Dr. Marino Müller AG
Process Control Instrumentation

System Specification TUW-2015.08-TP-02A

Gas Analysis System
For the Measurement of O2 and CO2 in a Group of Biotechnology Fermenters

1) Problem Statement

1.1 Context and Nature of Measurement Problem

The Technische Universität in Wien is installing a number of fermenters whose exhaust air shall be measured for its contents of Oxygen and Carbon dioxide.

1.2 Installation Site

Fermenters and Analysis Equipment will be installed inside a building, and therefore be protected from extremes of temperature, rain and sunshine.

The installation site is classified as a non-hazardous area.

1.3 Services Provided

Electric energy is available at 230/400V 50 Hz.

Calibration Gases will be available from cylinders.

Cooling water can be made available if required.

1.4 Vents and Drains

Analysed gases can be released to atmosphere or removed via a suitable vent. Condensate can be removed to a suitable sink.

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1.5 Sample Gas

The sample gas coming from the fermenters is mainly composed of air / oxygen and Carbon dioxide. Oxygen and CO2 shall be measured.

Other gases are not present in concentrations likely to interfere with the O2 and CO2 measurement.

The sample gas is available at the end of a heated line from the fermenter, after a sterile filter. The gas is available at a pressure of approx 200 hPa, so a pump will not be required. The gas will be saturated with water vapour at the operating temperature of the fermenters, which is about 40°C.

Dust loading of the gas is expected to be minimal.

1.6 Output Signals Required

Output signals shall be provided for the O2 and CO2 levels as
4 ... 20 mA analogue signals. These shall generally be scaled as follows:

0...25 % O2	4 ... 20 mA
0...10 % CO2	4 ... 20 mA.

In the case of the oxygen measurement, the measurement range is user selectable and a suppressed zero may be desirable, i.e 16 ... 21% O2.

1.7 Special Requirements

The entire fermenter plant will be controlled by a Lab view synthetic instrument installation provided by the operator. The analysis equipment shall also be controlled by the Lab view program. This will govern which fermenters are measured when, what dwell times shall be applied, sequence of measurements etc. The analysis equipment shall provide the necessary control interfaces. The analysis equipment shall provide measurements of high accuracy and long- term stability.

A manual override will be provided to control reactor assignment without Lab View, for test purposes or backup of an automatic system. LED's, on the terminal strip will indicate the activated solenoid valves.

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2) Proposal

2.1 General

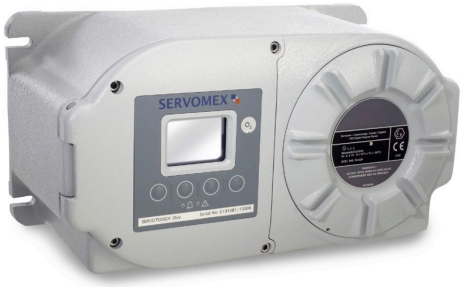
To meet these requirements, an analysis cabinet is proposed, housing a Servomex Servotough 1910 Oxy Analyser and one Servomex 2500 Infrared Analyser, for CO2 with suitable sample preparation as discussed below.

In view of the accuracy and stability requirements, a “wet” system is proposed which would measure the fermenter headspace conditions without first removing one sample constituent - water. Since the water content is not precisely known, removal of water changes the gas composition considerably and not always in a predictable manner. Therefore a wet system is proposed, similar in concept to the systems already in use at the Technische Universität in Wien.

This concept requires that the sample gas is ducted to the analyser cabinet by a heat traced line, and kept at a temperature well above the dew point (assumed to be 40°C) until after the gas has passed through the analysers. The oxygen analyser is heated to 60°C, the infrared analysers have a heated sample cell which can be heated to any temperature between 30 and 130°C.

2.2 Analytical Instrumentation

The Oxygen analyser is the new Servomex Servothough 1910 Oxy, which follows the successful Servomex 2200 Series oxygen analysers. The Servomex Servothough Oxy employs the magnetomechanical measurement cell, which Servomex has perfected and of which well over 100’000 units have been produced to date.



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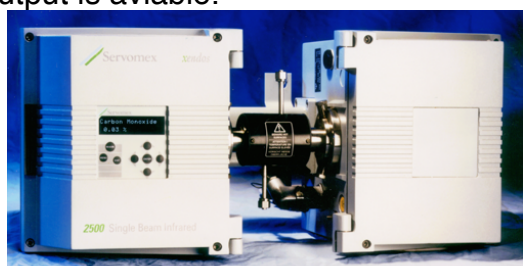
The Model 2500 infrared analyser employs the “single tube - two wavelength” principle. The 2500 is microprocessor controlled and permits automatic calibration. In the current 2500D also an Modbus output is aviable.



