

The Extrel® MAX300™ series of quadrupole mass spectrometers is the economical High Performance solution for PAT in fermentation control applications.

The Extrel CMS MAX300 series of quadrupole mass spectrometers is an ideal Process Analytical Technology (PAT) solution for monitoring bioprocess reactions. The Extrel MAX300's ability to monitor multiple components in multiple streams, speed of response, parts per billion (ppb) detection limit and flexible analysis will help you improve your fermentation control. The performance benefits include:

- **Reduced Cycle Time:** The Extrel MAX300 can analyze one component in approximately 400 milliseconds. This equates to one full sample analysis in less than 10 seconds. This speed of response enables you to monitor dozens of bioreactors with one analyzer.
- **Improved Yields:** The continuous monitoring of the bioreaction process gives the operator a full understanding of the health of the culture and the efficiency of the process. The analysis accuracy provided by the Extrel MAX300 allows the calculation of the Respiratory Quotient to within a standard deviation of 0.007.
- **Reduced Waste:** The Extrel MAX300 has a dynamic range of 100% down to 10 ppb. Many fermentation process problems are indicated by the presence of part per million (ppm) level components. Monitoring for these components will enable you to quickly adjust the process without comprising the batch quality.

Typical Analysis Information

The Extrel MAX300 is used to provide full, fast and precise analysis of the incoming air and the off-gas from the Fermenter. A typical Fermenter exhaust gas composition is shown in Figure 1 along with the expected Relative Standard Deviations, RSD(F), for each component.

The analysis of oxygen and carbon dioxide, along with the analysis of inerts, is used to calculate the Respiratory Quotient (RQ), a major parameter in controlling the growth and health of the bacteria. Based upon the expected analysis performance RSD(F), of the Extrel MAX300, it is expected that the RQ can be calculated to within a standard deviation of 0.007.

The additional analysis of minor ppm/ppb level concentrations of by-products such as formaldehyde, methanol, acetic acid or ammonia allow for rapid process adjustment to avoid undesired reactions and batch

quality problems. Figure 2 shows an analysis trend of fermentation head-space data, including formaldehyde, obtained via a MAX300 with Questor 5 software. The standard deviation of the analysis data, as calculated by the trending program, is displayed for each component.

Name	Estimated Concentration (%)	Sensitivity	Detection Mass	RIF	RSD (F)	RSD (M)
Nitrogen	70.00	1.000	28	< 0.01	0.0366	–
Formaldehyde	0.10	1.000	29	5.251	2.4208	–
Oxygen	20.00	.980	32	< 0.01	0.0692	–
Argon	0.93	1.500	40	< 0.01	0.2592	–
Carbon Dioxide	0.05	1.860	44	< 0.01	1.004	–
Water	0.50	.800	18	< 0.01	0.4841	–

Figure 1: Typical Fermenter Analysis Method

FERMENTATION CONTROL

Application Background

With the advancement of PAT and a focus on process improvement and efficiency, there has been an increasing industry demand for accurate and quantifiable low level analysis.

In most fermentation processes, the desired metabolic changes take place in a narrow environmental range. Tight control of parameters such as: temperature, aeration rate (dissolved oxygen) and pH is essential to achieve maximum yield and product quality. Computerized process control in the fermentation industry becomes a necessity in order to minimize production costs and maintain product quality. Only a fast analyzer like a mass spectrometer can achieve the short analysis times required to optimize the fermentation process and still maintain a high quality measurement.

The Extrel MAX300 quadrupole mass spectrometer is the economical alternative to multiple infrared and oxygen analyzers installed on the top of each Fermenter. Extrel offers various inlet solutions to meet your sampling needs including the Extrel FASTValve, an 80-port high flow rotary valve.

Key Application Facts

- The Dual Faraday and Electron Multiplier Detector and its Autoranging capabilities enable the MAX300 to achieve a continuous dynamic range of 100% down to 10 ppb.
- With a typical analysis cycle < 10 seconds/stream, the MAX300 is capable of monitoring 80 sample points in less than 15 minutes when equipped with the Extrel FASTValve, an 80 port high flow rotary valve.
- Extrel's Questor 5 web-based user interface has the capabilities to meet 21 CFR Part 11 requirements.
- The Extrel MAX300 supports a variety of industry standard communications including ethernet, Bi-directional MODBUS, MODBUS RTU or TCP/IP, OPC and analog communication protocols.

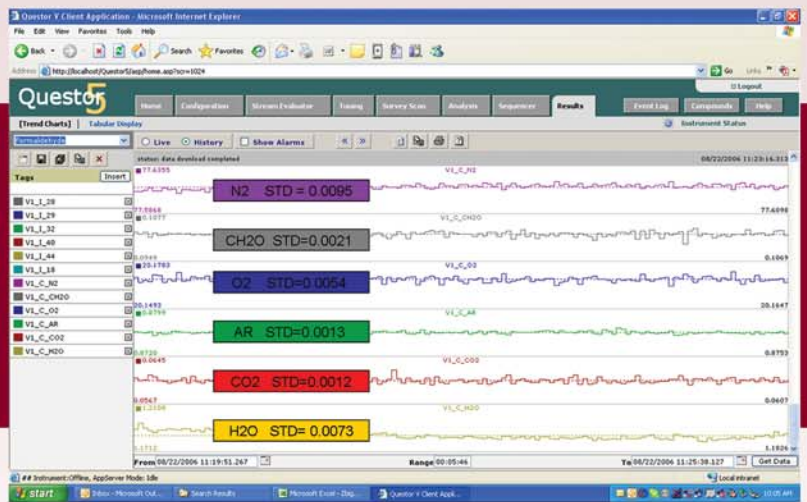
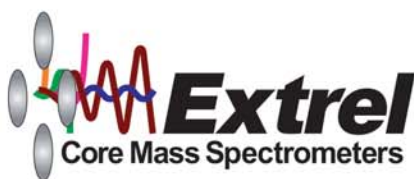


Figure 2: Fermentation Data Trend with Standard Deviations (STD)



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