PRIMA PRO PROCESS MASS SPECTROMETER

SENTINEL PRO ENVIRONMENTAL MASS SPECTROMETER

Thermo SCIENTIFIC

Introduction

The Thermo Scientific Prima and Sentinel family of Process mass spectrometers have been successfully deployed worldwide to provide fast, accurate and complete gas composition analysis in a wide range of applications for the purpose of process optimization, enhanced safety and regulatory compliance. Ever-increasing global competition, over-stretched maintenance departments and strict requirements for carbon emission auditing require continuous improvements in process analytical technologies. Because of its inherent flexibility, mass spectrometry is expected to play a major role in the next generation of process gas analyzers. The new Prima PRO has been designed to provide true next-generation performance with significant improvements in accuracy, precision and stability in a package that is highly reliable and easy to deploy and maintain.

The design team at the Process Systems business unit set out to design a totally new analyzer that would offer the following attributes:

- The best available online measurement precision
- The best available measurement stability
- Totally flexible analysis configuration using intuitive software
- Fault-Tolerant design to drive uptime close to 99.9%
- Extended preventative maintenance intervals
- Highly simplified maintenance procedures
- Multi-Language support for all HMI screens
- Excellent analyzer-to-analyzer repeatability
- A design that would support a comprehensive 3-year warranty

We are pleased to announce: they succeeded!

Technology Selection

Thermo Fisher Scientific has a wide-range of mass spectrometer technologies at its disposal, more in fact than any other process analyzer company. The technology selected for the Prima PRO and Sentinel PRO is the scanning magnetic sector. This provides a flat-topped peak profile that tolerates mass scale drift with no effect on the measurement results. It is also a high-energy device that offers the best resistance to contamination. Finally, the ability to measure very small concentrations at masses immediately adjacent to high concentrations is made possible by the clean baseline between peaks.

Prima PRO or Sentinel PRO?

The **Prima PRO** is intended for use in process development and online process optimization where gas component concentrations in the range 20ppm - 100% require precise measurement. Additional low parts per million (ppm) concentrations can be added to the analysis by use of the optional multiplier detector.

The **Sentinel PRO** is intended specifically for use detecting fugitive emissions of toxic volatile organic compounds (VOC) in the ppm and parts per billion (ppb) range. The Sentinel is basically the same product as the Prima PRO but it uses membrane inlet technology to lower the detection limit down to 10 ppb for selected VOCs. This type of inlet is not appropriate for measurements in the % range. If you are looking for an online process gas analyzer then the Prima PRO provides the best available measurement quality. If on the other hand, you require an analyzer that will monitor as many as 100 sample points around a process unit within the 15 minutes that define short-term exposure limits (STEL) to potentially leaking VOCs then the Sentinel PRO should fit the bill perfectly.

