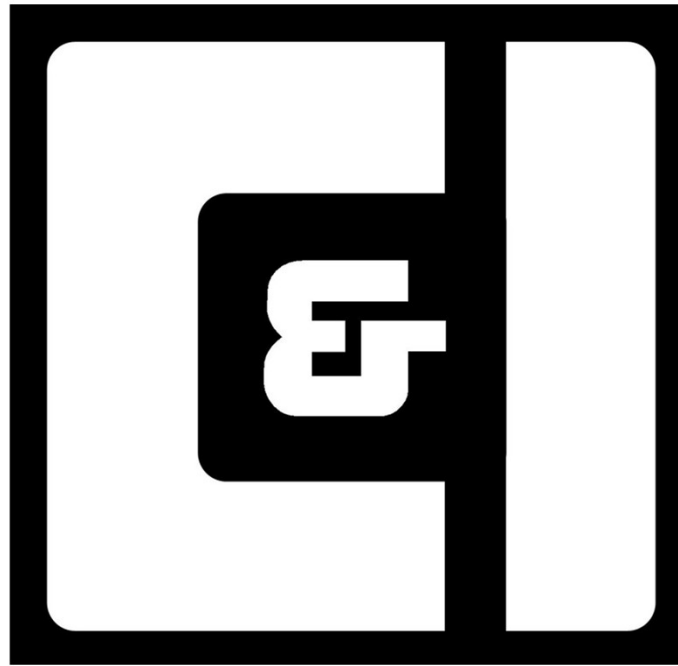




**Controls and Instrumentation Ltd**

Independent Gas Analysis Specialists

| CEMS | Syngas | Process |

# **FTiR based CEMS**



# **What are CEMS?**



# What are CEMS?

## Continuous Emission Monitoring System

**Continuous** – Must be in operation whenever the plant is in operation (with a couple of exceptions).

**Emission** – Gases, Particulates (dust) + temperature, pressure, water content, flow rate

**Monitoring** – data must be recorded, presented & reported to suit the operator and the regulator.



# Why do we need CEMS?

## Clean Air Act 1956

The Clean Air Act 1956 was an Act of the Parliament of the United Kingdom enacted principally in response to London 's Great Smog of 1952.

The act was brought in following the 1952 London Great Smog disaster that claimed up to 12,000 lives.

Even today UK air pollution is estimated to cause 36,000 deaths each year.

The Clean Air Act is still in force today, alongside the Environment Act 2021.



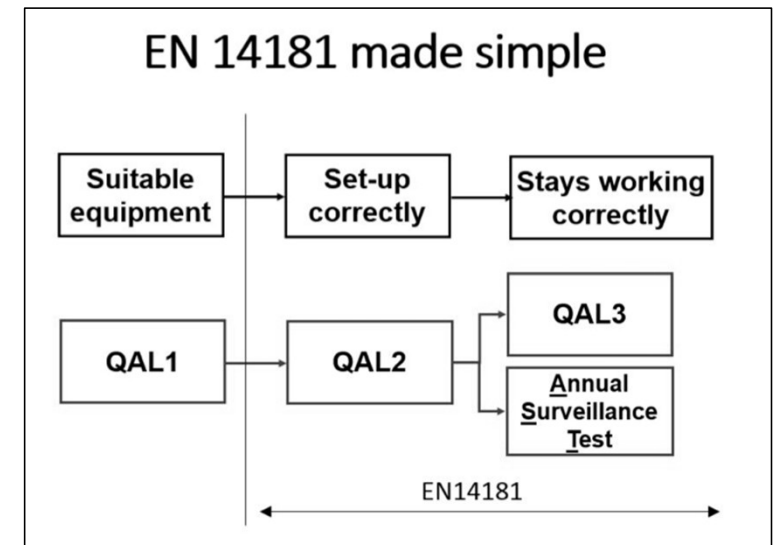
# Legislation

## Industrial Emissions Directive (IED) 2010/75/EU

CEM systems serve to provide compliance to IED. In particular the Medium & Large Combustion Plant Directives (MCPD, LCPD) and Waste Incineration Directive (WID). This is implemented through Environmental Permitting (England and Wales) Regulations 2016.

## EN 14181

Covers quality assurance of AMS, which includes CEMS. This is the legislation that most plant personnel will come in to contact with. QAL1, QAL2, QAL3 and AST.



# Legislation

## EN 14181

The responsibilities of operators under EN 14181 are:

- using CEMS certified to the appropriate MCERTS performance standards
- performing the QAL3 procedures
- making sure that the functional tests take place before each QAL2 and AST
- submission to us, when required, of information and reports on QAL2, QAL3 and ASTs
- applying a procedure for QAL3
- retaining reports and other records related to EN 14181 for periods specified by us.

Operators have overall responsibility for complying with EN 14181. Test laboratories must carry out the activities specified in QAL2 and the AST.

However, CEMS suppliers, operators or test laboratories may perform the functional tests specified in QAL2 and the AST.



# Legislation

## EN 14181 – QAL1 (MCERTS within UK)

Certification showing the equipment complies with IED & MCERTS criteria.

Accurate

Correct measurement technique

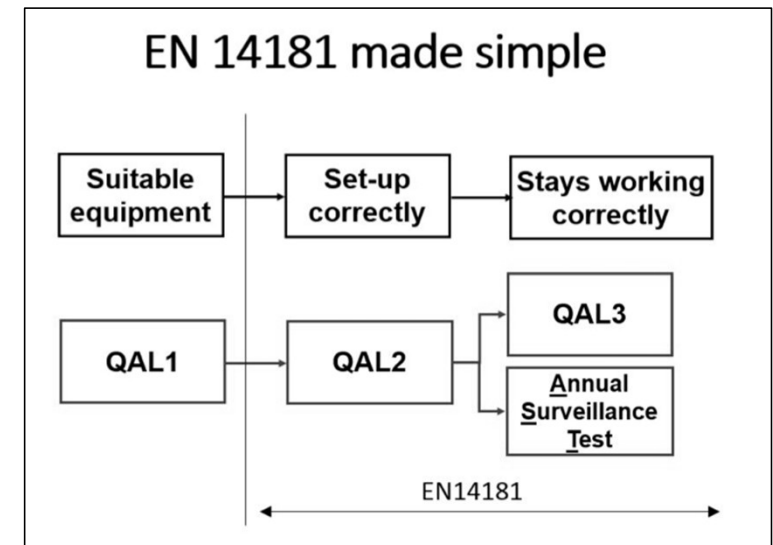
Low drift

Little interference from pressure, temperature, voltage, etc

Valid for 5 years – usually renewed without retesting if analyser design hasn't changed.

Certificate applies to all instruments made to that design.

Provided a QAL1 Cert is in place when commissioned, should the certification lapse, the system remains compliant.



# Legislation

## EN 14181 – QAL2

Testing of the installed system against the standard reference method (SRM) for the given measurand

Three day test per stream (one report per system)

If measurements match (with given tolerance) QAL2 Calibration function produced for each measurand

Must be carried out at least every 5 years

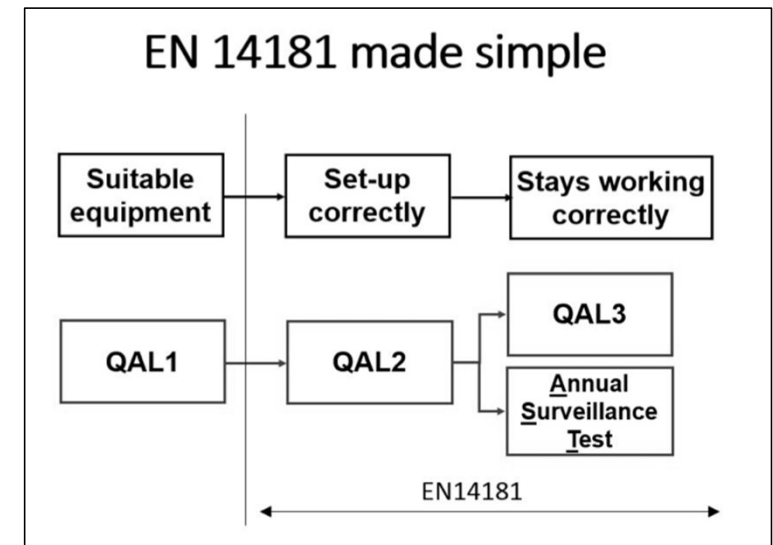
## EN 14181 – AST

AST – Annual check that QAL2 is still valid. Failure of AST initiates a new QAL2

One day test

### QAL2 requirements

Following CEMS failures, all investigations repairs and re-testing must be completed within 6 months.



# Legislation

## EN 14181 – QAL3

Regular check that the system is not drifting out of specification.

Each applicable measurand must be 'zero' tested and 'span' tested

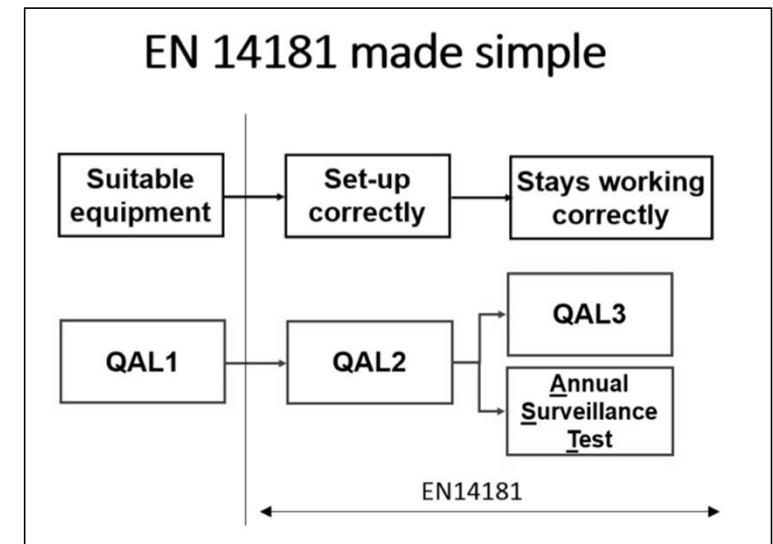
This is a calibration check, not a calibration

Results are plotted on to a Shewhart Chart to highlight drift

CDAS has selectable pass/fail criteria built in

Measurement result is checked against  $S_{AMS}$  value

$S_{AMS}$  - Standard Deviation of Automated Measuring System)



# Legislation

## Guidance

The Environment Agency (England), Natural Resource Wales, SEPA (Scotland) and NIEA (Northern Ireland) produce Technical Guidance Notes to assist with the application of the various directives, standards and norms that must be adhered to. These documents provide plain English assistance and examples of how the legislation should be applied.

TGN M1 – Sampling requirements for stack emission monitoring

TGN M2 – Monitoring of stack emissions to air

TGN M20 - Quality assurance of continuous emission monitoring systems

These used to be available as downloadable/printable PDF files. Unfortunately, they now exist as web pages, making it more difficult to keep a copy on hand for reference.



# System Requirements

## **Compressed Air -**

Instrumentation quality

VOC (oil) free

<-20°C or better dew point

## **Power supply -**

Constant

Stable

## **Compressed gases (calibration gases) -**

Certified (EN ISO/IEC 17025\*)

- Only relevant to single mixture in N<sub>2</sub>
- Gas mixtures, if used, should be certified to at least 2% of range at 95% confidence

## **Fuel gas (FID Fuel) -**

- H<sub>2</sub>/He Mix



# Choosing CEMS

## How to select CEMS

The following applies when selecting CEMS:

- the CEMS must be MCERTS certified for the measurands specified in the permit that require continuous monitoring
- the CEMS must be MCERTS certified for a range that is suitable for the application
- site and stack conditions do not reduce the performance of the CEMS to below the required standard
- the intended CEMS is proven on comparable installations
- all CEMS must have provisions to do zero, span and linearity tests after installation of the CEMS
- extractive CEMS must have the means for leak and response time checks, such as the provisions for applying test gases at the sampling probe



# Choosing CEMS

## **Location of the CEMS**

Operators must follow the provisions for location and access described in EN 15259, Stationary source emissions – Requirements for the measurement sections and sites and for the measurement objective, plan, and report.