Both the Oxygen and the CO2 analysers will be pressure compensated to eliminate errors due to changing ambient pressure conditions. - The pressure compensation in the Servomex Servothough Oxy Analyser reduces the effects of ambient pressure changes by a factor of 256.

The present design provides for the sequential or randomly sequenced analysis of up to 4 fermenters. The exact sequencing function is determined by the Lab view system. Stream selection is by Lab view-controlled solenoid valves, which - together with flow meters, foam deviation valves and a Stop-Eau device are housed in a heated box inside the analysis cabinet.

In view of the short line length between the fermenters and the Gas Analysis System, a preflush of the lines not currently measured is not considered necessary.

2.3 Output Signals

The oxygen analyser will provide a 4...20 mA signal for the oxygen content of the sample gas. In addition, 4 alarm relays are available which can be assigned to the following status signals:

- Concentration alarm
- Automatic calibration failed
- Automatic calibration in progress
- Instrument failure

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Similarly, there are 3 status relays in the 2500 infrared analyser, which can be assigned as follows:

- Concentration alarm
- Automatic calibration in progress
- Instrument failure

The 2500 provides - in addition to the standard 4 ... 20 mA signal - a second analogue signal which can be scaled differently from the first and so enables some fine-grain analysis of certain data.

2.4 Sample Preparation

The sample gas remains hot and wet and is filtered 5μ. In normal operation no condensation occurs. In the case that condensation occurs, a moisture detector will lead the gas to a bypass to prevent analyser failure.

2.5 Calibration

Calibration of both analysers can be done manually or automatic. In the automatic mode, calibration can be initiated either by an internal clock in regular, programmable intervals, or by external command. In a process environment, the latter method is generally to be preferred. The command is the momentary closure of a contact. Autocal takes typically 5 minutes to perform (per analyser).

Calibration Gases required will be

- Nitrogen 48 or 50 for zero in both analysers,
- “Controlled Air” (=dry) for span of the oxygen analyser,
- 10% CO2 for span of the CO2-analyser.

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2.6 System Design

2.6.1 Mechanical Construction

The Analyser System Housing will be housed in Rittal cabinet, 1800 mm high and 600 mm deep. A 100 mm plinth can be provided on request. The width of the cabinet is 1200 mm.

Inside the cabinet will be the two analysers, a hot box containing the multiplexer and flow control. Flow meter settings can be made through covered openings in the glass window on the hotbox.

Also included will be three precision pressure reducers to provide the 50 ... 100 hPa pressure of the calibration gases. Input to these would be from cylinders fitted with standard regulators providing 2 ...3 bars, or - if available - from a instrument air distribution system. (This method is more economical than using expensive precision regulators, such as Alphagaz, on the cylinders.) Maximum input pressure to these regulators is 8 bar.

2.6.2 Chemical Compatibility and Choice of Materials

The sample gas is compatible with the use of stainless steel for pipe work and Viton for seals, as no corrosive elements are present. Gas connections will be made to Swagelok bulkhead feedthroughs can be on either site of the instrument cabinet, need to be affirmed at time of order. Heated lines shall be extended to the wall of the heat box.

Internal pipe work in the cabinet will be of stainless steel or Teflon tubing.

2.6.3 Hazardous Areas Provisions

The site at which the analyser system is to be used is a non-hazardous area. No special precautions are therefore required in this regard. It should be mentioned however that both analysers in a slightly different version are approved - without need for supplementary protection measures such as purging - for the use in hazardous areas Zone 2 IIC T3, which may be of interest in a future application.

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2.6.4 Cable Connections

Interface to the external equipment will be at a terminal strip inside the analysis cabinet, which will terminate all incoming cables. A cable plan detailing connections will be provided.

Cable entry will be through cable glands and can be on either side of the instrument cabinet, need to be affirmed at time of order.

3) Scope of Delivery

The instrument cabinet will be supplied complete for connection to the Lab view system and to the fermenters. Heat traced lines to the fermenters are not included since lengths are not known.

4) References

Please find attached a Reference List.

Egg ZH, 18.11.2015 Dr. Marino Mueller AG

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