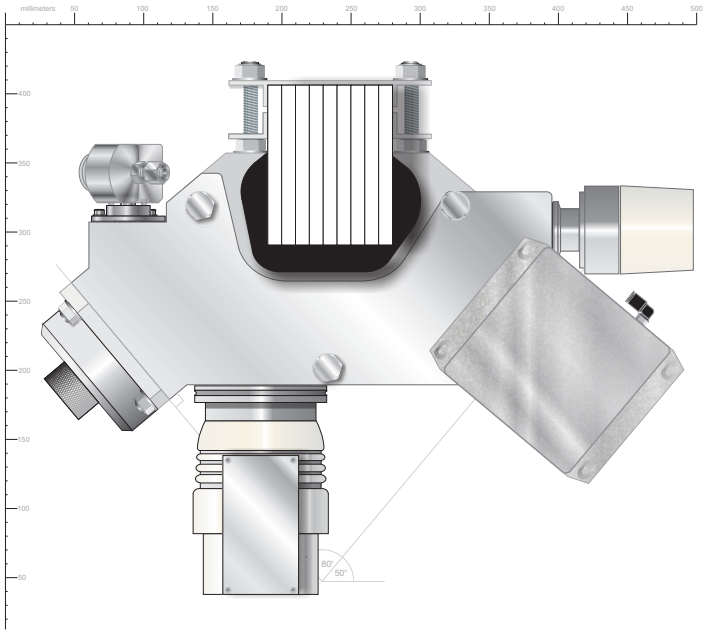
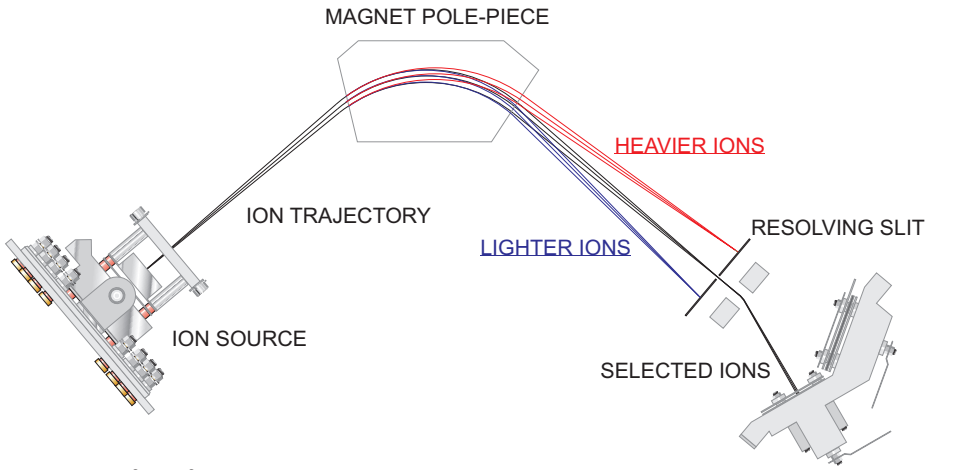


Figure 1

Principles of Operation

Magnetic sector mass spectrometers rely on the interaction of ionized sample molecules and magnetic fields in order to filter and measure individual atomic mass components that collectively contribute to the total sample composition. The ions are formed in an ionization chamber by interaction of the neutral gas-phase sample molecules with a beam of energetic electrons. The newly formed ions are immediately accelerated towards the magnetic field. Each charged particle will experience a sideways force that is proportional to the strength of the magnetic field, the velocity of the particle and its charge. Each appropriate mass can be selected in turn by setting the magnetic field strength to a value that will direct the selected ions through a narrow window in front of the detector. The signal measured here is directly proportional to the molecular concentration of the selected component. By measuring a predetermined number of ions, a complete compositional analysis can be performed. **Figure 2** illustrates the operation of the analyzer. **Figure 3** illustrates the components that are used to implement the analysis and **Figure 1** above shows the complete mass spectrometer assembly.



$$\frac{M}{e} = \frac{\beta^2 \times r^2}{2V}$$

Where:
r is the radius of orbit (6 cm)
M is the mass of the particle
V is voltage applied to the particle to accelerate it to velocity v (1kV)
β is the magnetic field strength
e is unit charge (the charge of one electron)