This enables them to determine the most representative location for the CEMS, according to the homogeneity test described in EN 15259. Operators must locate CEMS at a point where there is safe access and other provisions for the effective and continued operation of the CEMS, and where samples are representative of the emission.

The laboratory must assess the homogeneity of the stack before they carry out the QAL2. A homogeneity test involves taking grid measurements of the stack gas at centres of equal area across the sampling plane and comparing the results to a fixed reference point within the sampling plane. Additionally, locate the SRM and the CEMS (or its sampling location) so that they do not interfere with each other.

EN 15259 describes the requirements for locating sample ports used for the SRMs.



# Management system requirements

EN 14181 requires operators to have a systematic approach to managing and maintaining the CEMS, documented through procedures within an existing management system, such as those meeting the requirements of EN ISO 9001 Quality management systems – Requirements.

Procedures should include specific provisions for CEMS covering:

selection

maintenance and servicing

responsibilities and training of personnel

calibration, quality assurance checks and controls

records and data management

prevention of unauthorised adjustment of the CEMS and its data recording devices

maintaining availability – spares, contingencies, and back-up monitoring



# System Description

## Analysers

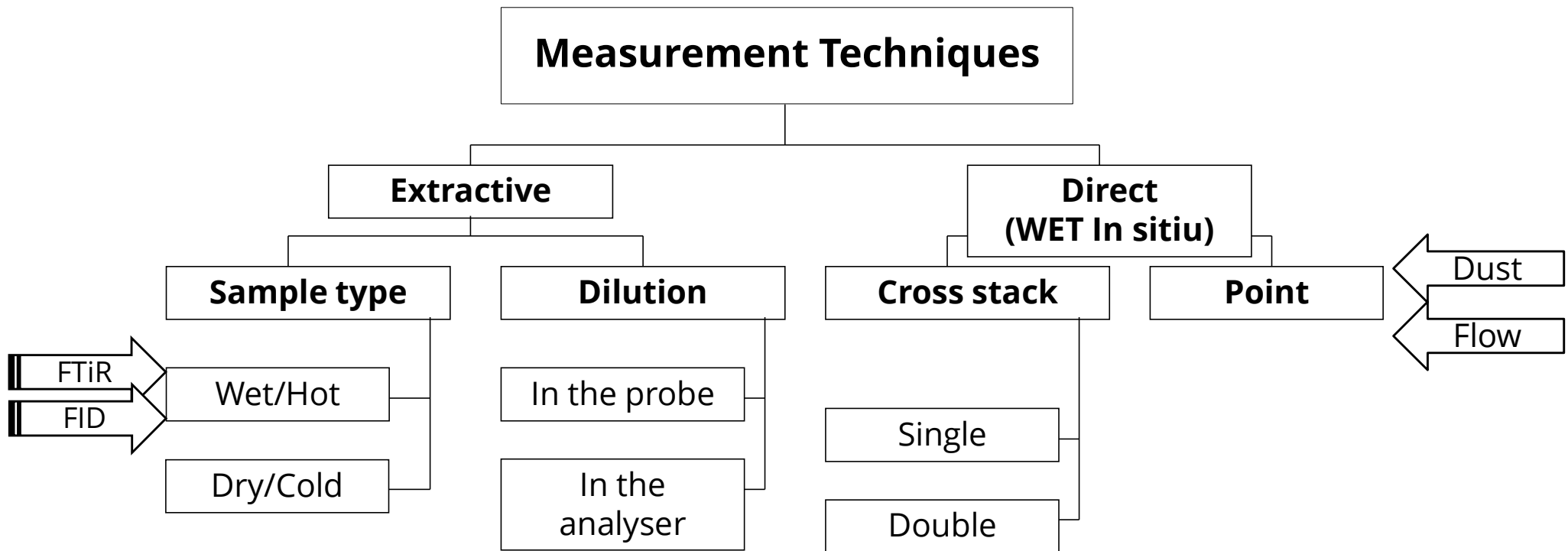
- Multigas analyzer
- FID monitor
- Dust monitor
- Wet oxygen monitor
- Temperature sensor
- Pressure sensor
- Flow monitor

## Peripheral Equipment

- Sample probe
- Sample line
- Data Acquisition System
- A/D converters
- Calibration gases
- Hydrogen bottles
- Hydrogen Auto-changeover unit
- Hydrogen alarm
- Nitrogen bottle
- Compressed air



# CEMS Measurement Methods



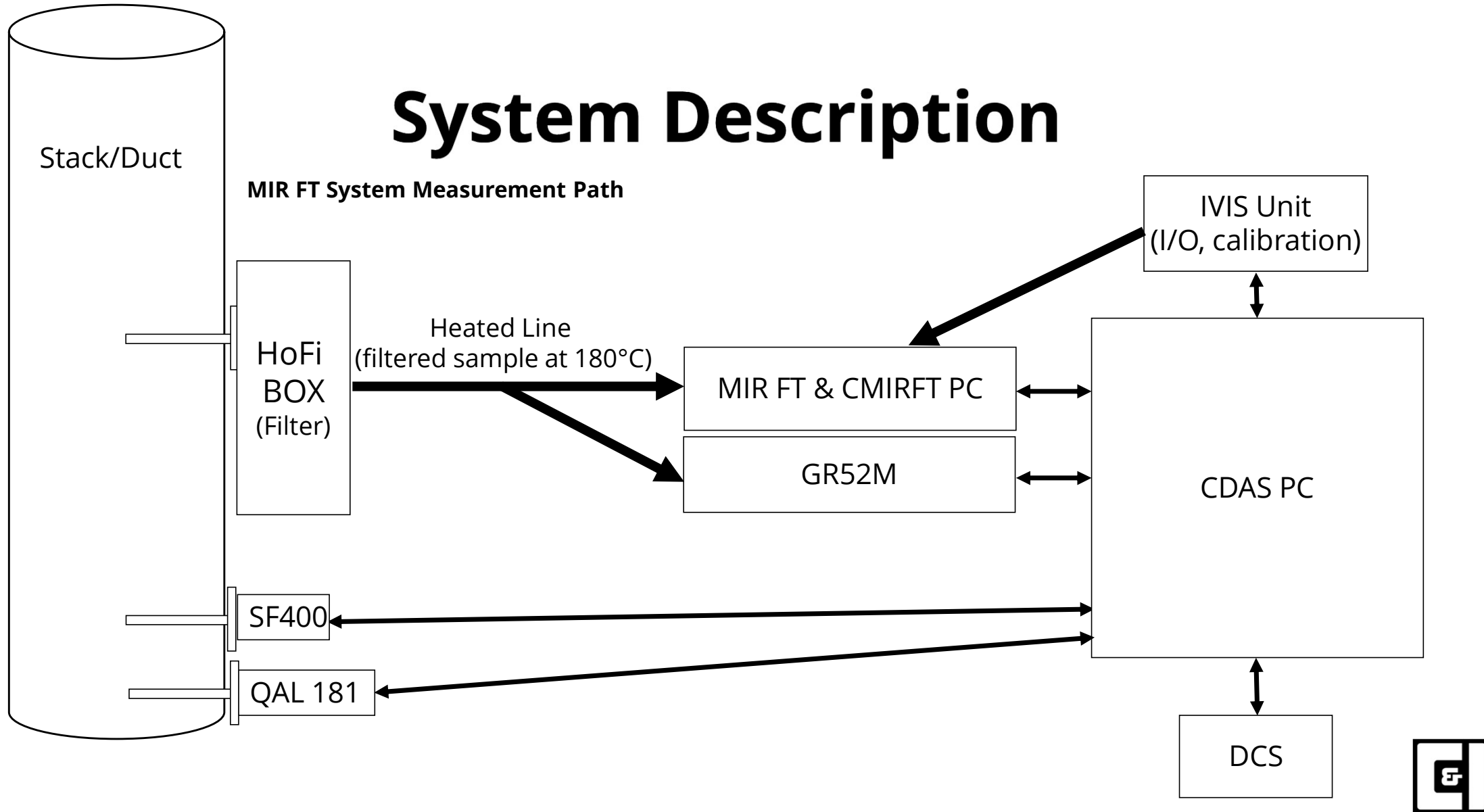
# Measured parameters

| Analyser          | Technology                      | Species                                                                              |
|-------------------|---------------------------------|--------------------------------------------------------------------------------------|
| <b>FTiR</b>       | Fourier Transform Infrared      | CO<br>SO2<br>NOx (NO + NO2)<br>HCL<br>NH3<br>CO2<br>H2O<br>Wet O2 (add-on)<br>+ more |
| <b>FID</b>        | Flame Ionization Detector (FID) | VOC (hydrocarbons)                                                                   |
| <b>Dust Probe</b> | Forward Light Scatter           | Particulates (Dust)                                                                  |
| <b>Flow Probe</b> | Time of Flight (Ultrasonic)     | Flow/Velocity                                                                        |
| <b>Oxygen</b>     | Zirconium Dioxide               | Wet O2                                                                               |



