

# Mass Spectrometers

Quadrupole Mass Spectrometers



Process Mass Spectrometers



Service for Mass Spectrometers



## Quadrupole Mass Spectrometers

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## Quadrupole Mass Spectrometers

### Introduction

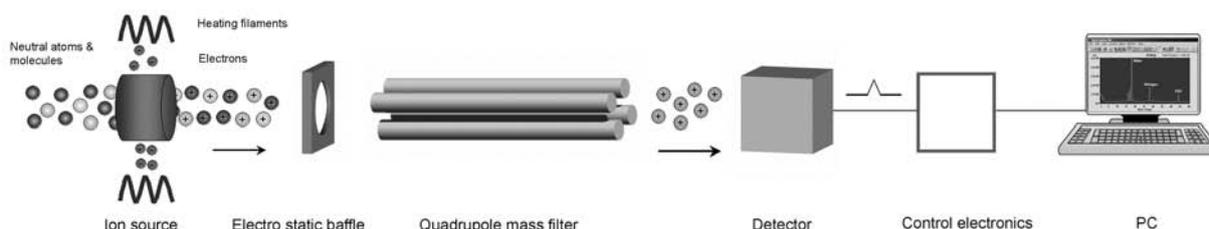
Gases and composite gases play a decisive role in many processes in research, development and production. CVD and plasma processes or the vacuum analysis of UHV systems are only a few examples. In order to monitor, control and optimise processes, it is necessary to analyse the composition of the gases. Very often Quadrupole Mass Spectrometers (QMS), proved as in various ways applicable analysers for process technology during the last decades, are used for this task. They were improved steadily over the years and can now be used easily offering a high efficiency.

VACOM offers Quadrupole Mass Spectrometers from AMETEK®, a leading American manufacturer of process analytics. The product series for qualitative and quantitative analysing within a mass range up to 300 amu consists of single devices as well as complete systems. The single devices of the DYCOR® series can be configured for various applications. Together with the ProLine Process Mass Spectrometer, we are able to offer optimal process analysing and controlling.

### Functional principle

Quadrupole Mass Spectrometers consist of four elements: the ion source, the mass filter, the detector and the control electronics.

The ion source ionises the gas particles forming detectable ion particles by electron bombardment. Usually one distinguishes between open and enclosed ion sources. The conductance limited ion source is a special form of enclosed ion sources. The differences between the various types are going to be explained later on. The ions are channelled by an electrostatic focus plate system and directed from the ion source to the mass filter after the ionising process.



The mass filter works according to the Quadrupole principle. A system consisting of 4 rods of stainless steel forms an electric quadrupole. A direct voltage as well as an alternating voltage are impressed on this rod system. These voltages are so specified that only ions with a certain mass-to-charge ratio can pass the mass filter. All the other ions are deflected. A vacuum of about  $10^{-4}$  mbar or better is needed that the ions can pass the mass filter. Otherwise the mean free path length of the particles is too short to reach the detector at the end of the quadrupole.

The ions that pass the mass filter are collected by the detector. Faraday cup or SEV detectors are commonly used. Each time an ion hits the detector a small current is created that is amplified and processed by the control electronics. The differences between the various kinds of detectors are going to be explained later on.

The control electronics supply the voltage for the ion source, the quadrupole system and the detector. In addition, the electronics receive the detector signal, amplify and process it, as mentioned above. A connected computer controls the measurements and displays the results.

## AMETEK® DYCOR® Quadrupole Mass Spectrometers

### Mechanical construction

DYCOR® QMS have a simple construction consisting of very few parts. The analyser head is installed on a DN40CF standard flange. The complete construction consisting of detector, mass filter and ion source is protected by a stainless steel tube with a DN40CF flange or - depending on the type - a DN40CF tee with a sidewise connection for a turbo pump. If the measuring heads are equipped with an open ion source, the source will not go in deeper into the vacuum system as a normal ionisation vacuum gauge. The enclosed ion sources are completely capsuled and have to be connected to a separate pumping system. The gas inlet is carried out with aligned pressure reduction (capillary manifold, baffles) through angle valve and bypass valves.

The parts of such a measuring head can be easily dismantled for maintenance and also just as easily be assembled again by the user his-/herself.

