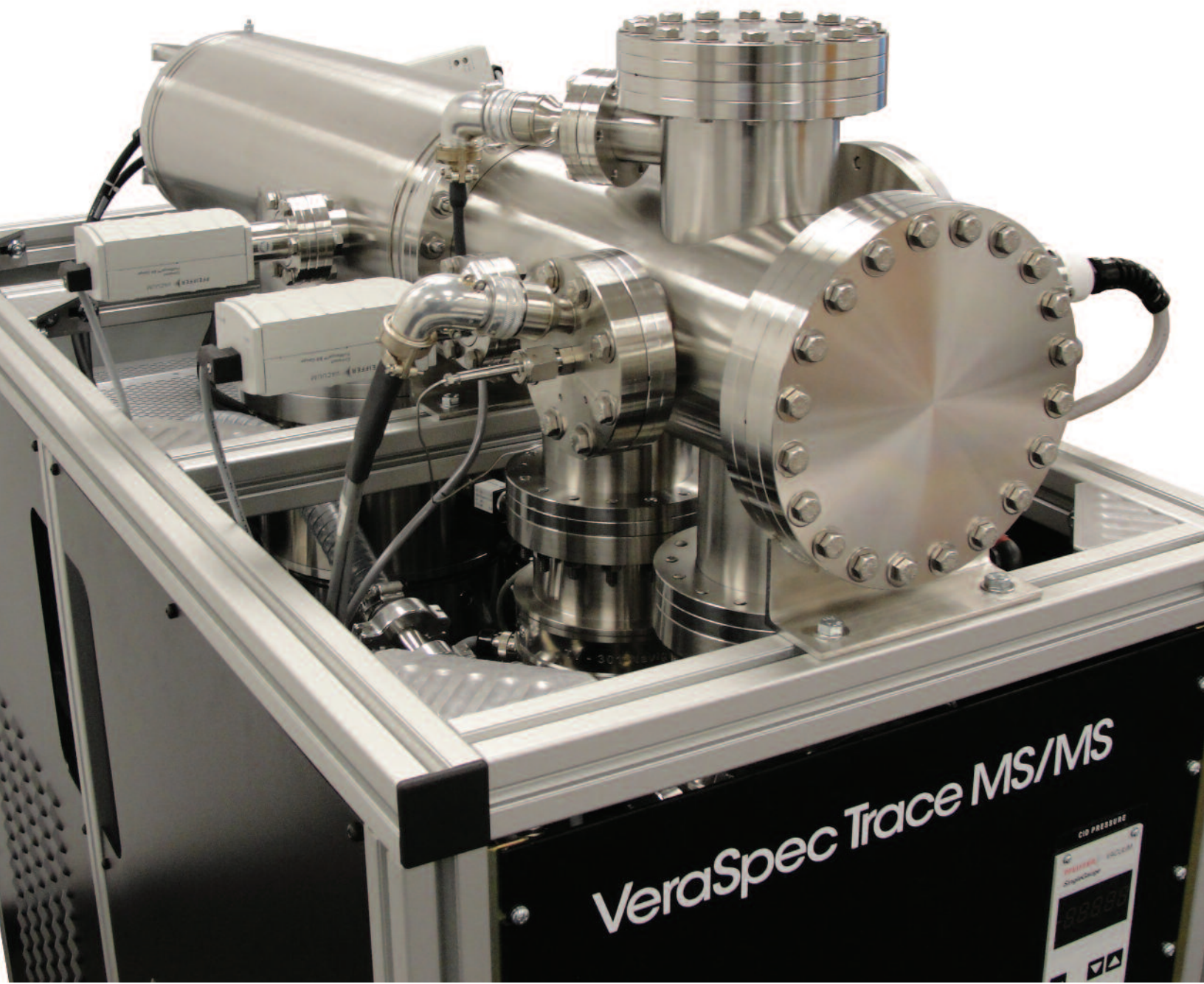


VeraSpec Trace



PRODUCT NOTE



VeraSpec Trace

The VeraSpec Trace DS is the dual-source model with both an API and Extrel's decidedly capable closed source EI ionizer with a capillary inlet in the standard configuration.