Figure 2

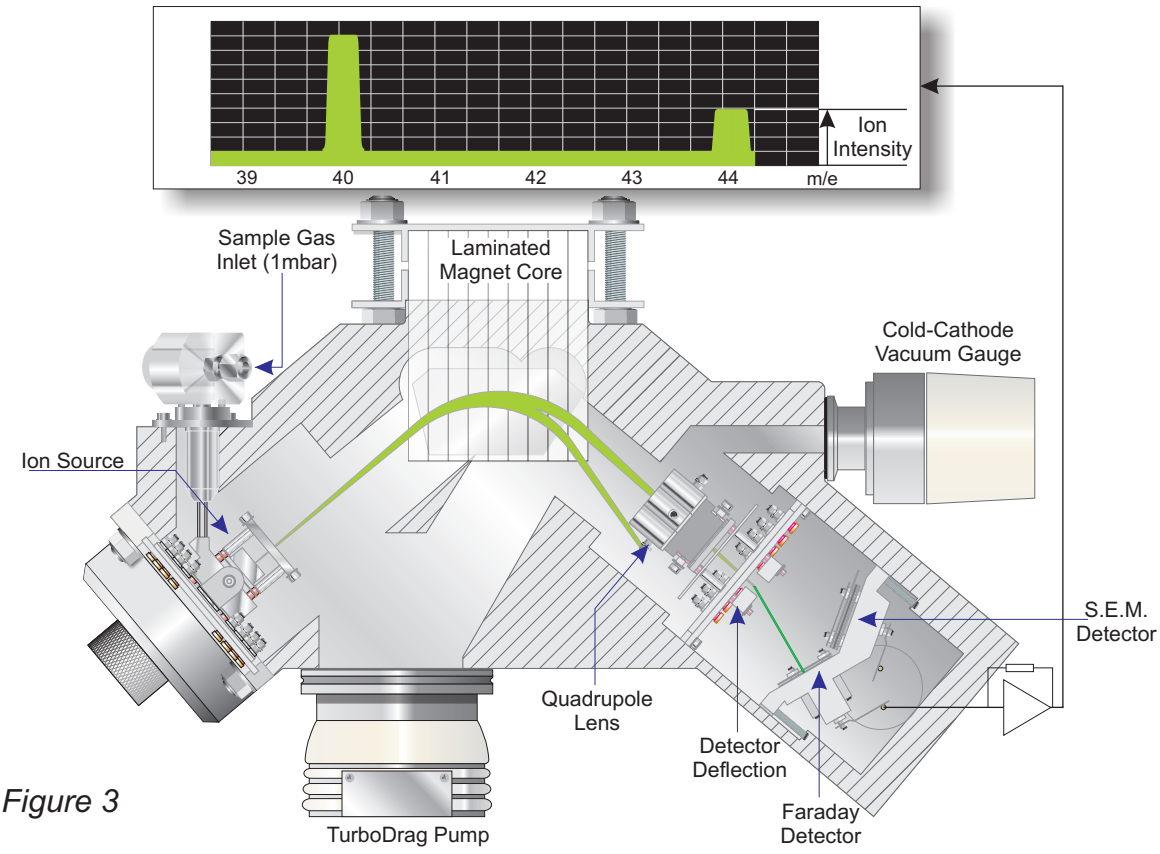


Figure 3

Design Philosophy

In order to aggressively reduce analyzer downtime, a design philosophy towards fault-tolerance was adopted at the outset of the project. For example, a thorough review of the predecessor products was used to identify all the subassemblies that contribute to temperature dependence. The new design of those sub assemblies ensured that these temperature dependencies were eliminated. With that goal achieved, the design team added a cabinet temperature control system just in case any of those temperature dependencies returned due to a fault condition. The analyzer peak profile was designed to provide a mass alignment that could tolerate significant internal temperature changes due to a failure of the cabinet control system. Just in case the mass scale stability isn't quite good enough under these circumstances, the mass scale is realigned automatically once or twice an hour. The time penalty for this isn't noticeable for most applications but this feature can be disabled during fast batch process applications where a sampling interval of about 1Hz is achievable for up to six components.