## AMETEK® DYCOR® Quadrupole Mass Spectrometers



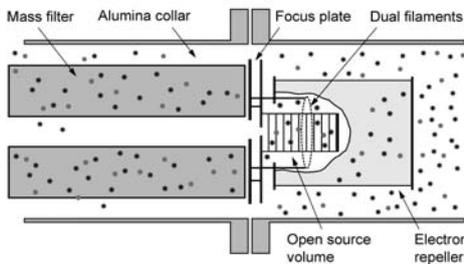
DYCOR® Quadrupole Mass Spectrometer with an Open Ion Source



DYCOR® Quadrupole Mass Spectrometer with an Enclosed Ion Source

### Ion Sources

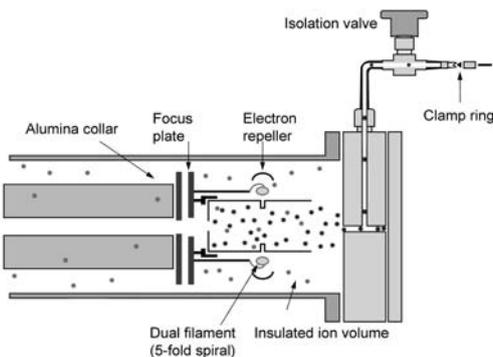
DYCOR-QMS can be built with 3 different types of ion sources, each of them is optimised for special applications:



#### Open Ion Source

The open ion source is the most basic and cost effective solution. Normally it is directly connected with the vacuum chamber. The ion source, the mass filter and the detector are surrounded by the same vacuum. This enables the following applications:

- Excellent for UHV applications and leak detection
- Applicable from UHV to  $10^{-4}$  mbar
- Simple design and construction reduce maintenance requirements
- Most inexpensive ioniser option
- Preferential applications: HV and UHV systems, MBE systems, ion implant systems, lock/transfer chambers



#### Enclosed Ion Source

The enclosed ion source is optimised for applications in rough and fine vacuum and for analyses of processes at atmospheric pressure or higher. Detector, mass filter and filaments of the ion source are separated from the ionising gas and evacuated separately. The ionisation room is connected to the process vacuum by baffles and capillary tubes only. This enables to analyse gases even under high inlet pressures. Important criteria for the application of this ion source are the following.

- Minimised influence of the residual gas analyser on the process gas ratio
- Minimised background interferences, because the filament is not placed directly in probe ionisation area
- Works in a wide spectrum of gas inlet pressures
- Less pumping speed required than for the conductance limited source
- Ideal for reactive gases
- No problems with hydrogen-containing gases
- Applications include: CVD, vacuum furnaces, fermentation processes, atmospheric sampling, process stream sampling, etching

#### Conductance Limited Ion Source

The conductance limited ion source is a special type of the enclosed ion source. It is optimised for high vacuum applications and non-reactive gases, where the ionisation room should be amplified by a high pressure. Therefore you need an additional faceplate which reduces the conductance and causes a higher gas density and ionisation chance in the ionisation room. A higher detection sensitivity is achieved therewith. The conductance limited ion source is not applicable to reactive gas mixtures.

- Increases the signal-to-noise ratio by 100 times over the open ion source
- Applications include: PVD, sputter processes, high purity gas analysis

## AMETEK® DYCOR® Quadrupole Mass Spectrometers

### Detectors

Faraday cup detectors, which enable partial pressure measurements from  $10^{-4}$  mbar to UHV, are standard for DYCOR® QMS. Detectors with secondary electron amplifiers (SEV or SEM) with which partial pressures up to  $5 \times 10^{-14}$  mbar can be detected, for example so-called channel plate detectors, have a higher sensibility and a faster scanning speed.

DYCOR® QMS with open ion source are optionally available with channel plate detectors. Devices with conductance limited or enclosed ion sources are equipped with both detectors as standard.

### Control Electronics

DYCOR® analyser heads and control electronics can be replaced among each other and therefore offer a maximum of flexibility. Special properties are:

- No need to match analyser head with electronics, integrated Auto-Tune capability
- Repeatable data due to electrometer-amplifier technology with zero-drift
- Optional installation of analogue/digital I/O cards for integration and monitoring of extern sensors (pressure, temperature etc.)
- LC-D: Ethernet interface, Dymaxion: RS232 and RS485 or Ethernet interfaces optional

### DYCOR® System 200/2000 Software

DYCOR® QMS are supplied with fully developed software packages for operation by Windows PC.

