Thermo Scientific MAT 253

The Gold Standard for Isotope Ratio MS
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Features of the MAT253

- Highest sensitivity and linearity
- Amplifiers register up to 50 V
- Computer switchable amplifier gain
- Hydrogen continuous flow capability
- "Fast bellows" system
- Computer-controlled ion source potentials and parameters
- Up to eight simultaneous acquisition channels
- "Plug and measure" peripheral recognition
- Total Isodat software suite integration
- Small footprint

All the Features of the Established Standard, the Thermo Scientific MAT 252

- 10 kV acceleration voltage
- Ion source with variable conductivity
- All-metal sealed ion source and analyzer
- Monolithic all-metal valves with gold gaskets
- 100% analyzer transmission
- 460 mm mass dispersion
- Mass range m/z 1 - 150 at full acceleration voltage
- Mass resolution 200 (C,N,O,S)
- The only system for e.g. SF₆, SiF₄, Xe...
- Proven robustness
The Thermo Scientific MAT 253 stable isotope ratio mass spectrometer system delivers the highest precision for the determination of D/H, $^{13}$C/$^{12}$C, $^{15}$N/$^{14}$N, $^{18}$O/$^{16}$O, $^{34}$S/$^{32}$S (from SO$_2$ and SF$_6$), $^{28}$Si/$^{29}$Si as well as Ar, Kr and Xe isotope ratios.

It is unique in its capability to achieve precision measurements from the smallest amounts of sample. The MAT 253 provides a flexible and open platform for the connection of inlet systems and preparation devices. Thermo Fisher Scientific-supplied inlet systems are automatically recognized by a "plug and measure" concept. In addition, the system is open for easy connection and control of custom inlet/preparation systems.

Full integration of Isodat software suite, the dedicated gas isotope data system, enables the MAT 253 to be easily set up, tuned and run fully automatically.

The powerful Isodat Script Language (ISL) provides access to all processes and allows modification of supplied scripts as well as development of entirely new measurement and evaluation protocols.

Highest Sensitivity in Isotope Ratio MS
The 10 kV Mass Analyzer

The Ion Source
The electron impact ionization source, held at 10 kV acceleration voltage, delivers the highest sensitivity while giving the tightest and most comprehensive specifications for linearity. The variable ion source conductance window allows source conductance to be optimized for the specific application.

The ion source is pumped with a hybrid two-stage turbo molecular pump, giving high pumping capacity for H₂ and He, while guaranteeing the lowest background and a low and stable H₃⁺ factor.

Ion source parameters are set by the data system. Tuning can be manual or automatic. Ion source parameters can be stored and retrieved. The ion source manifold is weld-free, machined from a single piece of stainless steel, and all-metal sealed.

The Analyzer
The analyzer geometry with stigmatic focusing and the largest dispersion by far of any gas IRMS (460 mm), is the foundation of the MAT 253’s analytical performance and ruggedness. Perfect peak shapes, unrivaled mass resolution, and a mass range which covers all stable isotope ratio applications translate directly into precision, accuracy, sensitivity, versatility and reliability.

All gas species except H₂ are measured using the full deflection radius. H₂ is measured on a smaller radius with an effective dispersion of 180 mm. The magnetic sector field is generated by an electromagnet. The field strength is controlled by a high precision current regulator which is under full data system control.

The analyzer can be equipped with an optional differential pumping module, ensuring optimum vacuum conditions even with a high He load of the ion source.
The Collectors
Collectors for C, N, O, S, Si, Ar, Kr, and Xe are located at the focal plane of the full deflection radius. They use deep, individually shielded Faraday cups with secondary electron suppression. Up to eight individual cups can be present, depending on the application. Data can be acquired from any number of these cups simultaneously.

The collectors for D/H are located at a smaller deflection radius. The cup for m/z 3 (DH) is equipped with a retardation lens. This enables the MAT 253 to determine the D/H ratio by continuous flow, in excess of He.