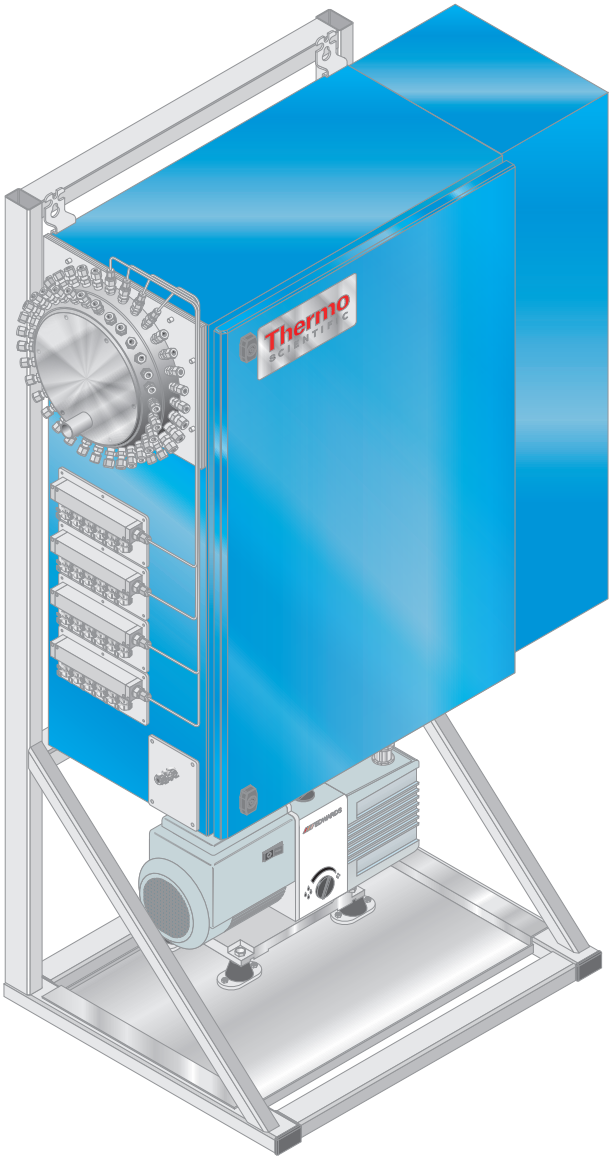


Figure 4

Sample Introduction

The most popular device for introducing sample gas into the analyzer is the Rapid Multistream Sampler (RMS). This is a highly reliable device for switching sample streams without compromising the quality of the sample presented to the analyzer. The RMS has a long track record of rock-solid reliability with its proven capability to switch streams six million times a year (for year after year) with little or no maintenance. This allows a single RMS system to monitor up to 63sample ports and a dual RMS Sentinel to monitor up to 126 streams. The stepper-motor driven device diverts one sample stream at a time to the mass spectrometer and records the flow for each stream in turn. The device can be heated to 120° C and has been designed to ensure rapid response to polar species such as methanol, ethanol and ammonia.

Figure 4 illustrates the gas connection ports for a typical configuration. Note that since the RMS is not a rotary valve but a sample selector where all gas streams continually flow, it is necessary to add control valves for calibration gases. These are typically located below the sample stream selector. The patented design of the calibration manifolds, provides valve actuation from inside the cabinet, which permits their use in potentially explosive atmospheres.

Figure 5 shows a popular alternative configuration that provides a remote gas management module that can be installed on the outside of the analyzer shelter. Since no gases pass into the shelter at a positive pressure, this arrangement is particularly safe and can often lead to a general purpose classification inside the shelter even when flammable vapors or toxic mixtures are being analyzed. This reduces the cost of the installation and simplifies maintenance. The dual RMS option is a combination of both configurations illustrated in figures 4 and 5.