With the LC-D series comes DYCOR® SYSTEM 200 and with the DYMATION series the DYCOR® SYSTEM 2000. Both software packages use the advantages of Windows NT and XP and enable process monitoring in real time. Both of them have a multiplicity of user-optimised capacities:

- Clear, self-explanatory and user-friendly menu navigation
- Integrated simulation mode for user training and demonstration purposes
- 7 different measurement modes enable applied data acquisition and data presentation
- Individually combined on-screen displays can be simply generated and stored in a user-defined mode
- Auto-Tune option for a high-class and reproducible data acquisition; peak position and resolution can be optimised according to the particular devise and process conditions
- Detector head monitoring by dint of the Head status display mode
- Comfortable possibility for data conversion, processing (e.g. Excel)
- Dynamic data exchange DDE for real time data processing and process control
- Large spectral library for the identification of the spectra, user-specific expandable

### Additional Options Software DYCOR® System 2000

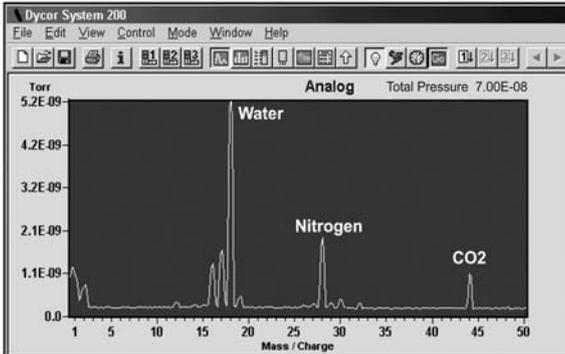
- Connection to serial interface RS232/485 (10/100 Base - T Ethernet option)
- Real time account with performance data and demonstration in the particular mode, data link among each other and with external input data
- Processing of analogue and digital input-/output signals (e.g. from external pressure sensor or temperature sensors) for process monitoring and control - optional
- Multi-Sensor software for acquisition, demonstration and combination of data from several RGA gauges and macro-coding to facilitate the process flow - optional

# Mass Spectrometers

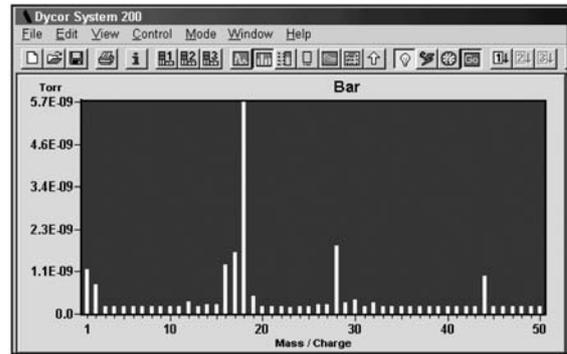
## AMETEK® DYCOR® Quadrupole Mass Spectrometers