Source selection is accomplished using Extrel's large ion bender for maximum flexibility and sensitivity. Adding a membrane inlet to the EI system pushes the detection limits for applicable analytes into the sub-ppb range in the VeraSpec Trace DS-MIMS system.

Dual Source Performance

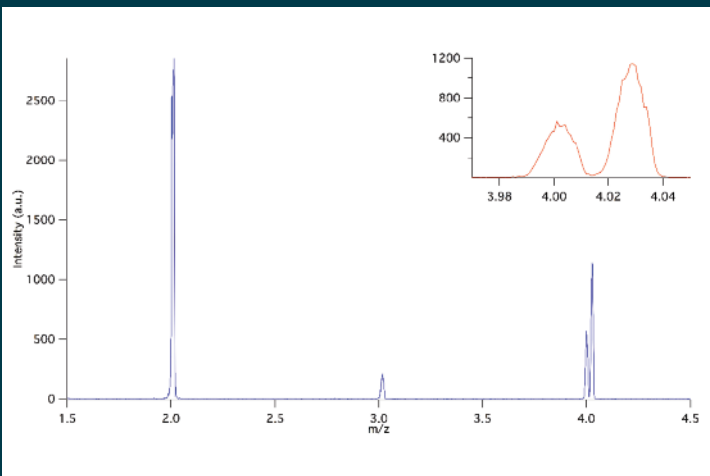
One of the most innovative capabilities of the VeraSpec Trace is found in the Dual Source version. While API ionization allows for high ion currents resulting in low detection limits, the technique is limited to molecules whose ionization energy is less than that of the balance gas or any other component at a high concentration, and which have sufficient proton affinity to be ionized. As a result, every table of lower detection limits for pure gas analysis using API has gaps for components that cannot be measured. With the

VeraSpec Trace DS, the gaps are filled as seen in Table 2. The addition of a high-performance, closed EI source delivers detection to ppb levels.

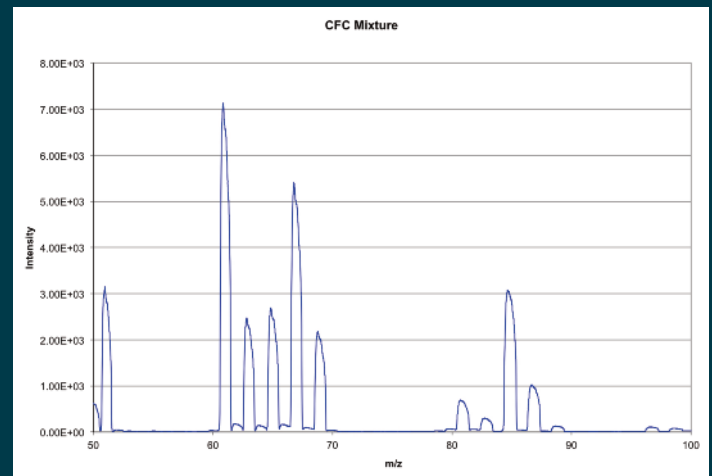
With the membrane inlet, analytes — examples of which are shown in Table 3 — can be preconcentrated, allowing for sub-ppt levels to be achieved. The VeraSpec Trace draws from the strength of both Extrel's research and industrial experience. Membrane inlets work by allowing the VOCs to permeate through the membrane while the water or other liquid phase flows past. The result is an instrument with exceptional detection limits for all required components, with the stability and reliability required in an industrial setting. In addition, it has unprecedented flexibility and capability for trace analysis in one instrument.

All of the data in Table 4 was taken using a VeraSpec Trace DS MS/MS.