# System Description

## MIR FT System Measurement Path

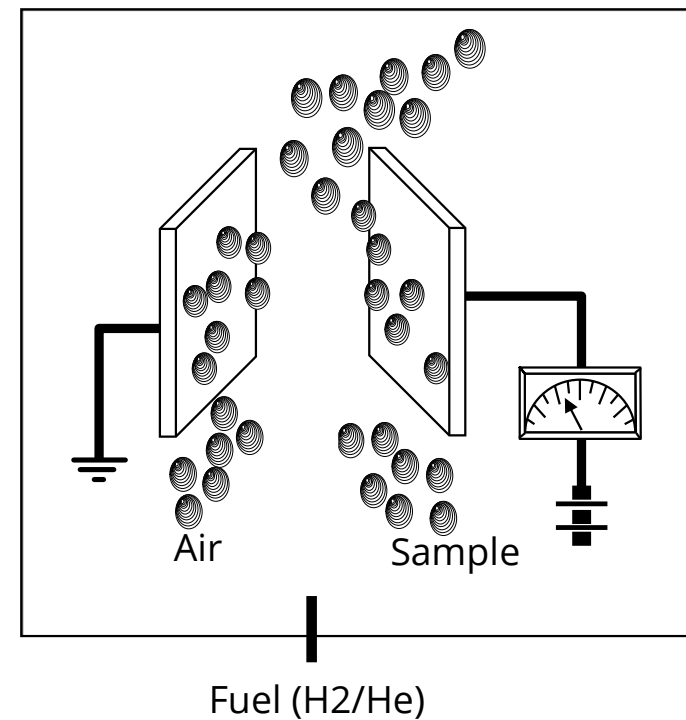


# Graphite 52M – FID

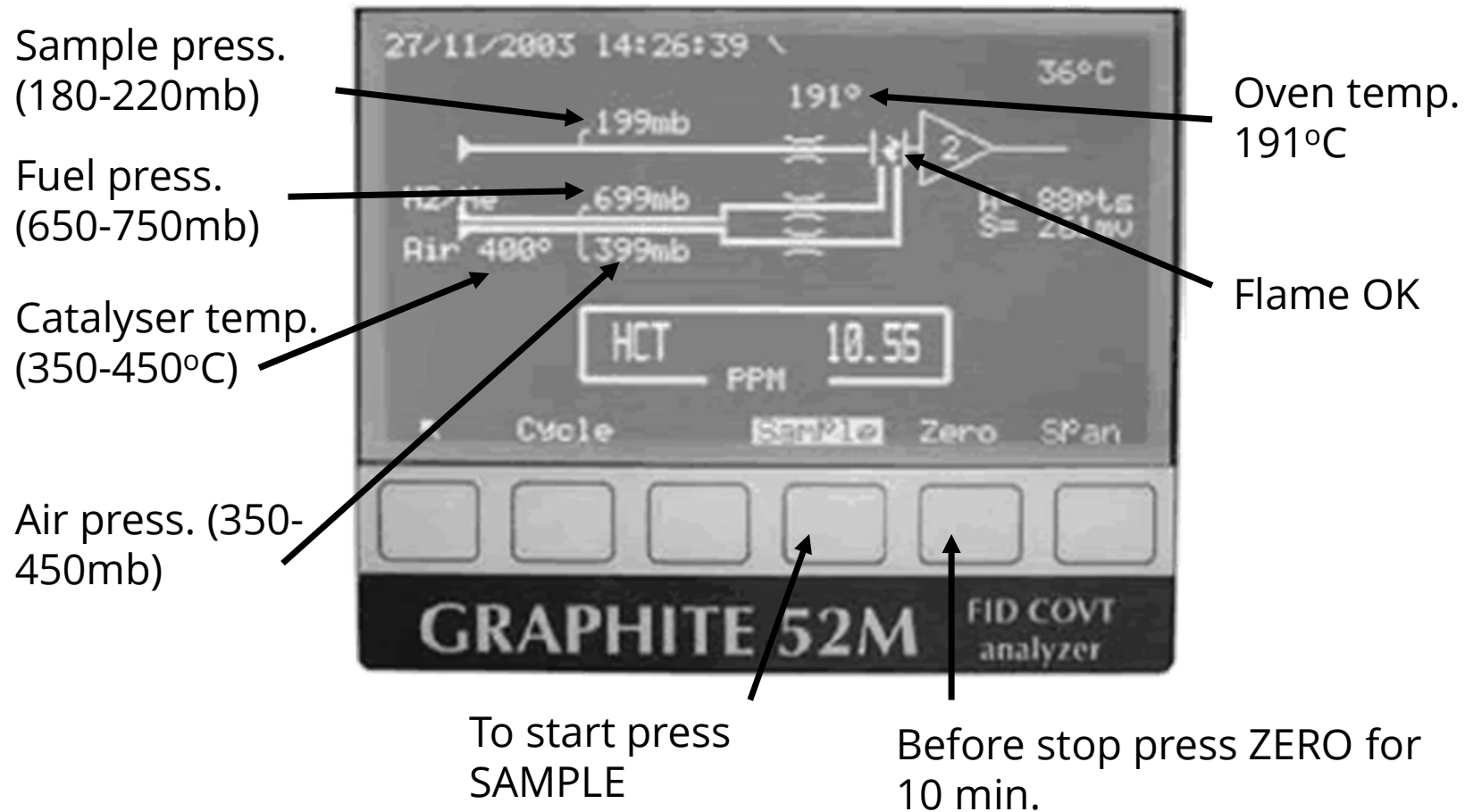


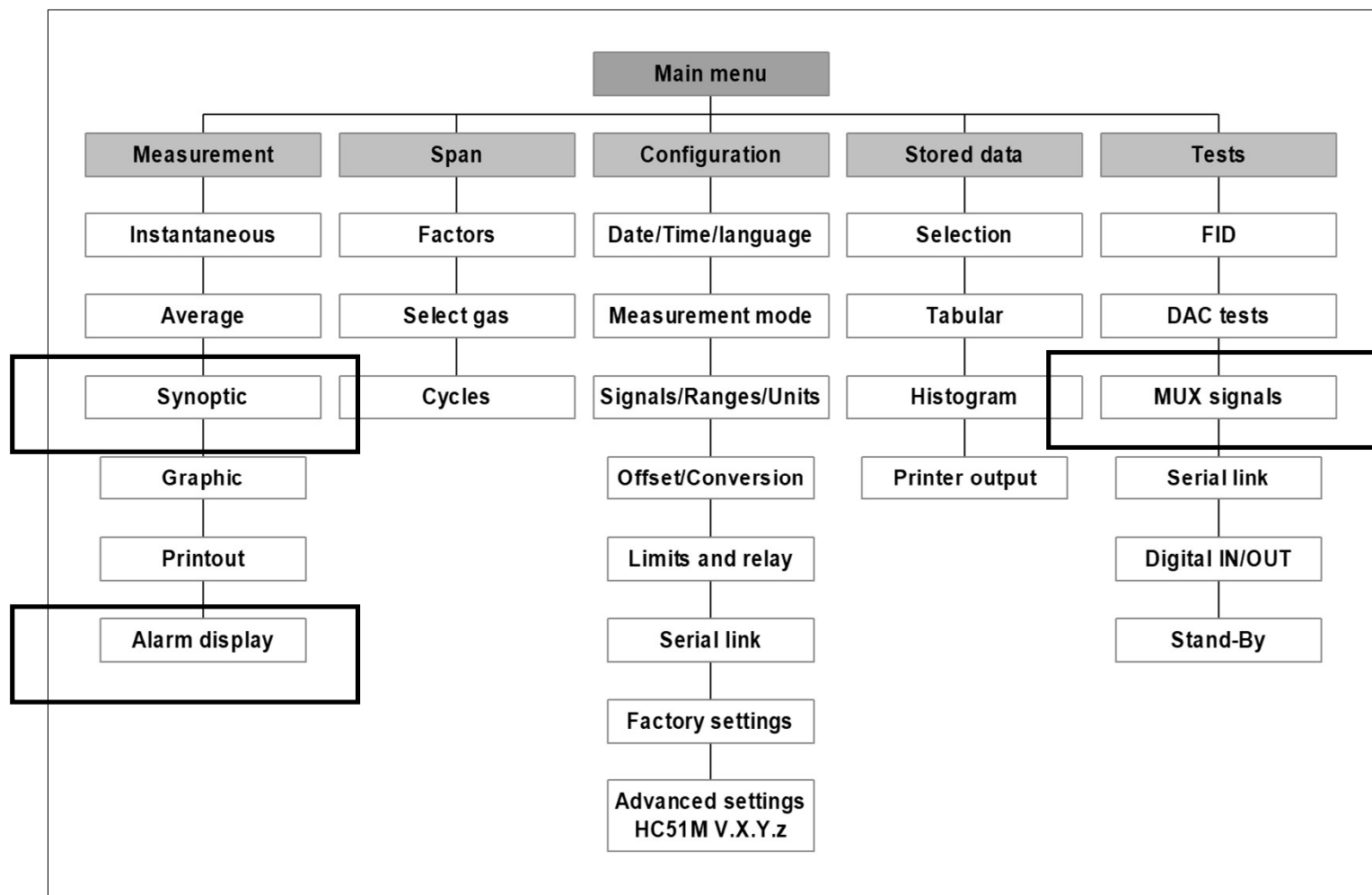
# FID – VOC monitor

- ◆ **FID Flame Ionisation Detector**
- ◆ Utilising a flame ionisation detector for continuous measurement of total hydrocarbons at trace levels within a gas stream, the principle of operation is based on measuring the ion current generated when organic compounds are burned in a hydrogen flame (FID).



# Graphite 52M - FID



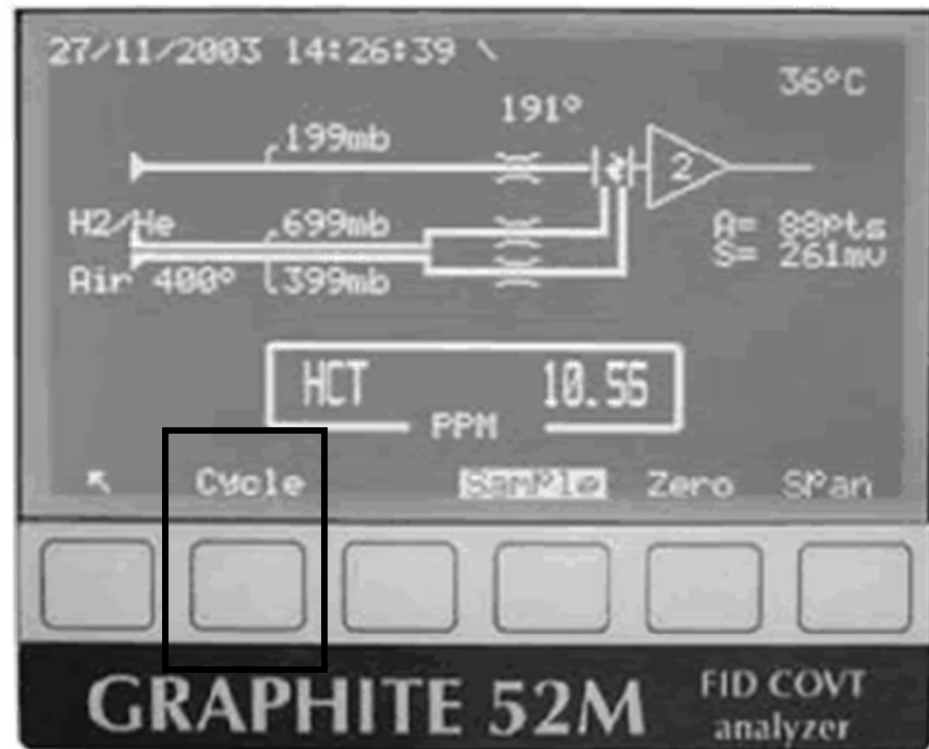


# Graphite 52M – FID

## Manual zero calibration

1. Press cycle
2. Press Z.Ref
3. The analyser will perform a zero-reference calibration and return the analyser to sample mode once complete.

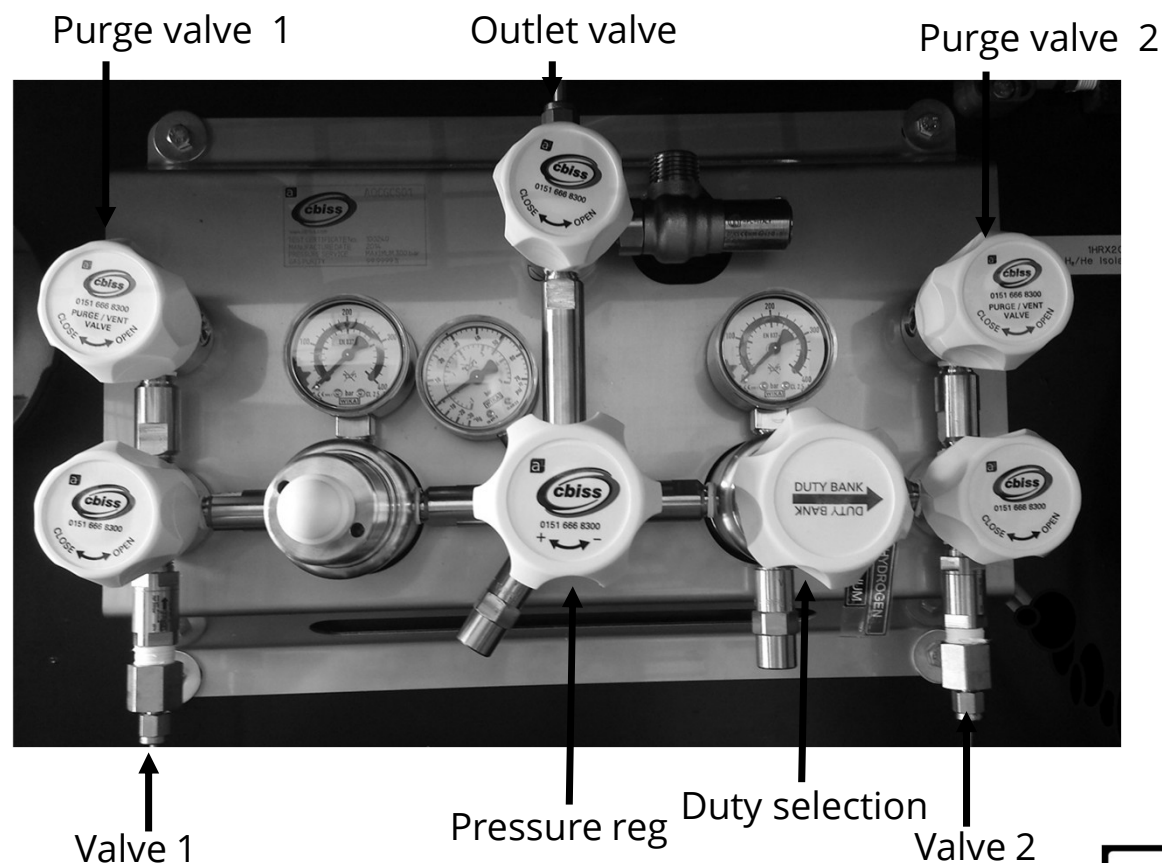
\* The Z.Ref can be set to run on the Z.Ref air inlet or via the sample inlet. The latter requires N<sub>2</sub> to be injected into the system using CMIRFT.