### Display Modes DYCOR® SYSTEM 200/2000

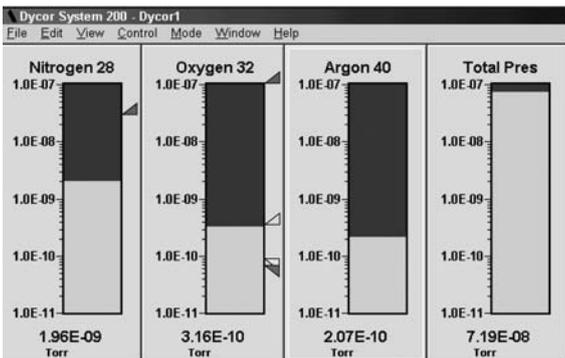
Analogue Mode



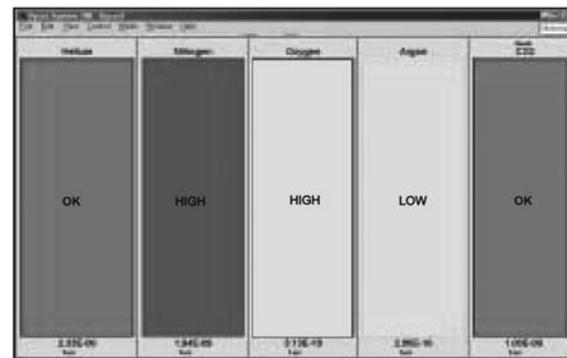
Histogram Mode



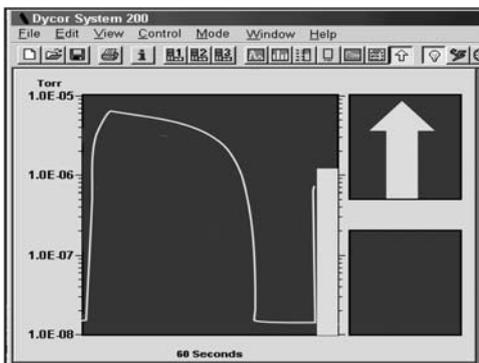
Meter Mode



Annunciator Mode



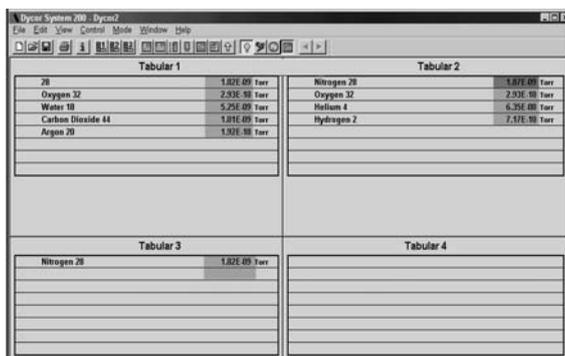
Leak Detection Mode



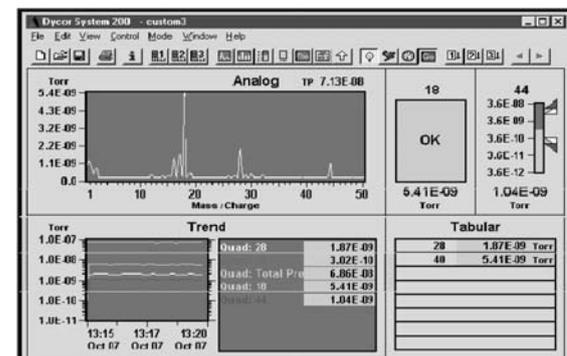
Trend Mode



Tabular Mode



Custom Mode



# Mass Spectrometers

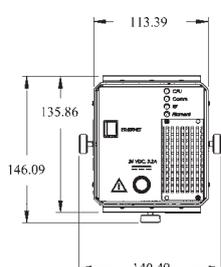
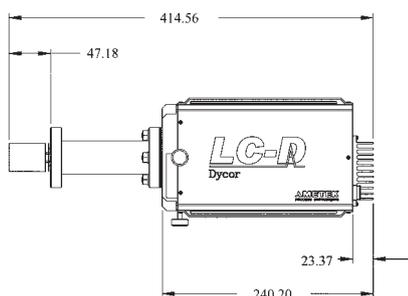
## AMETEK® DYCOR® Quadrupole Mass Spectrometers

### Display Modes DYCOR® SYSTEM 200/2000

Mode	Description
<b>Analogue or Histogram</b>	<ul style="list-style-type: none"><li>- Display of analogue or bar diagram for analysis of vacuum environments</li><li>- Scans covering a certain mass range</li><li>- Display of total pressure</li><li>- Cursor position provides display of possible molecules or molecule fragments</li><li>- Display of customised descriptions in diagrams</li></ul>
<b>Meter</b>	<ul style="list-style-type: none"><li>- Display of the current total pressure and customer defined partial pressures of individual mass numbers on separate charts</li><li>- Kind of gas, mass number and limits are displayed</li></ul>
<b>Annunciator</b>	<ul style="list-style-type: none"><li>- Status report of the vacuum system via differently coloured display panels</li><li>- Information whether selected partial pressures are within a defined pressure range</li></ul>
<b>Leak detection</b>	<ul style="list-style-type: none"><li>- Pressure vs. time diagram of partial pressures of the gas used for leak detection (usually He)</li><li>- Arrow display (increasing/decreasing) for trend indication</li></ul>
<b>Trend</b>	<ul style="list-style-type: none"><li>- Pressure vs. time diagram of one or more selected masses, total pressure or external input data</li><li>- All values are recallable by DYCOR software or data conversion, e.g. into Excel</li></ul>
<b>Tabular</b>	<ul style="list-style-type: none"><li>- Tabular list of current partial pressures of selected masses, also useable for further with DDE in real time</li></ul>
<b>Custom</b>	<ul style="list-style-type: none"><li>- Customised display consisting of arbitrary combinations of standard displays</li></ul>

## DYCOR® LC-D Series

Capable Quadrupole Mass Spectrometers for analysing residual gases and processes in the range up to 300 amu.



