/s lindane
- Linear Dynamic Range: >104 with lindane
- Maximum Temperature: 400 °C in 0.1 °C steps
- Make-up Gas: Nitrogen or 95% argon/5% methane

Data System

- Complete computer control of parameters for GC, liquid autosampler and mass spectrometer
- Complete integration of autosampler, gas chromatograph, and mass spectrometer

methods and set-up procedures

- Fully automated data processing programs
- The software must operate with Windows 7 operating system for true 32-bit multi-tasking that allows the simultaneous generation and printing of reports as an acquisition proceeds without interruption
- Real time data analysis
- Library Browser – Library search and report program by the National Institute of Standards and Technology (NIST)

Specifications for only liquid AS

- The AS should be compatible with vaporizing injectors (SSL, PKD, PPKD and PTV) ONLY.
- Sample capacity: minimum 105 x 2 ml vials
- Solvent vials: 4 x 4ml vials
- 50 ml waste bottle
- Single solvent rinsing: Solvent A, B, C, D
- Solvent rinsing: solvent A+B, solvent C+D
- Solvent Rinsing: Pre and/or Post injection
- Injectable volume selection in 0.1 ul steps
- Bubble elimination strokes: 0-15 with pre-set and optimized speed

2. SPECIFICATIONS FOR ACCELERATED SOLVENT EXTRACTION SYSTEM (ASE)

- Accelerated Solvent Extraction (ASE) System with integrated Solvent Controller and sequential capability of extracting more than 20 solid or semisolid samples carousel mounting unattended with typical extraction times of 12-15 min. using common solvents at elevated temperature and pressure for faster extraction process.
- The equipment should have approval by US EPA. For EPA method 3545 & 3545A.
- The oven should be able to accept any sizes of 10, 22, 34, more than 64 & more than 99 ml cells with temperature control of ambient to 200 deg. C and Pressure delivery upto 1500 psi.
- Collection bottles of 250 ml are to be provided along with Collection bottle tray capable of holding more than 10 such bottles.
- The System should have following in built functions.

- The extracts should be automatically filtered for direct injection.
- It should be faster than soxhlet, sonication and other extraction methods.
- Convenient multiple method & schedule storage for automatic operation
- Sensors for temperature, pressure or solvent leaks should be there to alert the operator to a problem. If necessary audible alarm or system shut down to be provided.
- Standard accessories like caps, fittings, vials should be provided with the system.

TERMS AND CONDITIONS

1. **Warranty & Maintenance:** The warranty of the equipment should be specified in detail which should indicate period, cost etc. Warranty for the instrument, support sub-systems and the computer systems from the date of satisfactory installation of the instrument. Response should be ‘with-in 48 hours’ after lodging a warranty call for troubleshooting. Machine down-time during warranty period should be allowed for extended warranty.

   Separate quote for annual comprehensive maintenance of the instrument and subsystems including spares parts as an when required for five years post warranty may be given.
2. **Routine Consumable components for the first three years of operation:** Routine consumable components shall be supplied with the instrument for the first three years of the operation of the instrument.
3. **Training:** Post-installation, application related training for two personnel at the factory site in operation, maintenance and application, after a period of exposure time on the instrument.
4. **Accessories:** A comprehensive list of accessories with catalogue/part number and cost should be provided.
5. **List of Users in India:** A complete list of Indian Users and the systems that are being handled shall be provided with the name and address of the contact person against each user institute.
6. Vendor must have India-based service organization, for which detailed documentation is required, including full disclosure of names, locations, training, and years of experience.
7. Vendor must have local parts stocking, for which documentation is required.
8. Availability of telephone support, including telephone numbers and email addresses, must be detailed.