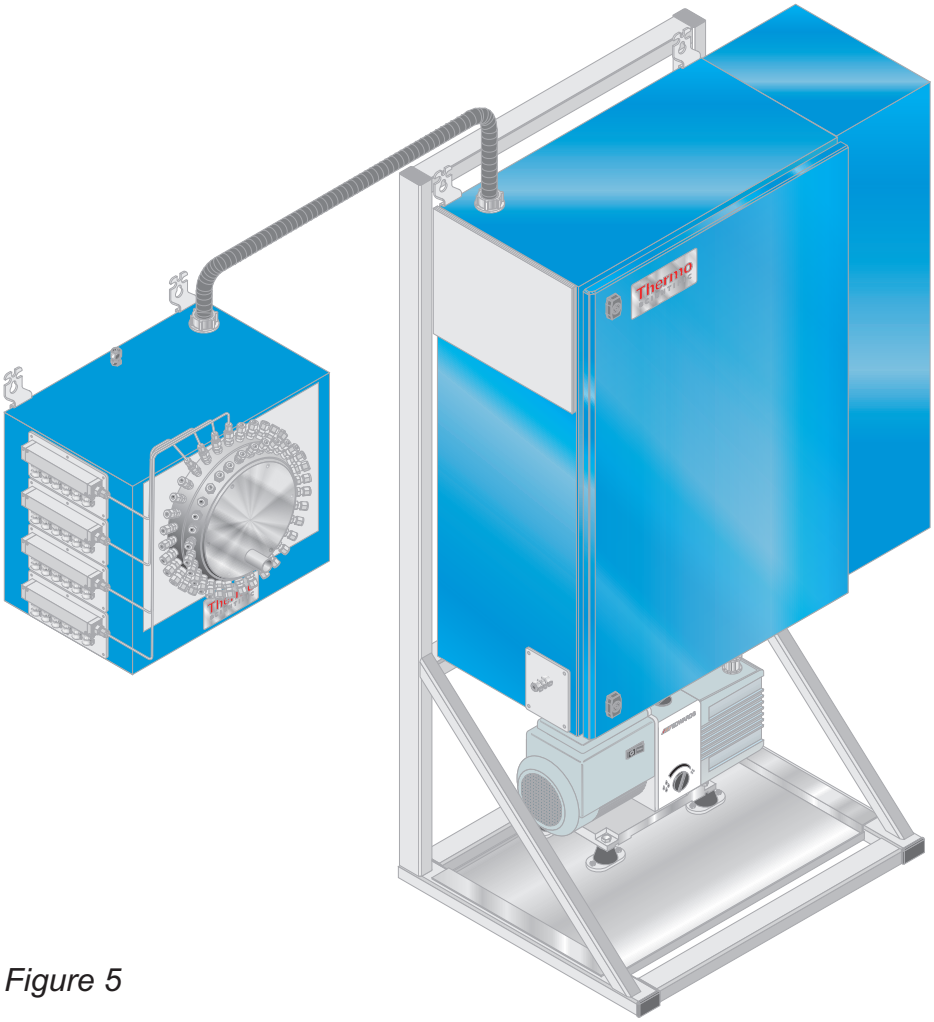


Figure 5

In situations where the 32-port or 64-port RMS is more than required there are two solenoid-based alternatives. One provides a single heated sample port, the other 6 heated sample ports. Either of these can be configured with a single 6-port calibration assembly.

Sub-atmospheric gas sampling is possible by use of the variable pressure (VP) inlet. This permits sample monitoring from 1,000 mbar down to 0.1 mbar with rapid response to process pressure changes. This type of inlet is typically used on specialty steel conversion and degassing in an integrated iron and steel works, or in vacuum drying applications in a pharmaceutical plant.