High Resolution Analysis



CFC Detection



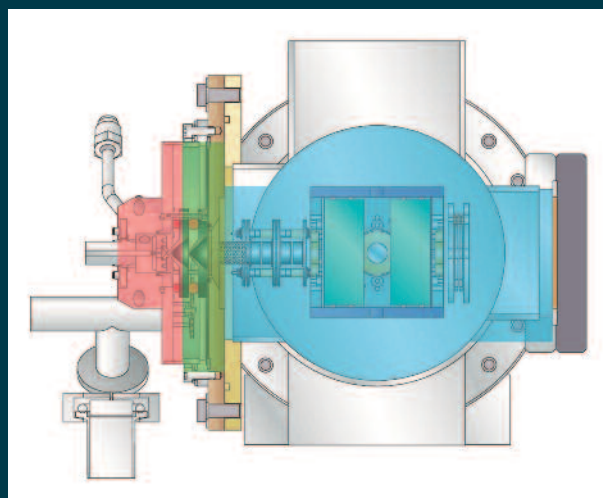
A Breadth of Gas Analysis

API and EI dual source ionization allows for the flexibility of having two systems worth of analysis in one. From High Resolution analysis to CFC detection in atmospheric samples, the VeraSpec Trace can manage difficult atmospheric and gas analyses.

VeraSpec Trace

Trace level analysis of impurities in pure gases is a critical capability in the development and implementation of semi-conductor and other high technology industrial applications. Atmospheric pressure ionization mass spectrometry (API-MS) has developed into a critical tool for pure gas analysis, providing part-per-trillion (ppt) level detection of certain impurities in pure gases. For other impurities for which API is not a viable technique, electron impact ionization (EI) mass spectrometry can be used to supplement the analysis. In some cases, membrane introduction mass spectrometry (MIMS) with an EI source can provide sub part-per-billion (ppb) detection limits for some components. Extrel's VeraSpec Trace has the unique capability to combine these techniques in a single instrument.

The VeraSpec Trace system provides the ideal ionization techniques for pure gas analysis in one system. The system can be configured for both ionization techniques, eliminating the need for two mass spectrometers, and significantly reducing the overall expense. The base system utilizes either Extrel's high-performance, closed-source EI ionizer, or the proven, reliable DC Corona Discharge API source. The DC Corona Discharge source is a chemical or soft ionization source that is ideal for monitoring molecules in the ppb and ppt range. The EI system is taken from Extrel's MAX300 industrial mass spectrometers, and has the same proven performance available on those systems with detection limits in the low ppb range. The system utilizes a 19 mm tri-filter quadrupole, and is available in several mass ranges noted in Table 1. The system is also offered in an MS/MS configuration, the VeraSpec Trace MS/MS.



Schematic of API-MS System.

- A. Corona Discharge Region (~1 atm)
- B. Declustering Region (2.5×10^{-6} Torr)
- C. Quadrupole Region (1×10^{-7} Torr)