# H<sub>2</sub>/He Change Over Panel

1. Wait until the manifold automatically changes over. Then operate Duty Selection valve.
2. Close off the empty cylinder using the cylinder isolation valve.
3. Close valve 1 or 2 depending which side is being changed.
4. Vent off the excess pressure using the appropriate purge valve.
5. Change the empty cylinder for a full one ensuring the cylinder connection is tight.
6. Close purge valve.
7. Open the cylinder isolation valve and purge the line briefly using the purge valve.
8. Close purge valve.
9. Ensure the cylinder connection is leak free.
10. Open Valve 1 or 2 as appropriate.

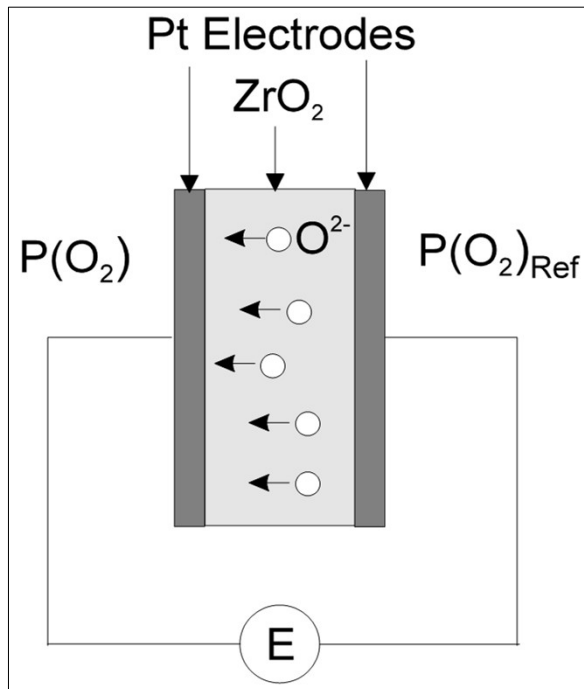
Your new cylinder will automatically take over when the current cylinder falls below 10 – 15 Bar.



As with all gas cylinder regulators, under BCGA best practice, regulators should be replaced (or refurb'd) at least every 5 years



# Oxygen Cell – Zirconia sensor



If there is a difference in oxygen concentration between the two sides of the zirconia disk, a voltage is generated across the platinum electrodes

The voltage generated between the electrodes is a function of the ratio of the oxygen partial pressure and its temperature.

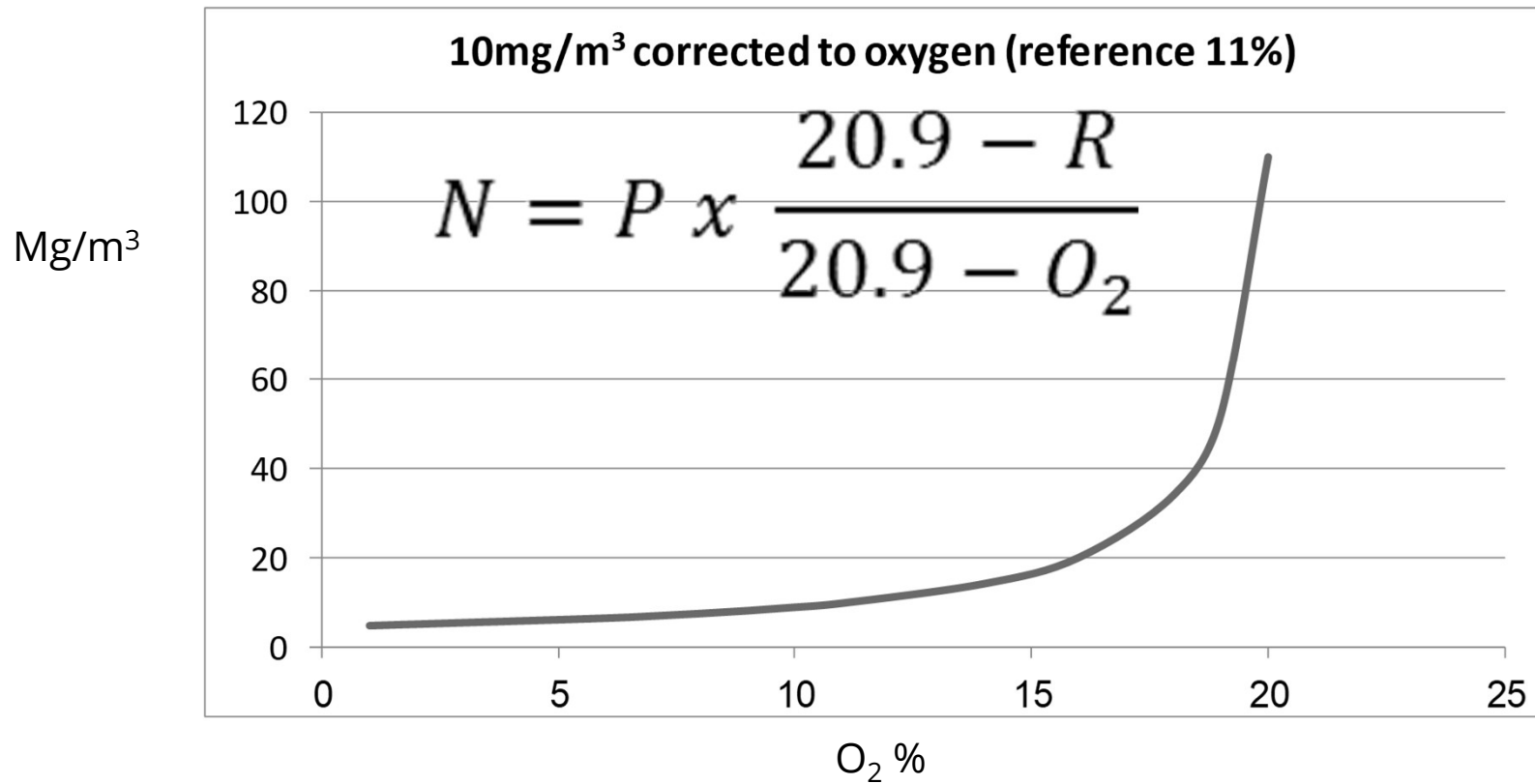
Any change in the oxygen concentration of the flue gas produces a change in the cell output voltage.

Faults will appear on CDAS as common faults. The probe display should be consulted for further diagnostic information.

For the cell to function, it must be heated to over 700°C



## Oxygen correction

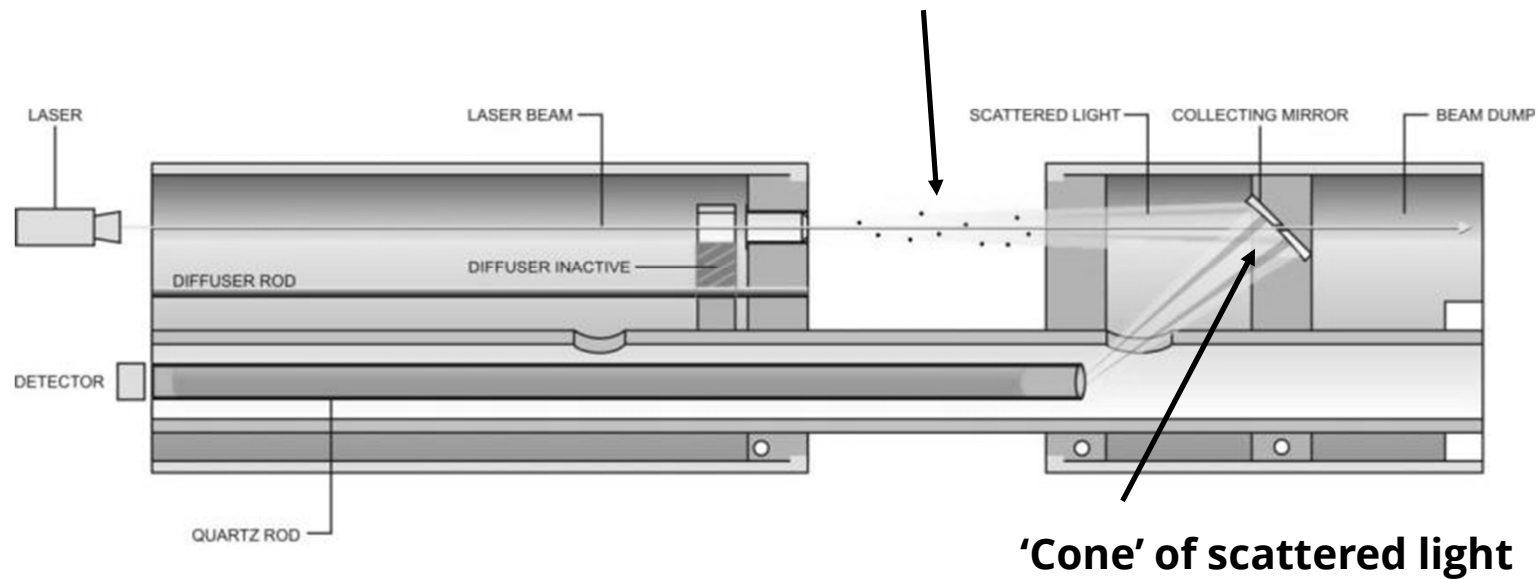


# QAL181 dust monitor



# Dust monitor

Particles create scattering in 'Interaction volume'

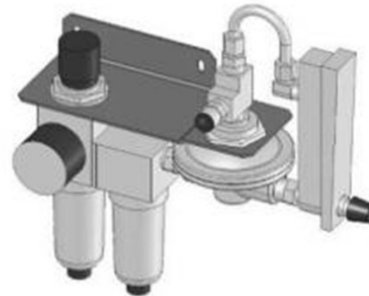
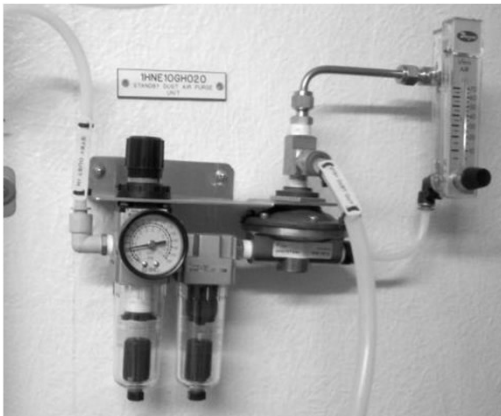


'Interaction volume' is positioned in representative part of stack beyond 150 mm of wall effects

