INFICON

TECHNICAL NOTE

Choosing the Appropriate RGA

Residual Gas Analyzers (RGAs) have been used in vacuum research applications for 25 years. Their role has changed in the last 10 years, as they have evolved from purely a research instrument to a production tool. As a production tool, the RGA can increase productivity, improve product yield, increase throughput and reduce costs, all of which ultimately increases profits.

However, it is up to the user to determine how the tool can best meet the needs of a specific application. This Tech Note is concerned with choosing the appropriate RGA instrument for a particular application.

HOW DOES AN RGA WORK?

A residual gas analyzer measures the individual partial pressures of gases in a mixture. The RGA system includes a sensor, which operates under high vacuum, the electronics, which operate the sensor, and software, working in conjunction with an external computer to display data and control the electronics.

The RGA sensor consists of three parts:

Ion source: The ion source contains a heated filament that emits electrons. These electrons collide with gas molecules in the vacuum system, giving them an electrical charge, which produces ions.

Quadrupole Mass Filter: Ions produced in the ion source move into the quadrupole mass filter to be separated according to their mass-to-charge ratio.

Ion Detector: Ions that have been transmitted through the quadrupole mass filter strike the detector, become neutralized, and draw a current that is proportional to and identifies the gas component present.

The RGA electronics module, which incorporates a “smart sensor” design, interprets the output of the sensor for display with the system software and an external computer. This system software is used for process monitoring, statistical process control, and maintenance procedures like mass calibration.

WHY USE AN RGA?

The residual gas analyzer can be utilized for a variety of tasks.

- **Leak Detection:** The RGA can continuously monitor for helium (or any other tracer gas) to perform a chamber leak checking function. The software will display a warning (audible as well as visual) to alert the user when the helium level rises above a defined set point.
- **Process Characterization and Background Monitoring:** The RGA can be used to characterize the background environment of a process chamber. Once it is known what is expected, the RGA can then monitor deviations in these levels.
- **Process Monitoring:** The RGA can continuously monitor a process and immediately report any anomalies or process deviations. Integration software can feed this information back to the tool for appropriate action.
- **Contamination Control:** The RGA can be used to pinpoint unexpected and unwanted substances in the system. These contaminants can come from a variety of sources and the RGA software contains a library of known spectra that can be used to help identify extraneous or unknown substances.
- **Process Control:** RGA information can be used for controlling a process. For instance, setpoint relays, programmed to close at predetermined partial pressures, can be used to control valves, or analog outputs can be fed into PLCs.

CONSIDERATIONS

Before recommending or specifying an RGA instrument, several factors must be considered:

Pressure Range: Standard RGA sensors operate at pressures lower than 10^{-4} Torr. (However, the INFICON Transpector XPR3 operates up to $2x10^{-2}$ Torr.) Therefore, if the system operating pressure is above this value, some type of pressure reduction scheme will also be required to keep the RGA sensor at a sufficient level of vacuum. A simple conductance limiting technique is used to draw a sample through an orifice to the sensor.

Mass Range: The mass range will depend on the particular gases of interest in the system. Sensors are specified by AMU (atomic mass unit), whereby a 100 AMU sensor will be able to detect gases of mass from 1-100. Likewise, a 200 AMU (or 300 AMU) sensor will detect masses from 1-200 (or 1-300). Atomic mass units for a certain species can be determined by looking at the Periodic Chart of Elements, which gives molecular weight information for each element. Gases can be atomic: made up of a single, individual element (like N at mass 14); or molecular, made up of a combination of atoms (like H_2O).

Some common gases and their atomic mass unit numbers:

Gas	Atomic Mass Unit Number
Hydrogen - H_2	2
Helium - He	4
Water - H_2O	18
Neon - Ne	20
Hydrofluoric acid - HF	20
Nitrogen - N_2	28
Air	28
Carbon Monoxide - CO	28
Silane - SiH_4	32
Oxygen - O_2	32
Hydrochloric acid - HCl	36
Argon - Ar	40
Mechanical pump oil	43
Carbon Dioxide - CO_2	44
NF_3	71
Xenon - Xe	132

Detection limits: There are two types of RGA detectors: the Faraday Cup (FC) and the Electron Multiplier (EM). The Faraday Cup is a simple metal plate or cup-shaped electrode that yields a minimum detectable partial pressure (MDPP) of $3x10^{-13}$ Torr. The FC has a maximum operating temperature of 250ºC (200ºC for Compact sensors). On the other hand, the Electron Multiplier acts as an amplifier for improved sensitivity, and can detect partial pressures down to the 10^{-14} - 10^{-15} Torr range (at maximum applied voltage). The EM has a maximum operating temperature of 150ºC. The user's application will dictate which detector, FC or EM, is necessary for their specific process requirements. For many applications, the FC is adequate. However, for lower base pressures and more stringent detection requirements, the EM is necessary.