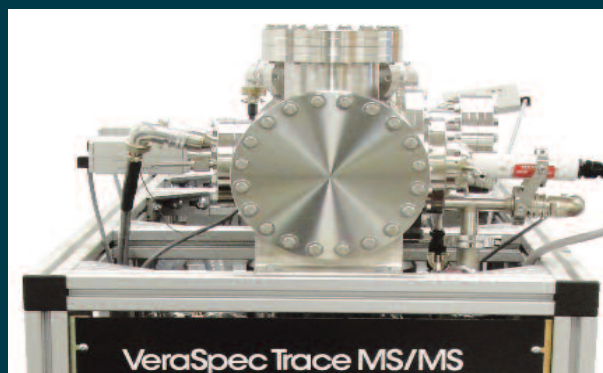
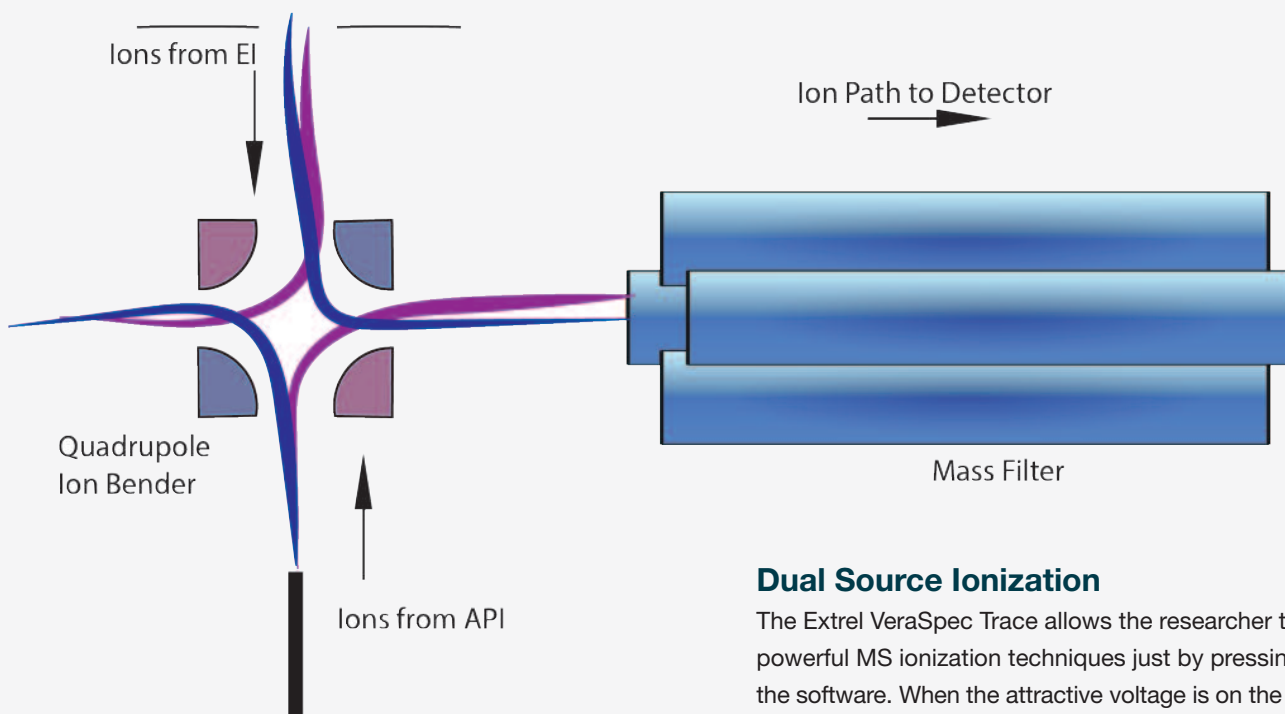


Table 1: Gas Analysis Systems

	API	EI	MS/MS	MIMS
VeraSpec Trace	*Yes/No	*No/Yes	No	No
VeraSpec Trace DS	Yes	Yes	No	No
VeraSpec Trace DS-MIMS	Yes	Yes	No	Yes
VeraSpec Trace MS/MS	*Yes/No	*No/Yes	Yes	No
VeraSpec Trace DS MS/MS	Yes	Yes	Yes	No
VeraSpec Trace DS-MIMS MS/MS	Yes	Yes	Yes	Yes

*Note: The ionization system of the base system is selected by the customer. Either EI or API can be selected, but not both.

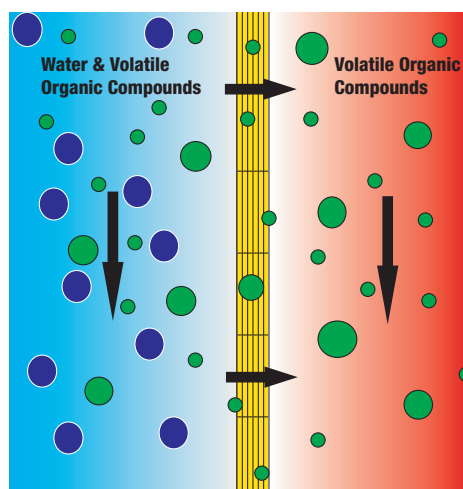


Dual Source Ionization

The Extrel VeraSpec Trace allows the researcher to use two powerful MS ionization techniques just by pressing a button within the software. When the attractive voltage is on the bottom right pole, it pulls the API ions into the MS (purple traces). When the attractive voltage is swapped to the upper right pole, it pulls the EI ions into the system (blue traces).

Lower Detection Limits in Pure Gas

Trace levels of carbon dioxide and oxygen in dry nitrogen were measured in the VeraSpec Trace at a series of levels below 2000 ppt. A multi-point calibration curve was constructed and the detection limits were calculated at a t value of 3 (a 99.5% confidence interval). The calibration curves had R^2 value of > 0.9 . The calibration curve was used to calculate incredibly low detection limits for CO_2 of 0.9 ppt, and for O_2 of 4.1 ppt displaying the power of the Extrel API-MS detection scheme.