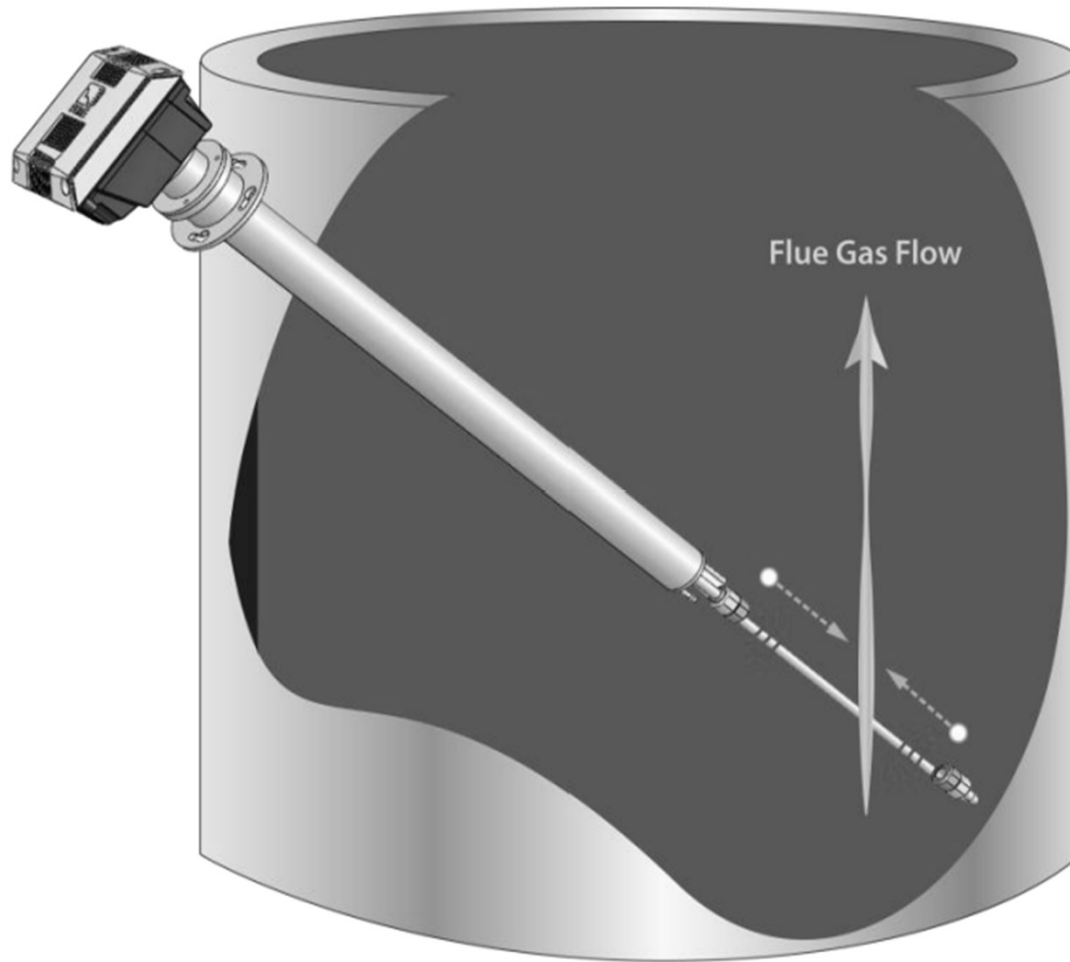


# Air Purge

- It is very important that at any time the sensor is installed that the air purge (Flow 30 l/min) is connected and running.
- Provided the air purge is working the instrument will operate reliably
- Should the air purge be either not connected or running the optical surfaces will contaminate and the instrument will require maintenance (cleaning)
- The instrument's automatic span and manual Audit Unit provide a robust check of any contamination



# SF400 Velocity Probe



Time of flight measured against  
stack flow

–

Time of flight with stack flow

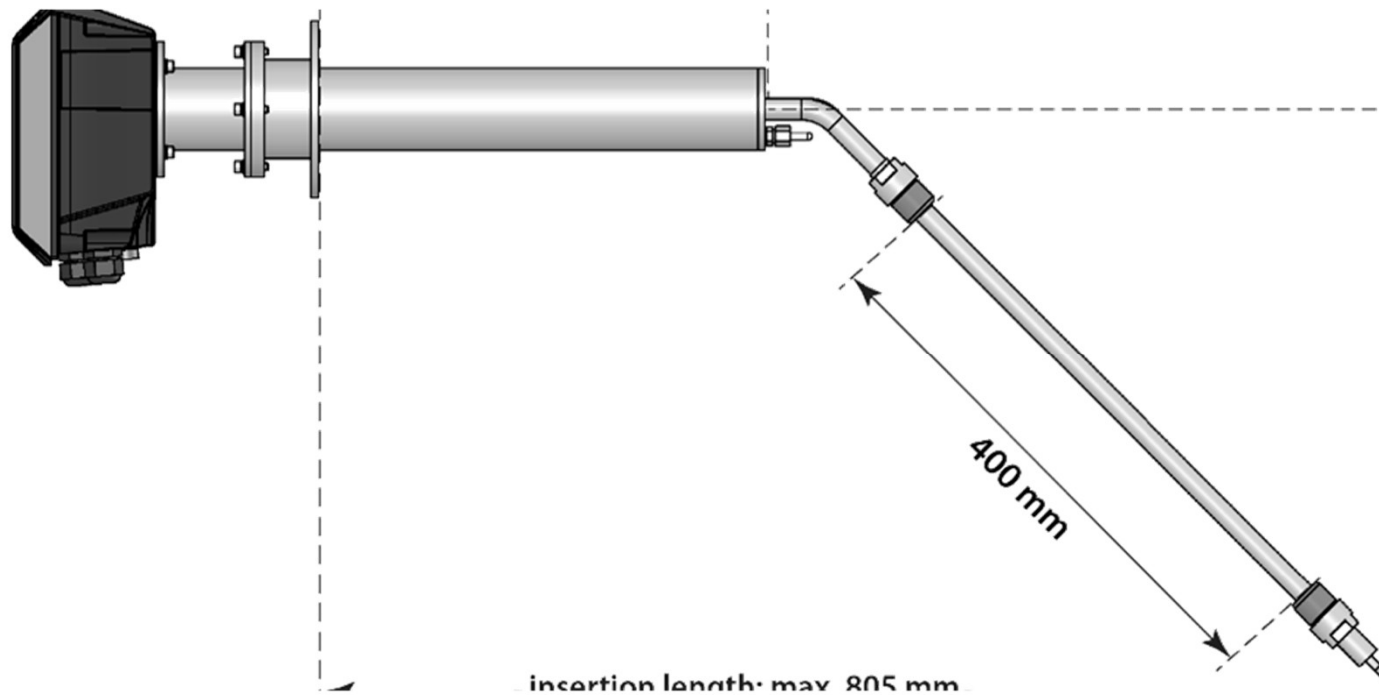
= stack velocity

$$v = \frac{L}{2 \cos(\alpha)} \frac{t_{up} - t_{down}}{t_{up} t_{down}} \text{ and } c = \frac{L}{2} \frac{t_{up} + t_{down}}{t_{up} t_{down}}$$



# SF400 Velocity Probe

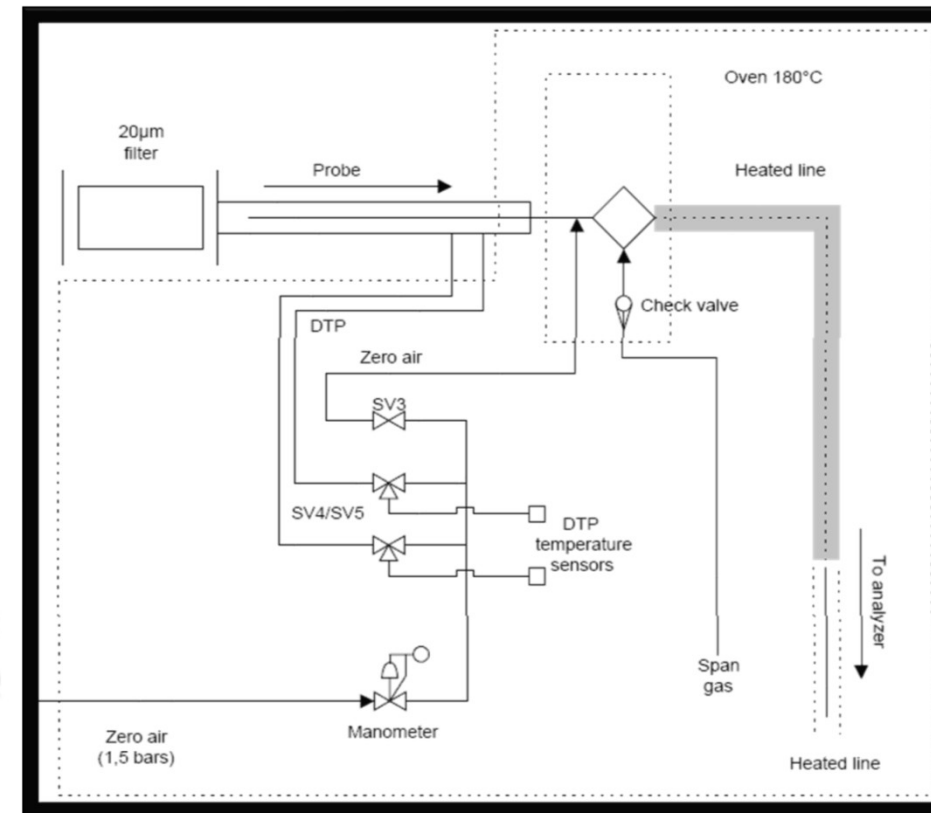
- Ultrasonic
- Time of flight
- Measures velocity, from which Flow can be calculated



# HoFi Probe

Extracts Sample

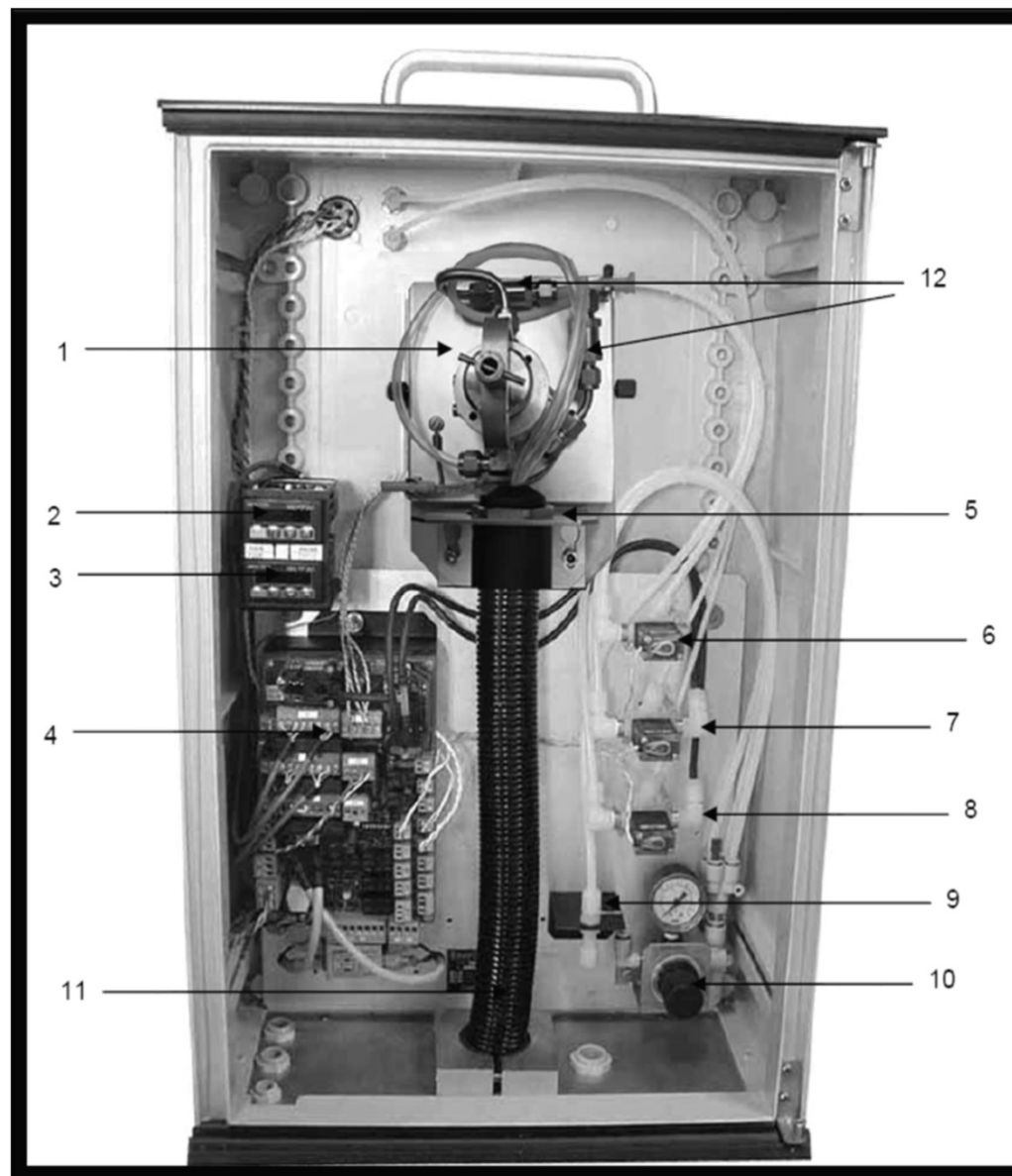
- Cleans sample - 2 stage filtration
- Maintains gas temperature to prevent gas losses
- Calibration to probe to validate complete system