- Easy and comfortable handling
- Excellent cost performance ratio
- Open ion sources
- Faraday cup detector
- Channel plate electron multiplier (SEV) optional
- Comfortable software package
- Ethernet interface

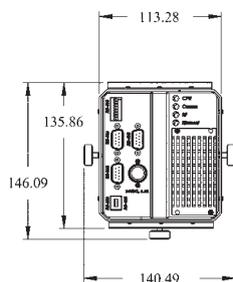
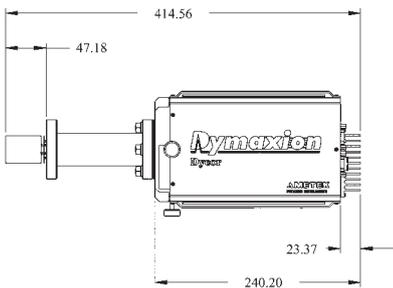
### Technical data

- Mass range
  - 1-100 amu standard,
  - 1-200 or 1-300 amu optional
- Operating pressure range
  - 10<sup>-4</sup> mbar to UHV
- Minimum detectable partial pressure
  - 5 x 10<sup>-12</sup> mbar with Faraday cup
  - 5 x 10<sup>-14</sup> mbar with SEV
- Mass resolution
  - adjustable to constant peak width (0.5 amu at 10 % height)
- Emission current
  - 0.1 mA to 10 mA;
  - 50 mA at degas
- Electron energy
  - 30 eV to 150 eV at normal operation;
  - 200 eV at degas
- Ion energy
  - 1 eV to 10 eV
- Ion source sensitivity
  - 2 x 10<sup>-4</sup> A / Torr at detector (measured with nitrogen at mass 28) with peak width = 0.5 amu at 10 % height and 1 mA emission current standard: iridium, thoria coated, optional: tungsten analyser (without electronics) 375 °C
- Filament, bipartite
- Max. bakeout temperature
  - 24 V DC at 3 A
- Operating voltage
- Stability
  - Mass stability ±0.1 amu after 30 min. warm-up
  - Peak height ±2 % after 30 min. warm-up
- Control software
  - DYCOR® SYSTEM 200
- Minimum PC requirements
  - Pentium or compatible, 60 MHz, Windows 95/98/2000, NT or XP
- Serial interface
  - 10/100BASE-T Ethernet, RJ-45 socket
- Weight
  - 3.4 kg (control electronics and measuring head), 2.1 kg (control electronics)

Order code	Description
LC-D100	DYCOR® LC-D QMS, 1 - 100 amu, open ion source, Faraday cup detector, software DYCOR® SYSTEM 200
LC-D200	DYCOR® LC-D QMS, 1 - 200 amu, open ion source, Faraday cup detector, software DYCOR® SYSTEM 200
LC-D300	DYCOR® LC-D QMS, 1 - 300 amu, open ion source, Faraday cup detector, software DYCOR® SYSTEM 200
LC-100M	DYCOR® LC-D QMS, 1 - 100 amu, open ion source, Faraday cup detector and SEV, software DYCOR® SYSTEM 200
LC-D200M	DYCOR® LC-D QMS, 1 - 200 amu, open ion source, Faraday cup detector and SEV, software DYCOR® SYSTEM 200
LC-D300M	DYCOR® LC-D QMS, 1 - 300 amu, open ion source, Faraday cup detector and SEV, software DYCOR® SYSTEM 200
PS-24VDC	Power supply for DYCOR® QMS, 110/240 V AC - 24 V DC, including connecting cable

## DYCOR® Dymaxion Series

Capable Quadrupole Mass Spectrometers for analysing residual gases and processes in the range up to 300 amu.