Analyzer Control Architecture

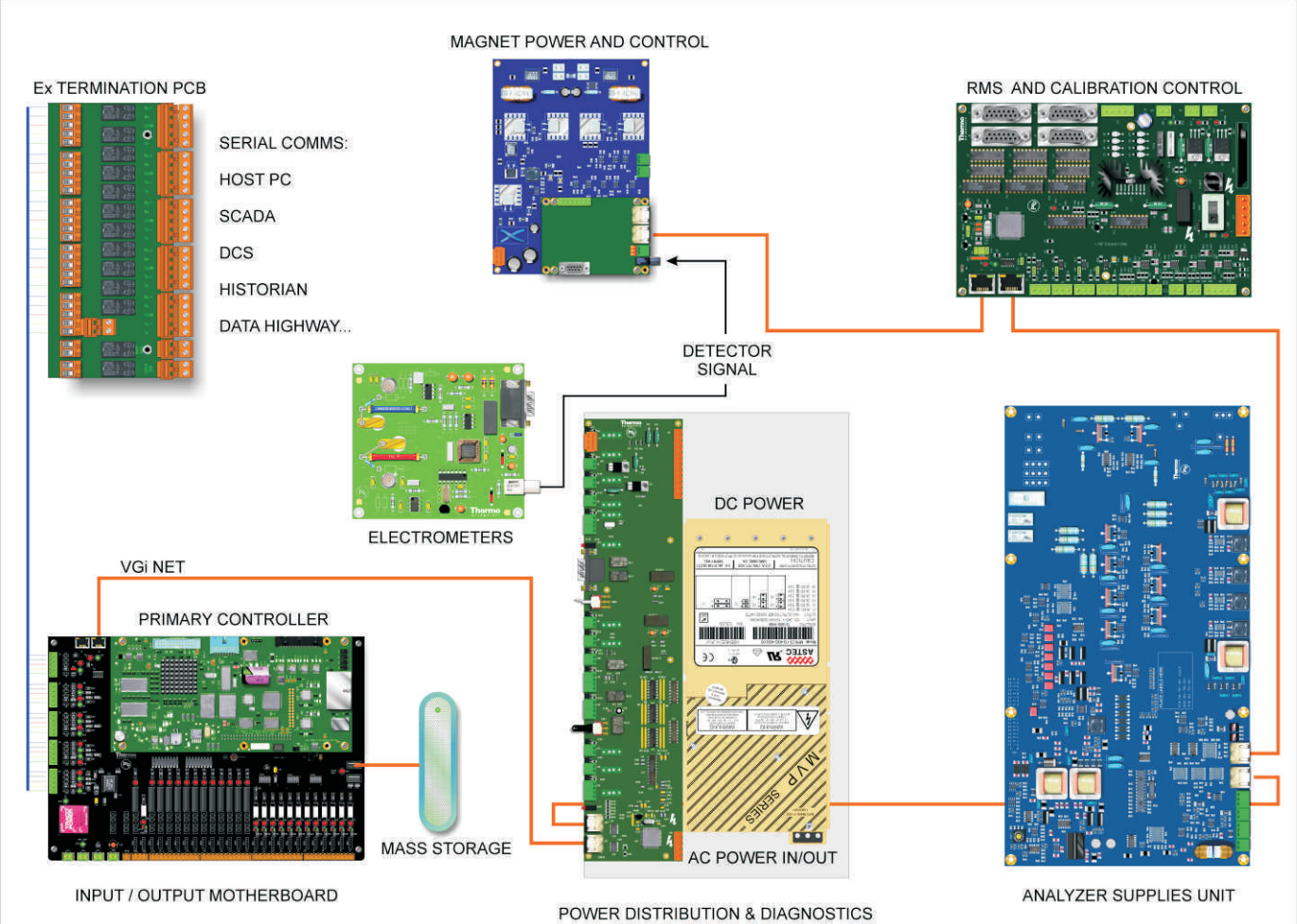


Figure 6

The analyzer control architecture is shown in figure 6 to consist of highly integrated circuit boards interconnected with network cables. Based on the RS-485 communications standard, it provides secure, deterministic control and monitoring of all instrument functions and allows replacement of individual system modules without powering-down the whole instrument. VGiNet is the internal communication network, which coordinates activity of the distributed control engines within the Prima PRO. The internal protocol is enhanced to increase speed and security for internal and external communications.

The combination of state-of-the-art plug and play electronics, the gold-standard analytics and the industry standard communication tools provide a flexible platform that can be easily adapted to a wide range of gas analysis applications.

At the heart of the control electronics is the Freescale -based controller which runs the ThreadX industrial real time operating system (RTOS) from Express Logic. With over a billion deployments, the RTOS is the most reliable available. The controller that runs it is a Thermo Scientific design with thousands of installations and a solid track record of reliability.

The processor's mother board was designed specifically for the Prima PRO and Sentinel PRO and provides a flexible range of communication options. One of the five serial ports is reserved for a remote Gas*Works* PC that is used for analyzer configuration and data presentation (when necessary). The stand-alone design ensures that PC lockups or corruptions have no impact on the performance of the analyzer which communicates data directly to the DCS, SCADA, PLC Data Highway or Host via the remaining four serial ports. These can be independently configured for a range of communication protocols. These include Modbus and OPC as standard. The board is also provided with 13 digital inputs and 13 digital outputs that can be configured for a wide variety of purposes. The cabinet can accommodate 16 optional analog inputs or outputs and a virtually unlimited number of external analogs.