# HoFi Probe

## HoFi Probe - Components

| Mark | Legend                                                                              |
|------|-------------------------------------------------------------------------------------|
| 1    | Heated block                                                                        |
| 2    | Heated block temperature regulator                                                  |
| 3    | Sampling probe temperature regulator                                                |
| 4    | Interface board                                                                     |
| 5    | Heated line fixation support                                                        |
| 6    | SV3 solenoid valve of zero air back flushing when alarm occurs (MIR FT application) |
| 7    | SV4 DTP                                                                             |
| 8    | SV5 DTP                                                                             |
| 9    | Span gas inlet                                                                      |
| 10   | Zero air pressure regulator                                                         |
| 11   | Heated line                                                                         |
| 12   | Check valves                                                                        |

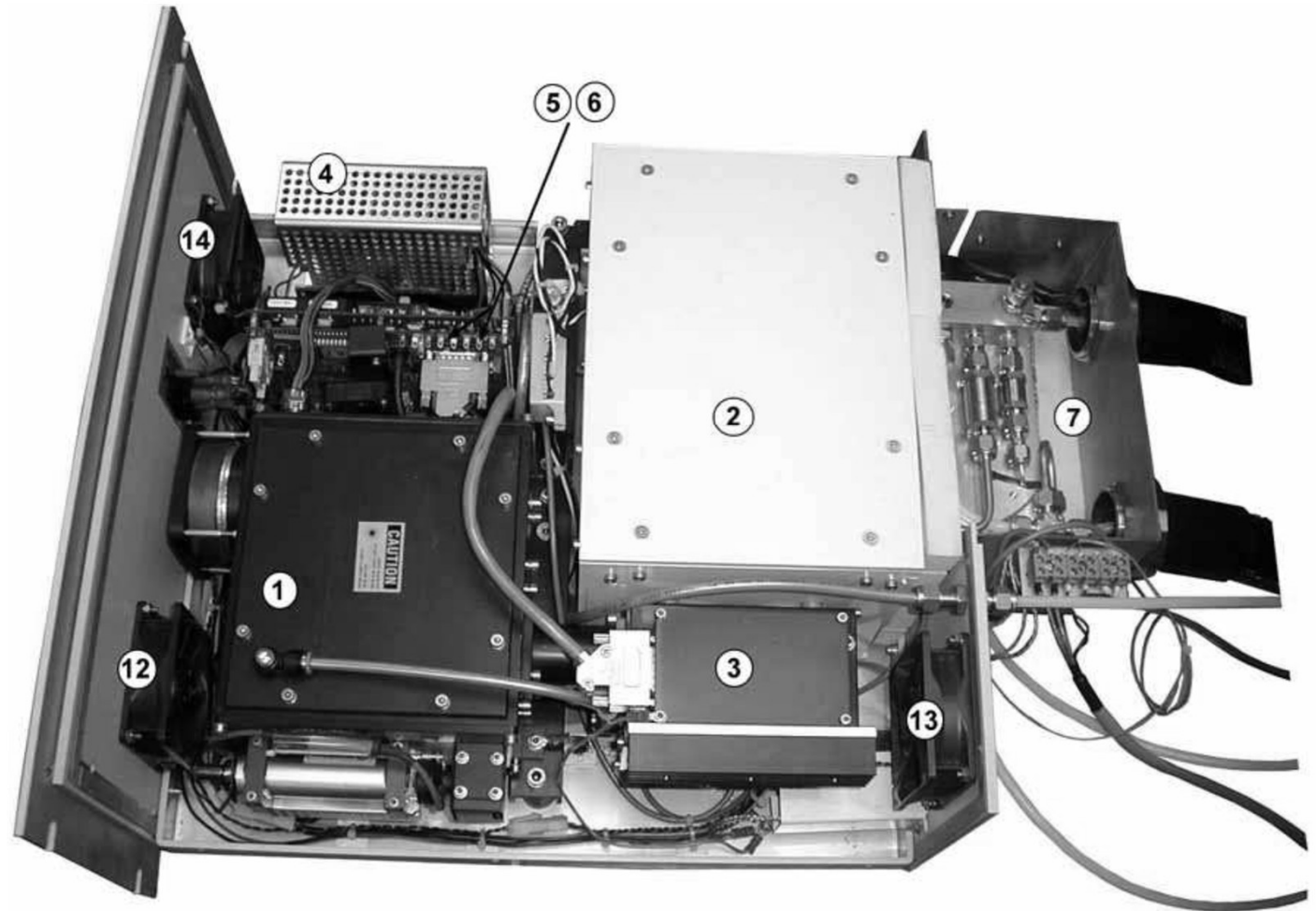


# MIR FT

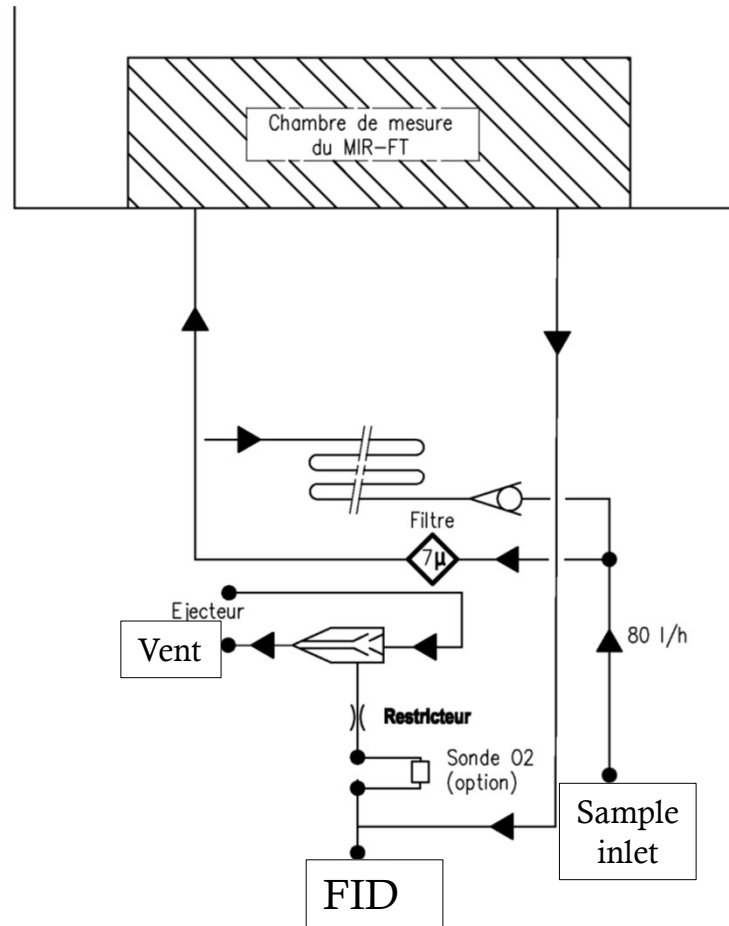


# MIR FT

- 1: Interferometer
- 2: Oven (Gas cell)
- 3: Detector
- 4: Power supply
- 5: DSP board
- 6: Power board
- 7: Heated manifold
- 12: Vent fan
- 13: Detector cooling fan
- 14: Electronics cooling fan