Both sets of collectors are connected individually to evacuated amplifier housings with new amplifiers. The amplifiers have a linear dynamic range of 50 V, and each channel can be equipped with computer switchable gain, implemented by switchable feedback resistors. This new design allows easier measurement of wide ratio swings, e.g., enriched samples.

Dual Inlet System
The optional Dual Inlet System uses monolithic all-metal valve blocks with gold-sealed and gold-seated valves. The changeover valve is mounted directly to the ion source housing. This design gives minimal dead volume, shortest transit distance and minimum gas path length.

The variable bellows can be adjusted between 3 and 40 ml volume. Adjustment of the bellows has been made faster for better sample utilization. The waste line is pumped by a dedicated turbo molecular pump. The Dual Inlet System can be heated in order to achieve high purity sample introduction. The Dual Inlet System can be expanded by one or two multiports (10 ports each). A cryogenic dual micro volume inlet system can be added. The built-in pressure transducers and intelligent software allow extreme flexibility using the multiport for sample inlet.
**Isodat Software Suite**

Isodat is the software suite for system control, data acquisition and data evaluation. It is an integral part of the system architecture and enables the analytical power and flexibility of the Thermo Scientific MAT 253 to be routinely brought to bear on solving the toughest applications.

**System Control**

All aspects of the mass spectrometer are controlled by software, including ion generation, mass separation and ion detection. *Control of the ion source* allows manual tuning, auto tuning, as well as storage and retrieval of ion source parameters. System configurations can be easily defined. Different configurations representing different analytical setups can be stored and retrieved. Up to eight simultaneous data acquisition streams are supported.

**Automation**

The system is designed to fully automatically execute pre-defined procedures and run sequences of analyses, including customized reporting.

**Open Architecture**

Isodat Script Language (ISL) is the tool giving the expert user full access to the mass spectrometer, the inlet systems and additional user-supplied devices. An input-output module allows connection and control of up to 5 interfaces. Scripts can be developed for customized applications. The export of all data is extremely flexible and can be easily customized.

**Data Evaluation and Display**

Isodat provides a comprehensive set of customizable data evaluation routines. Standard report forms are provided according to the application. In addition, reports can be easily customized using Isodat’s unique Result Workshop.
System Performance

Mass Range
1 – 150 Dalton at 10 kV

Resolution
CNOS: $m/\Delta m = 200$ (10% valley)
H/D: $m/\Delta m = 25$ (10% valley)

Peak Top Flatness
Better than $2 \times 10^{-4}$

Sensitivity
600 molecules CO$_2$ per mass 44 ion at the collector (600 molecules/ion) in the Dual Inlet mode

Ion Source Linearity
0.02 %/nA ion current (mass 44) at a sensitivity corresponding to 900 molecules/ion in the Continuous Flow mode

Abundance Sensitivity
The contribution of the mass 44 intensity to the intensity of mass 45 is less than $2 \times 10^{-4}$

Sample Consumption
0.031 nmol/s for 1.5 V signal (5 nA) at mass 44 in the Dual Inlet mode 0.047 nmol/s for 1.5 V signal (5 nA) at mass 44 in the Continuous Flow mode

H$_3^+$ Factor
Smaller than 10 ppm/nA

Dual Inlet Performance
Standard performance data of the Thermo Scientific MAT 253 by viscous flow gas introduction using the Dual Inlet system and changeover valve:

<table>
<thead>
<tr>
<th>GAS</th>
<th>MINOR ISOTOPES</th>
<th>PRECISION (%)</th>
<th>SAMPLE SIZE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(2σ mean)</td>
<td>INTERNAL</td>
<td>EXTERNAL*</td>
</tr>
<tr>
<td>CO$_2$</td>
<td>$^{13}$C</td>
<td>0.005</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>$^{18}$O</td>
<td>0.03</td>
<td>0.1</td>
</tr>
<tr>
<td>CO$_2$</td>
<td>$^{14}$O</td>
<td>0.01</td>
<td>0.03</td>
</tr>
<tr>
<td></td>
<td>$^{16}$N</td>
<td>0.02</td>
<td>0.05</td>
</tr>
<tr>
<td>N$_2$</td>
<td>$^{15}$N</td>
<td>0.008</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>$^{17}$O</td>
<td>0.05</td>
<td>0.1</td>
</tr>
<tr>
<td>SO$_2$</td>
<td>$^{34}$S</td>
<td>0.006</td>
<td>0.01</td>
</tr>
<tr>
<td>SF$_6$</td>
<td>$^{34}$S</td>
<td>0.006</td>
<td>0.01</td>
</tr>
<tr>
<td>H$_2$</td>
<td>$^{2}$H</td>
<td>0.09</td>
<td>0.4</td>
</tr>
</tbody>
</table>

Continuous Flow Performance
Standard performance data of the Thermo Scientific MAT 253 by continuous flow gas introduction. 10 pulses of reference gas at an amplitude of 5 nA (1.5 V, for H$_2$ 5 V):

<table>
<thead>
<tr>
<th>GAS</th>
<th>MINOR ISOTOPES</th>
<th>PRECISION (%)</th>
<th>LINEARITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO$_2$</td>
<td>$^{13}$C</td>
<td>0.06 %σ</td>
<td>0.02 %σ / nA</td>
</tr>
<tr>
<td></td>
<td>$^{18}$O</td>
<td>0.06 %σ</td>
<td>0.02 %σ / nA</td>
</tr>
<tr>
<td>N$_2$</td>
<td>$^{15}$N</td>
<td>0.06 %σ</td>
<td>0.02 %σ / nA</td>
</tr>
<tr>
<td>O$_2$</td>
<td>$^{17}$O</td>
<td>0.08 %σ</td>
<td>0.03 %σ / nA</td>
</tr>
<tr>
<td>CO</td>
<td>$^{18}$O</td>
<td>0.20 %σ</td>
<td>0.04 %σ / nA</td>
</tr>
<tr>
<td>H$_2$</td>
<td>$^{2}$H</td>
<td>0.15 %σ</td>
<td>0.04 %σ / nA</td>
</tr>
<tr>
<td>SO$_2$</td>
<td>$^{34}$S</td>
<td>0.10 %σ</td>
<td>0.20 %σ / nA</td>
</tr>
</tbody>
</table>

* measured using internal multiport -10
Installation Requirements

Environment
Heat output 2.5 kW during normal operation, 4.5 kW during bakeout. Ambient temperature must be 18 - 28 °C with a relative humidity of 20 – 70%

Power
230 V – 10% + 6%, 16 A, three-phase, 50/60 Hz, dedicated lines. Voltage must be free of spikes. Maximum permissible voltage between ground and neutral lines < 400 mV

Compressed air
350 to 500 Kpa (50 to 75 psi)

Dimensions
Mass spectrometer system: 101 cm (width) x 135 cm (depth) x 136 cm (height); 40 inch x 53 inch x 53 inch. Width for transport 87 cm (35 inch).

Weight
680 kg (1500 lb), basic system.

Thermo Scientific MAT 253
Footprint and Dimensions

Laboratory Solutions Backed by Worldwide Service and Support

Tap our expertise throughout the life of your instrument. Thermo Scientific Services extends its support throughout our worldwide network of highly trained and certified engineers who are experts in laboratory technologies and applications. Put our team of experts to work for you in a range of disciplines – from system installation, training and technical support, to complete asset management and regulatory compliance consulting. Improve your productivity and lower the cost of instrument ownership through our product support services. Maximize uptime while eliminating the uncontrollable cost of unplanned maintenance and repairs. When it’s time to enhance your system, we also offer certified parts and a range of accessories and consumables suited to your application.

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In addition to these offices, Thermo Fisher Scientific maintains a network of representative organizations throughout the world.

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