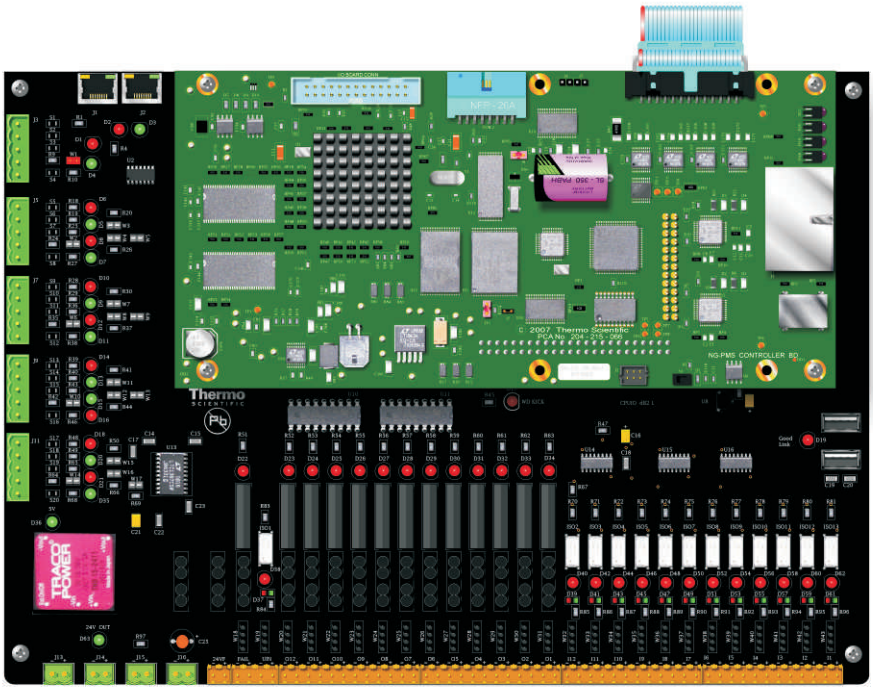


Figure 7

Data Historian

The local data historian is used primarily to record instrument diagnostics throughout the life of the analyzer. The data captured here is designed to provide a comprehensive health profile for the system giving the maintenance engineers the best possible chance of identifying the root-cause of any failures. The mass storage device is also available to archive analysis data when required.

Figure 8

Figure 8 illustrates the standard service kit that ships with all Thermo Scientific Prima PRO and Sentinel PRO systems. The kit includes all the components and tools necessary to complete the routine maintenance. The kit has been designed to accommodate significantly simplified maintenance procedures. For example, rather than changing filaments or cleaning the source, users now simply change the entire source, replacing it with the fully tested spare. Similarly with the vacuum gauge: no need to disassemble for cleaning - simply swap the gauge with the spare from the service kit. Once the service has been completed, simply ship the kit to your nearest service center for refurbishment. By careful design, the "inside the cabinet" service interval has been extended to three years. The only preventative maintenance that is required outside the cabinet is the routine maintenance on the secondary vacuum pump. The service interval for this will vary depending on the application-dependent model that has been supplied but the procedure generally only takes a few minutes.

World Class Service & Support

Our service and support options are designed to ensure instrument optimization and reduce downtime. Because every customer and every instrument has different requirements, we offer a variety of services to meet your unique needs.

- Service agreements
- Spare parts
- Technical support
- Field installation and service
- Product training

Specifications

Analyzer	High-Energy Scanning Magnetic Sector
Area Classification	General Purpose, or ATEX Zone 1, or Class 1 Div 2 (Z-purged) or Class 1 Div 1 (X-purged)
Dynamic Range	Faraday Detector: 10ppm - 100% (Application Dependent) Dual Faraday/SEM: 10ppb - 100% (Application Dependent)
Analysis Time	1-30 Seconds (Application Dependent)
Analytical Precision	Typically 0.1% Relative Standard Deviation (24 Hour) for concentrations in the range 1-100%
Calibration Interval	Typically 3-12 Months (Application Dependent)
Service Interval	Analyzer 3 years, External Vacuum Pump 6-12 months (Application Dependent)
Dimensions	0.97m Width x 0.72m Depth x 1.48m Height, 240 kg approximate weight
Power	115 VAC (±5VAC) or 230 VAC (±10VAC) Consumption 2.0-2.5 kVA
Environmental	Ideally 20°-25°C. Allowable Range between 12°C and 40°C
Inlet Options	Hazardous Area: 32-Port RMS (integral to cabinet or remote) 64-Port RMS (integral to cabinet or remote) Dual RMS with 64-Port RMS integral to cabinet + remote 32 or 64 Port RMS Single-Port Variable Pressure (0.1-1,000 mbar) 6-Port Variable Pressure (0.1-1,000 mbar) General Purpose - all of the above plus: Single Sample Port + 6 Calibration Ports 6 Sample Ports + 6 Calibration Ports Batch Inlet Reservoir System
Calibration Ports	Maximum 24 with single RMS or 48 with Dual RMS
Standard Communications	4-Ports (Modbus (serial RS232, RS422 or RS485) and/or OPC), 13 Digital Outputs, 13 Digital Inputs
Additionally Available Communication Protocols	Allen-Bradley (Data Highway, DH Plus, DH485, 1771, DF-1, Ethernet) Daniel Modbus, Echelon Lonworks, GE Fanuc Genius, MicroTrac Arcnet Modicon (Modbus, Modbus Plus, Remote I/O), Profibus-DP, Reliance Automate

LITERATURE FLAP

Prima PRO Process Mass Spectrometer

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