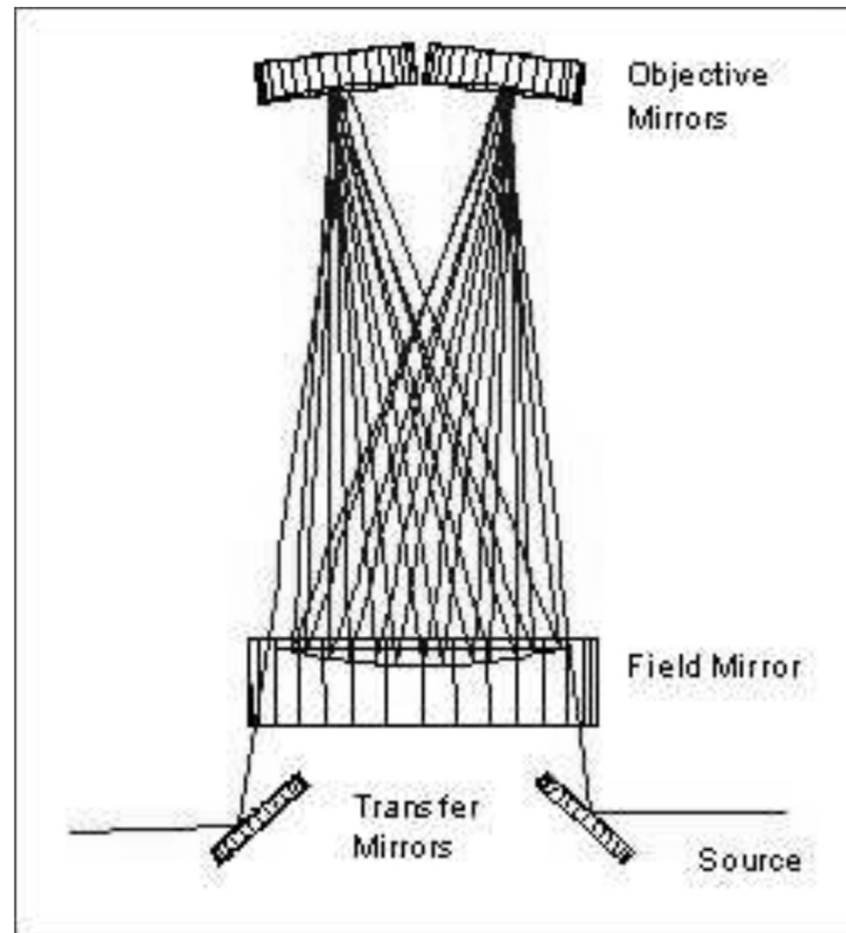


# MIR FT



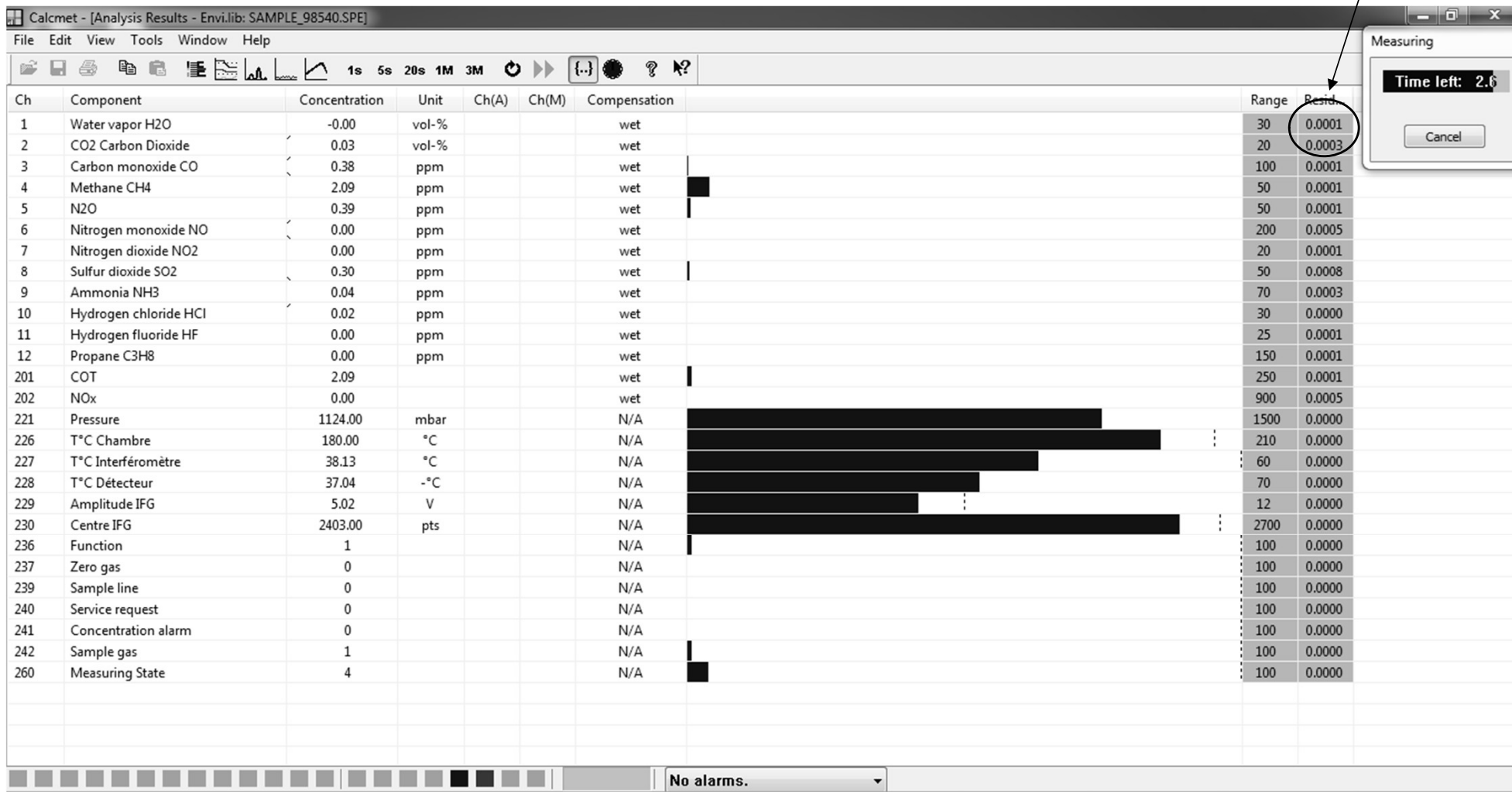
# FTiR

## Measurement Cell – Mirrors



# MIR FT - Calcmnet

Maximum 0.02

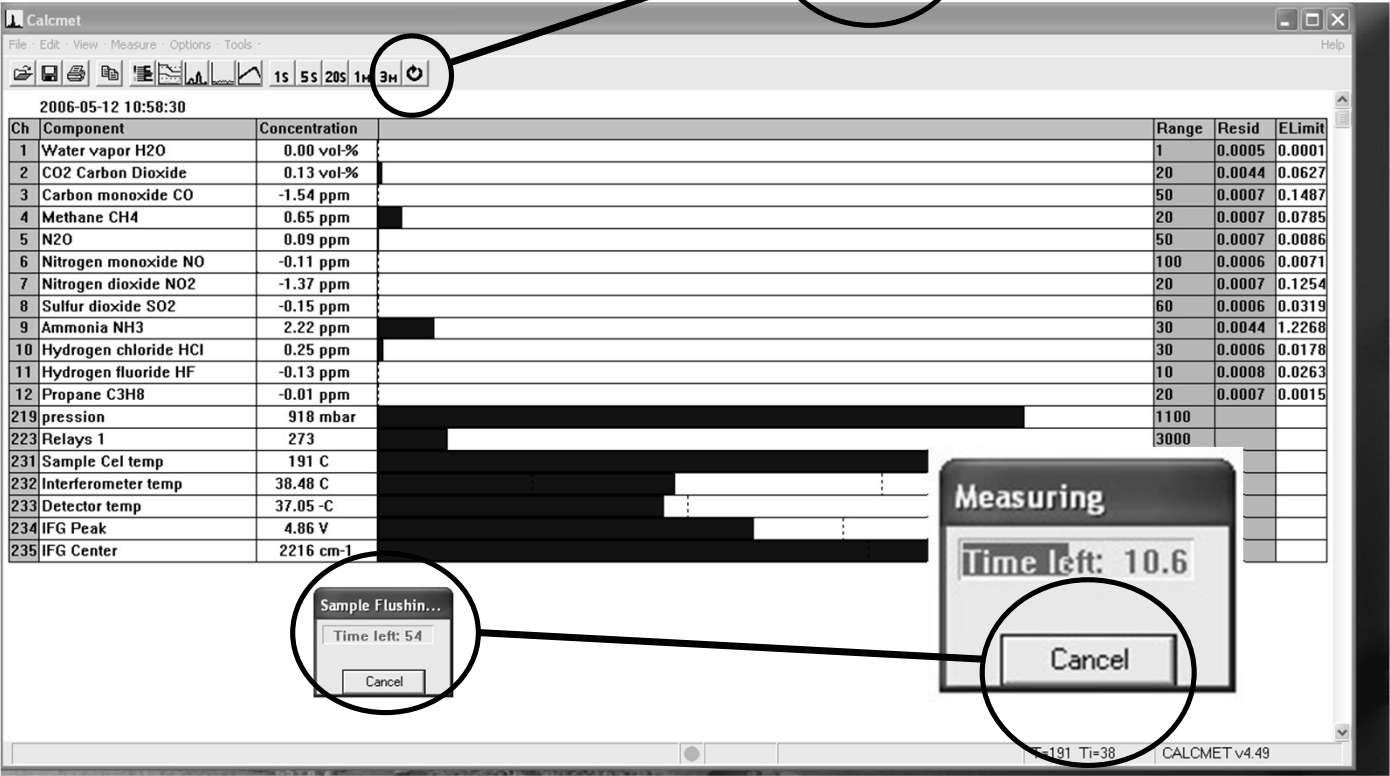


# Residual Alarm

## Calcmeter Software



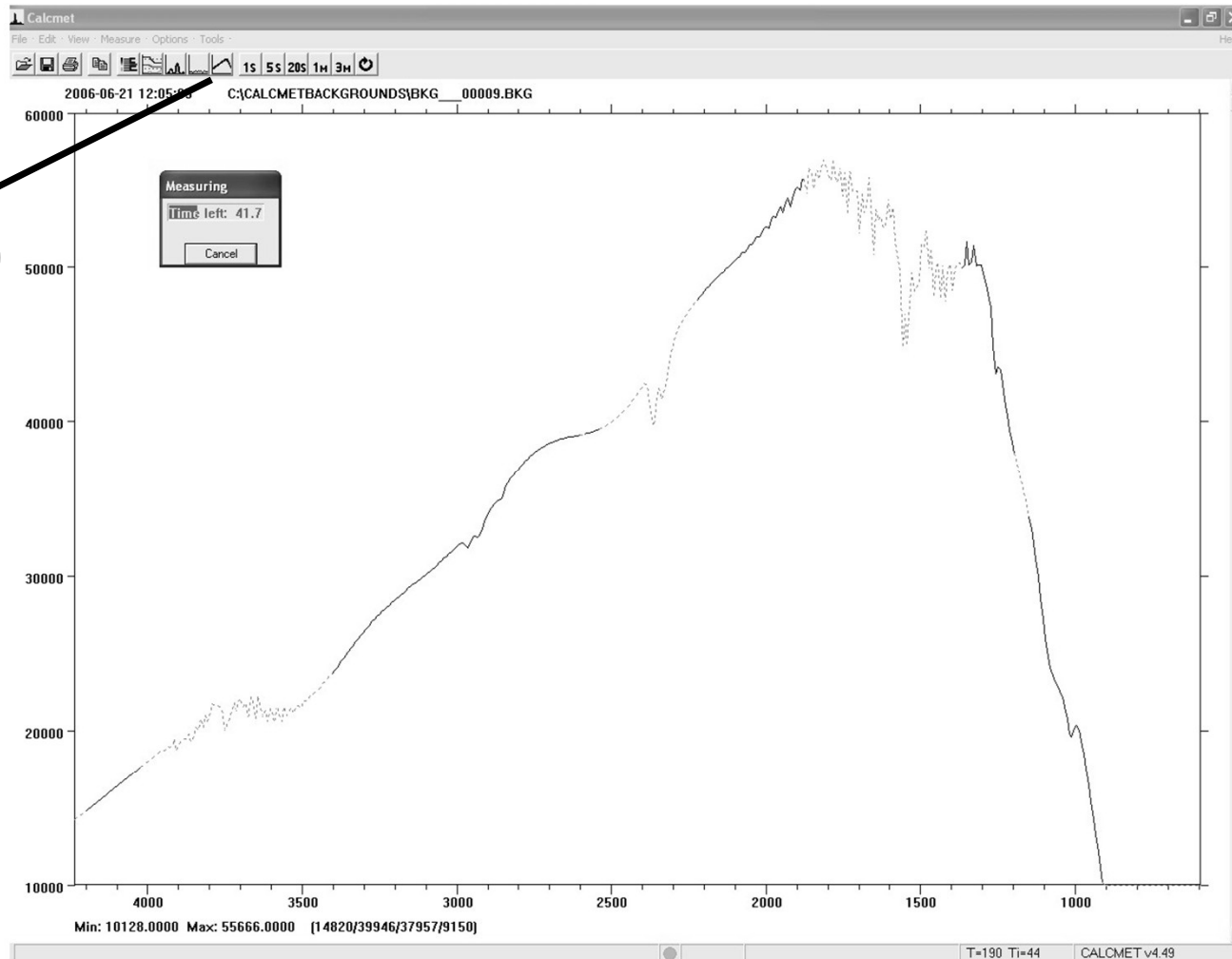
Start Measuring



Stop measuring - Cancel



# Background (zero spectrum)

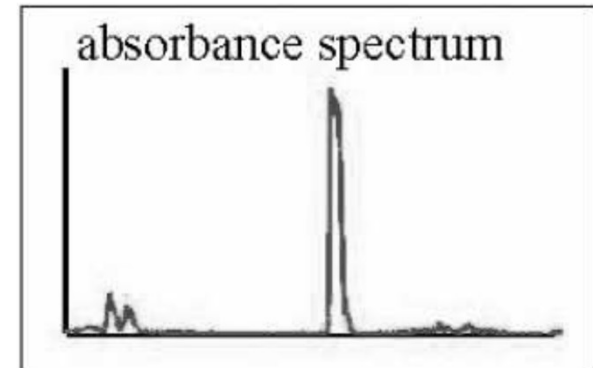
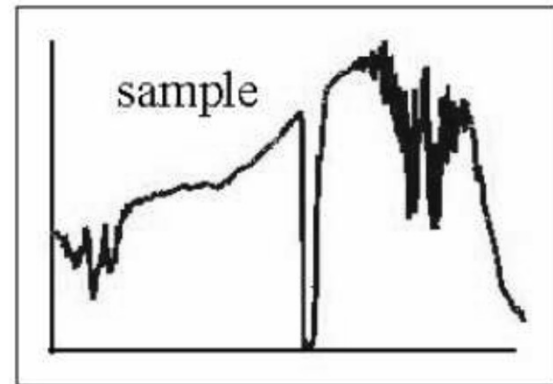
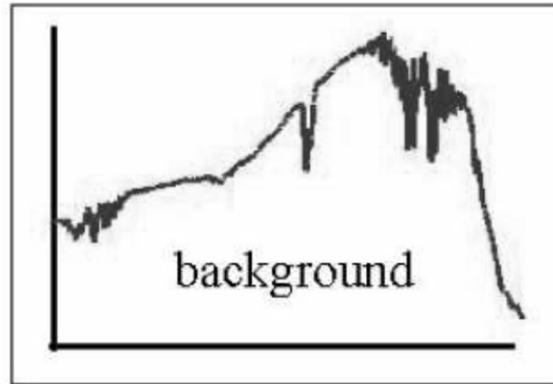