Graphical schematic of how a MIMS membrane works. Arrows show movement of flow.

System	Quadrupole Mass Filter	Operating Frequency	Mass Range	Relative Transmission	Resolution $M/\Delta M$ FWHM	General Sensitivity (mA/Torr)
MAX-4000HT	19 mm (3/4 inch) tri-filter	440 kHz	4-4000	50%	1500	0.75
MAX-1000	19 mm (3/4 inch) tri-filter	880 kHz	1-1000	50%	1800	1
MAX-500HT	19 mm (3/4 inch) tri-filter	1.2 MHz	1-500	60%	2000	2
MAX-120	19 mm (3/4 inch) tri-filter	2.1 MHz	1-120	65%	2500	3
MAX-50	19 mm (3/4 inch) tri-filter	2.9 MHz	1-50	75%	3000	4

Table 3: Detection Limits for Select Compounds in Some Bulk Gas

Impurities Bulk Gases	H2	H2O	N2	Ar	O2	CO2	CO	CH4	NH3
Hydrogen (H2)	—	10 ppt	*100 ppb	*10 ppb	*100 ppb	5 ppt	10 ppt	10 ppt	500 ppt
Helium (He)	*1 ppm	10 ppt	*100 ppb	*5 ppb	*10 ppt	5 ppt	10 ppt	10 ppt	500 ppt
Nitrogen (N2)	*1 ppm	10 ppt	—	*5 ppb	*10 ppt	5 ppt	*500 ppb	10 ppt	500 ppt
Argon (Ar)	*1 ppm	10 ppt	*100 ppb	—	*10 ppt	5 ppt	10 ppt	10 ppt	500 ppt
Oxygen (O2)	*1 ppm	*2 ppm	*500 ppb	*10 ppb	—	*500 ppb	*100 ppb	*500 ppb	*200 ppb
Carbon Dioxide (CO2)	*1 ppm	*2 ppm	N/A	*10 ppb	N/A	—	N/A	N/A	*250 ppb

Detection limits marked with * are based on EI ionization tri-filter.

Table 4: Measurement of Impurities in Air with MIMS Option on the VeraSpec Trace

Impurities	VOCs with MIMS in Air	Impurities	VOCs with MIMS in Air
Carbon Disulfide	45 ppt	Toluene	10 ppt
Dimethyl Sulfide	100 ppt	Pyrrole	15 ppt
Dimethyl Disulfide	90 ppt	Xylenes, Ethylbenzene	15 ppt
Benzene	6 ppt	VCM	28 ppt

Based on EI with a MIMS inlet.

Applications

- Trace analysis of impurities in bulk gas
- Atmospheric analysis
- Wind flux measurements
- Bulk gas manufacturing QA/QC
- Semi-conductor off-gassing
- Gas filter and purifier manufacturing QA/QC
- PTR/MS & CFC Detection



VeraSpec Trace Specifications

Detection Limits

- 5 ppt Oxygen and Nitrogen
- 5 ppt H₂O in Nitrogen
- 5 ppt CO₂ in Nitrogen

Mass Range

- 1-500 amu for standard system; Other mass ranges available per table 2.

Stability

- Better than +/- 0.1 amu after thermal equilibrium
- Long-term stability +/- 0.01 amu

Ionization Source

- Corona discharge with additional EI filament

Mass Filter

- Single 19 mm (3/4 inch) diameter rod tri-filter quadrupole or Triple tri-filter quadrupole mass filter available for MS/MS

Detection

- Positive and negative ions using electron multiplier with continuous dynode

Masses

- Continuous monitoring of up to 20 masses or mass windows. Additional masses or mass ranges can be added using easy-to-write Macros

Data System

- Merlin Automation data system with Windows 7 and 10 compatibility

Vacuum System

- Differentially pumped using turbomolecular drag pumps backed by oil rough pump; dry diaphragm backing pump optional

Power Requirements

- 115 Vac, 50/60 Hz, two 20 A circuits; Optional 220 VAC version

Support: For over 50 years, Extrel has been committed to providing the highest quality support services for thousands of instruments installed worldwide. Factory-trained and certified personnel offer industry-leading support to Extrel customers at every stage of the research application process.



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