INFICON RGA PRODUCTS

The INFICON family of Transpector® Residual Gas Analyzers meets the needs of the majority of applications found in a wide range of industries.

Open Ion Source: 100, 200, and 300 AMU sensors with Faraday Cup detectors or Electron Multipliers, depending on the operating pressures and detection limits required.

XPR "Extended Pressure Range": 100 AMU sensor primarily for process monitoring applications in the semiconductor market that have operating pressures up to 20 mTorr and require contamination detection down to 10 PPM. The XPR operates without external pumps (differential pumping).

Closed Ion Source (CPM): 100, 200, and 300 AMU sensors utilizing a high performance combination FC/EM detector for specialized applications and PPM / sub-PPM contamination monitoring. The closed ion source operates at a relatively high pressure, reducing the masking effects of background residuals, and allows sampling from atmosphere to high vacuum.

SOFTWARE

TWare 32™ is a Windows-based software package for Win 95, Win 98, Win NT, Win 2000, and Windows XP that interfaces INFICON RGA instruments to an external computer. From this computer, the user may study trends, examine spectra, perform calibrations, and initiate leak checking. A single computer can monitor one instrument via the RS232 interface, or multiple instruments through an RS485 network arrangement.

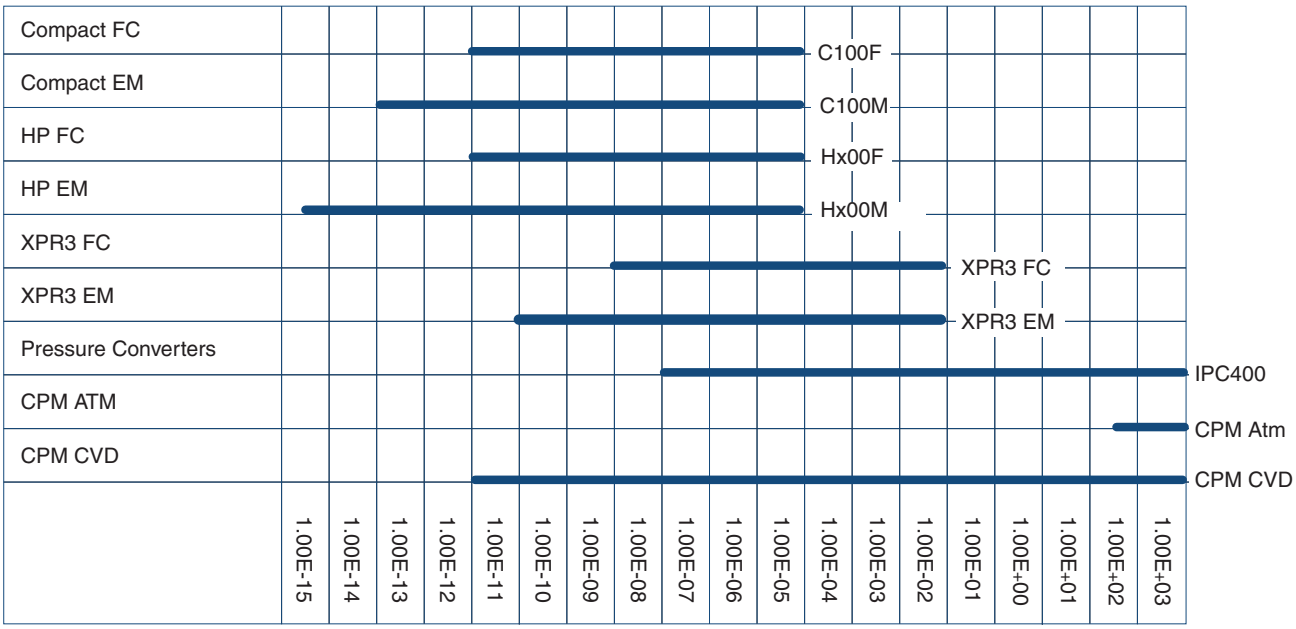
The **32-Bit DDE Driver** is a Dynamic Data Exchange application that interfaces with other Windows programs for the exchange of information. For example, the DDE driver can import RGA data to an Excel spreadsheet for further manipulation.

FabGuard™ software is used for semiconductor process monitoring applications where direct connection to the process tool is required. FabGuard is an integrated software system that interfaces with various sensors, including RGAs, and the tool itself for data correlation and analysis.

RECOMMENDATIONS

The process dictates the maximum benefit of using a particular RGA. With applications running from process monitoring to leak detection, there are a variety of products available to match every pressure range, mass range, and detection limit.

Note: Exact minimum detectable partial pressure (MDPP) is determined by inlet type, orifice, background gases, vacuum levels, process conditions, etc.



Process Pressure (Torr)

Instruments for Intelligent Control®

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