- Easy and comfortable handling
- Individually configurable
- 3 ion source types - open, conductance limited or enclosed
- Faraday cup detector - standard
- Channel plated detector (SEV) - optional
- Serial interface
- Comprehensive software package
- Integration of external signals - optional
- Optional gas inlet systems for process control from UHV to overpressure

### Technical data

- Mass range 1-100, 1-200, 1-300 amu
- Operating pressure range
  - Open ion source 10<sup>-4</sup> mbar to UHV
  - Conductance limited Atm./overpressure to UHV (with aligned pressure reduction system)
  - Enclosed ion source
- Minimum detectable partial pressure
  - 5 x 10<sup>-12</sup> mbar with Faraday cup
  - 5 x 10<sup>-14</sup> mbar with SEV
- Mass resolution adjustable to constant peak width (0.5 amu at 10 % height)
- Emission current 0.1 mA to 10 mA; 50 mA to degas
- Electron energy 30 eV to 150 eV to operate; 200 eV to degas
- Ion energy 1 eV to 10 eV
- Ion source sensitivity (Faraday cup detector) 2 x 10<sup>-4</sup> A / Torr at detector (measured with nitrogen at mass 28) with peak width = 0.5 amu at 10 % height and 1 mA emission current
- Filament, bipartite Standard: iridium, thoria coated, optional: tungsten
- Max. bakeout temperature analyser (without electric device) 375 °C
- Operating voltage 24 V DC at 3 A
- Stability
  - Mass stability ±0.1 amu after 30 min. warm-up
  - Peak height ±2 % after 30 min. warm-up
- Control software DYCOR® SYSTEM 2000
- Minimum PC requirements Pentium or compatible, operating system Windows 95/98/2000, NT or XP
- Serial interface RS232 and RS485, isolated, baud rate 1200 to 38400, 9 pin Sub-D connector
- Analogue / Digital I/O Board (optional)
  - 2 x analogue input
  - 2 x analogue output
  - 6 x relay contact
  - 4 x digital inputs (TTL)
- Ethernet interface optional
- Data connection of several mass spectrometers optional (with Multi-Sensor software)
- Weight 3.4 kg (control electronics and head), 2.1 kg (control electronics)

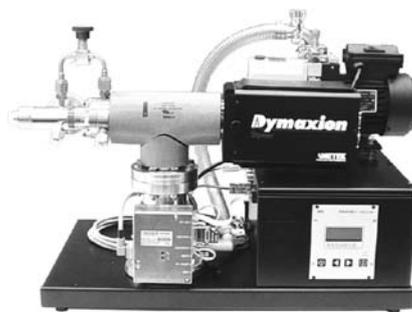
## DYCOR® Dymaxion Series

Order Code	Description
<b>DM100S</b>	DYCOR® DYMAXION QMS, 1 - 100 amu, open ion source, Faraday cup detector, Software DYCOR® SYSTEM 2000
<b>DM200S</b>	DYCOR® DYMAXION QMS, 1 - 200 amu, open ion source, Faraday cup detector, Software DYCOR® SYSTEM 2000
<b>DM300S</b>	DYCOR® DYMAXION QMS, 1 - 300 amu, open ion source, Faraday cup detector, Software DYCOR® SYSTEM 2000
<b>DM100MS</b>	DYCOR® DYMAXION QMS, 1 - 100 amu, open ion source, Faraday cup detector and SEV, Software DYCOR® SYSTEM 2000
<b>DM200MS</b>	DYCOR® DYMAXION QMS, 1 - 100 amu, open ion source, Faraday cup detector and SEV, Software DYCOR® SYSTEM 2000
<b>DM300MS</b>	DYCOR® DYMAXION QMS, 1 - 300 amu, open ion source, Faraday cup detector and SEV, Software DYCOR® SYSTEM 2000
<b>DMC100MS</b>	DYCOR® DYMAXION QMS, 1 - 100 amu, conductance limited ion source, Faraday cup detector and SEV, Software DYCOR® SYSTEM 2000
<b>DMC200MS</b>	DYCOR® DYMAXION QMS, 1 - 100 amu, conductance limited ion source, Faraday cup detector and SEV, Software DYCOR® SYSTEM 2000
<b>DMC300MS</b>	DYCOR® DYMAXION QMS, 1 - 300 amu, conductance limited ion source, Faraday-Cup-Detector and SEV, Software DYCOR® SYSTEM 2000
<b>DME100MS</b>	DYCOR® DYMAXION QMS, 1 - 100 amu, enclosed ion source, Faraday cup detector and SEV, Software DYCOR® SYSTEM 2000
<b>DME200MS</b>	DYCOR® DYMAXION QMS, 1 - 200 amu, enclosed ion source, Faraday cup detector and SEV, Software DYCOR® SYSTEM 2000
<b>DME300MS</b>	DYCOR® DYMAXION QMS, 1 - 300 amu, enclosed ion source, Faraday cup detector and SEV, Software DYCOR® SYSTEM 2000
<b>PS-24VDC</b>	Power Supply for DYCOR® QMS, 110/240 V AC - 24 V DC, including connecting cable
<b>DYSIGNAL</b>	I/O Board for extern signal and process control

DYCOR® DYMAXION QMS with conductance limited or enclosed ion sources work only in combination with an extra pressure reduction system. Further information about this subject can be requested.



Pressure Reduction System



Configuration Example: tabletop unit with pressure reduction system and pump station.

## ProLine™ Process Mass Spectrometers

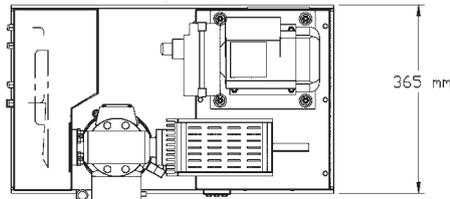
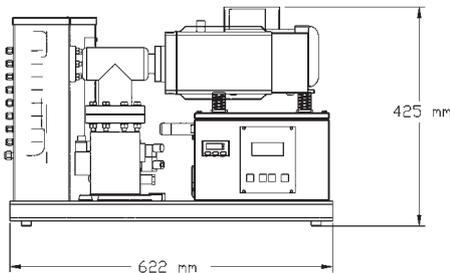


Process Mass Spectrometers for qualitative and quantitative analysis of composite gases in real-time for various applications, as follows:

- Fermentation/bioreactor off-gas analysis
- Fuel cell research and development
- Catalytic reactions
- Thermodesorption spectrometry TDS
- Semiconductor process exhaust gas monitoring
- Analysis of high purity gases
- Pharmaceutical solvent drying
- Synthesis gas

AMETEK® ProLine™ Process Mass Spectrometers are complete systems consisting of the following main parts

- Quadrupole measuring head with enclosed ion source
- Gas inlet system with up to 16 sample ports
- Integrated high vacuum pumping station
- Software package Process 2000 for real-time control and quantitative analysis



### Technical data

- |                                  |   |
|----------------------------------|---|
| ■ Ion source                     | enclosed  |
| ■ Detector                       | Faraday cup (SEV optional)  |
| ■ Mass range                     | standard: 1 - 100 amu,<br>optional: 1- 200 amu, 1 - 300 amu   |
| ■ Signal height variation        | ±2 % within 12 hours  |
| ■ Detection range                | from 1 ppm to 100 %   |
| ■ Multi-channel gas inlet system | 8 or 16 electronically controlled valves<br>for sample and calibration gases<br>- gas transportation system<br>- heated piping system |
| Options                          |   |
| ■ Inlet pressure                 | 0 - 1.4 bar relative  |
| ■ Gas connection                 | 1/8" stainless steel compression fitting  |
| ■ Operating voltage              | 100 - 230 VAC, 50/60 Hz, 500 VA   |
| ■ Ambient temperature            | 0 - 40 °C   |
| ■ Humidity                       | 10 % to 90 % relative, non condensing   |
| ■ Serial interface               | RS232 / RS485, isolated<br>1200 to 38400 baud<br>9 pin Sub-D connector  |
| ■ Software                       | Process 2000  |
| ■ Minimum PC requirements        | Pentium or compatible, operating system<br>Windows 95/98/2000, NT or XP   |
| ■ Dimensions                     | W 37 cm x L 61 cm x H 40 cm   |
| ■ Weight                         | 36 kg   |

Single components and assemblies like filaments, ionisation units, analysers, electronics units, heater bands and pressure reduction equipment offered on request.

## Service for Mass Spectrometers - RGA Service

VACOM has an own qualified RGA service department with comprehensive technical expertise.

- Qualified outgassing measurement - quantitative und qualitative residual gas analysis
- RGA measurement up to  $2 \times 10^{-14}$  mbar partial pressure and mass number 200 amu
- Characterisation of the outgassing behaviour of vacuum components - from small samples up to vacuum chambers
- Residual gas analysis with controlled probe heating
- Detection of the reasons for pressure increase in vacuum systems
- Residual gas analysis and leak detection, also on-site-service at the customer
- Training in operation of mass spectrometers - different instruments for demonstration purposes available
- Technical advice
- Maintenance and repair
- Wear parts like filaments, complete ionisation units, and selected circuit boards for DYCOR LC-D and DYCOR Dymaxion on stock

We are pleased to give detailed information on request.