$$A = -\log_{10} \left( \frac{\text{Background}}{\text{Sample}} \right)$$

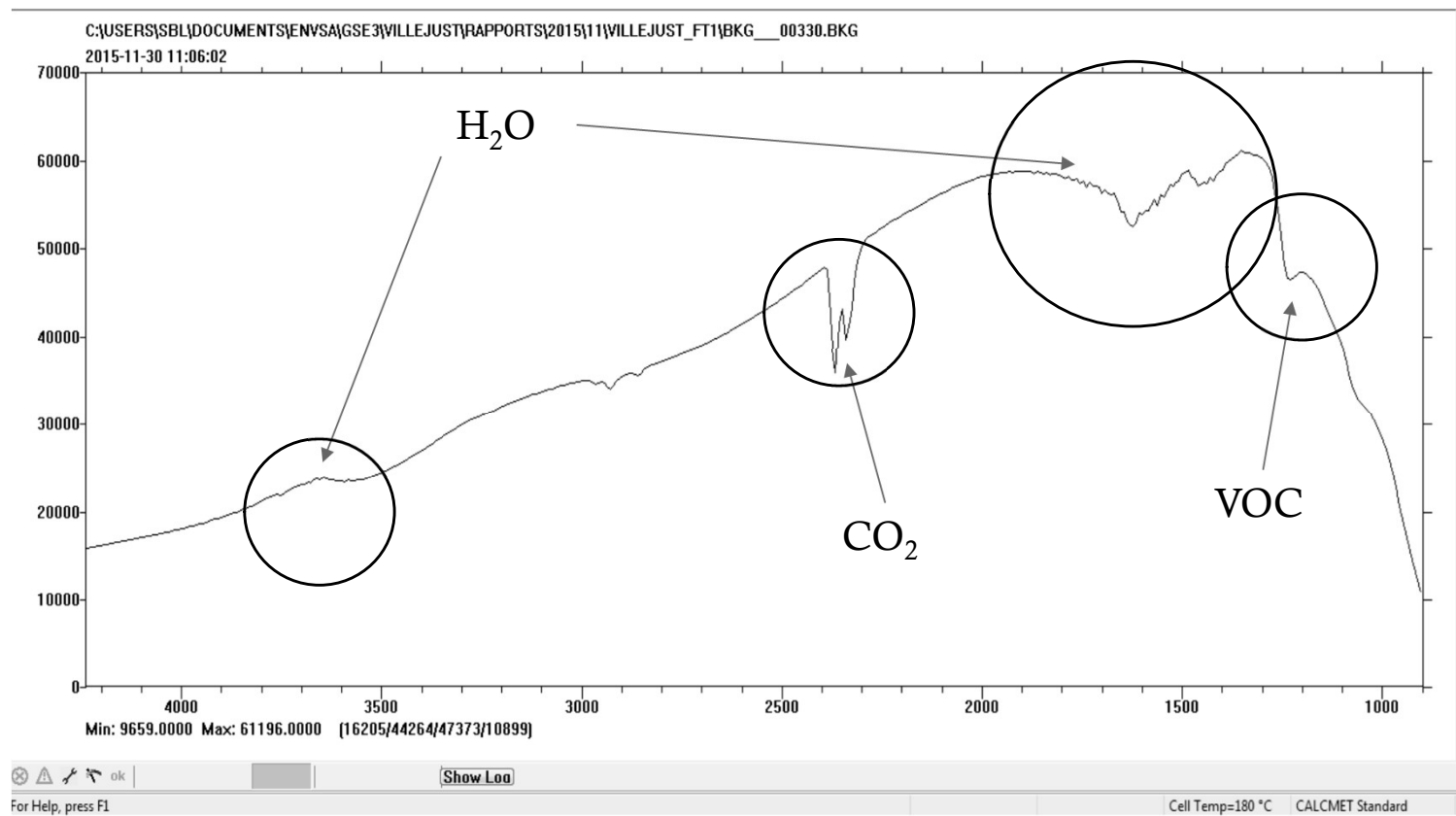


# Background (zero spectrum)

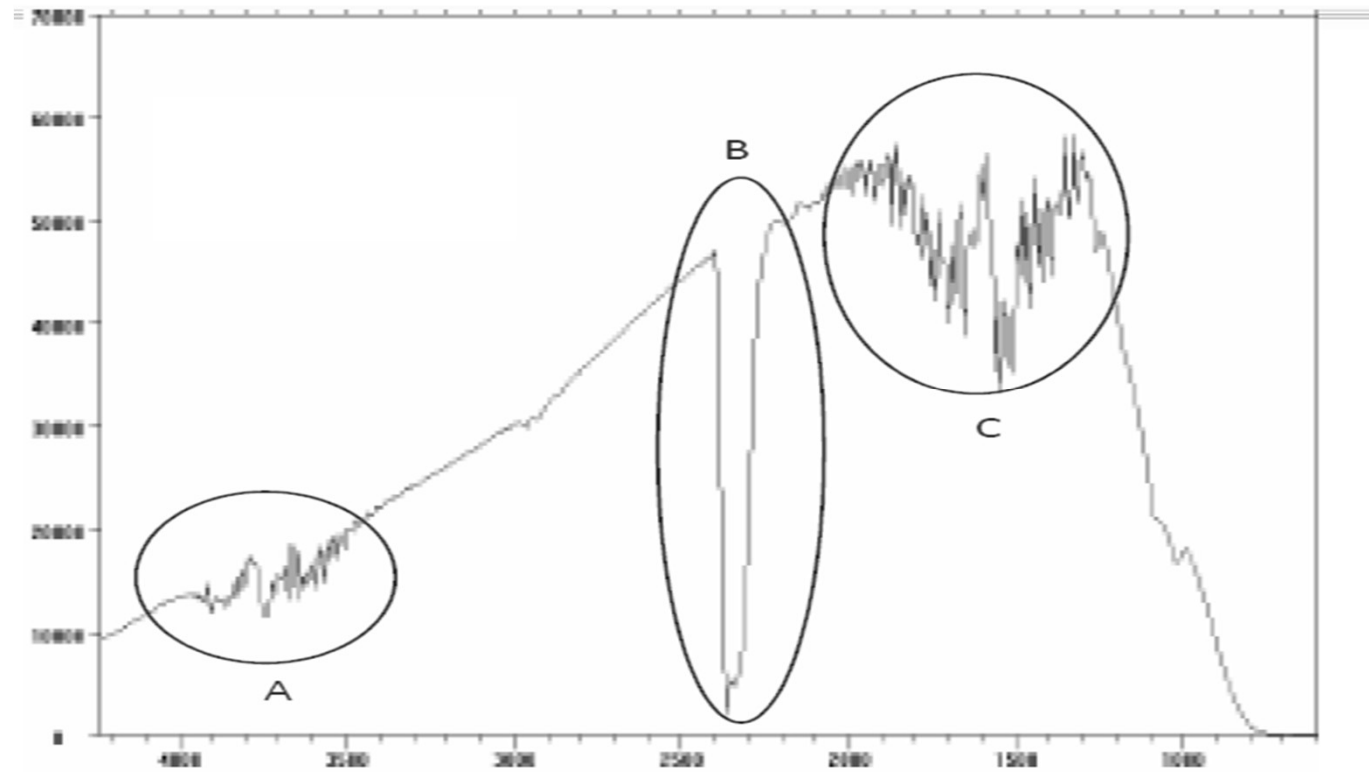
$$A = -\log_{10}\left(\frac{\text{Background}}{\text{Sample}}\right)$$



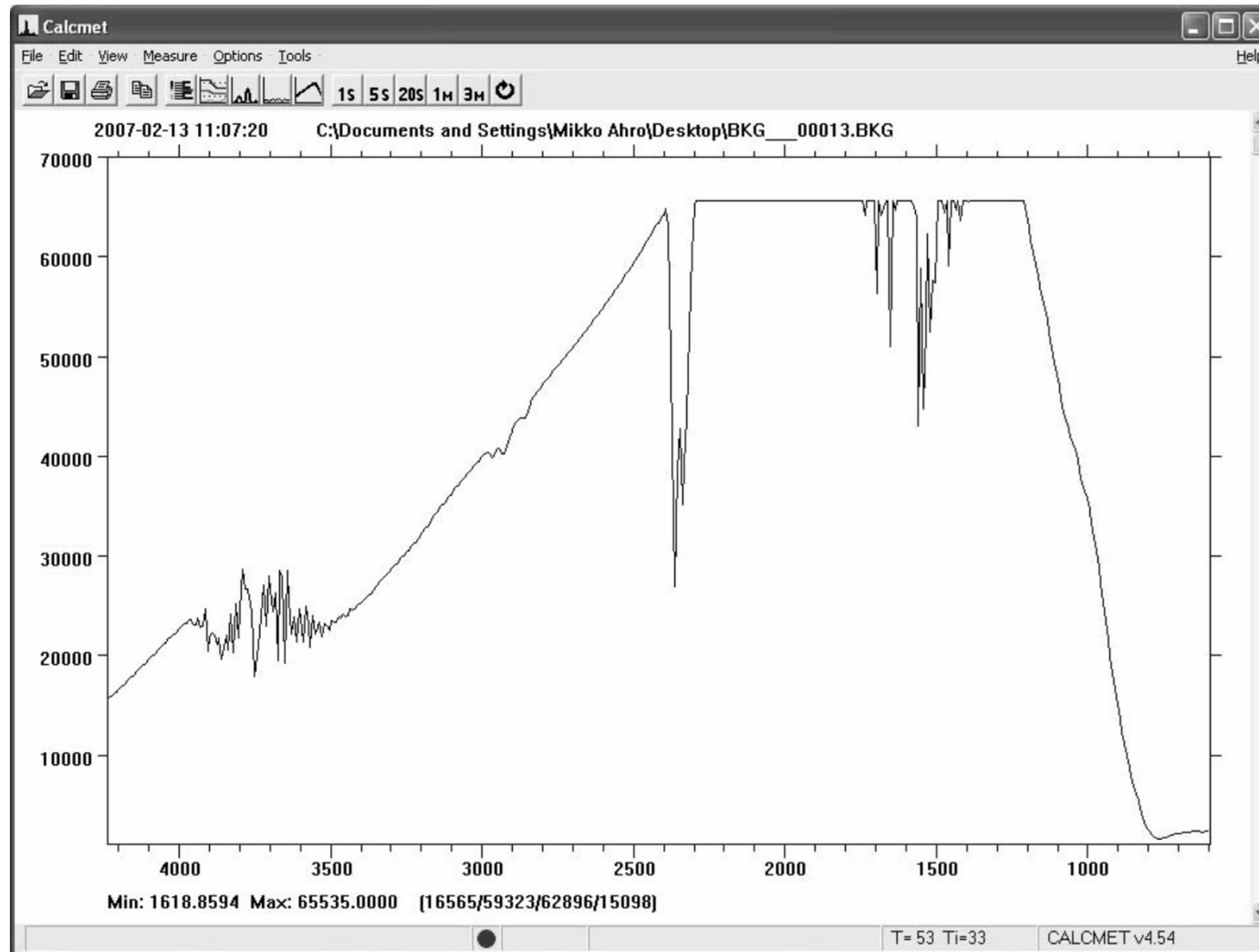
# Bad background



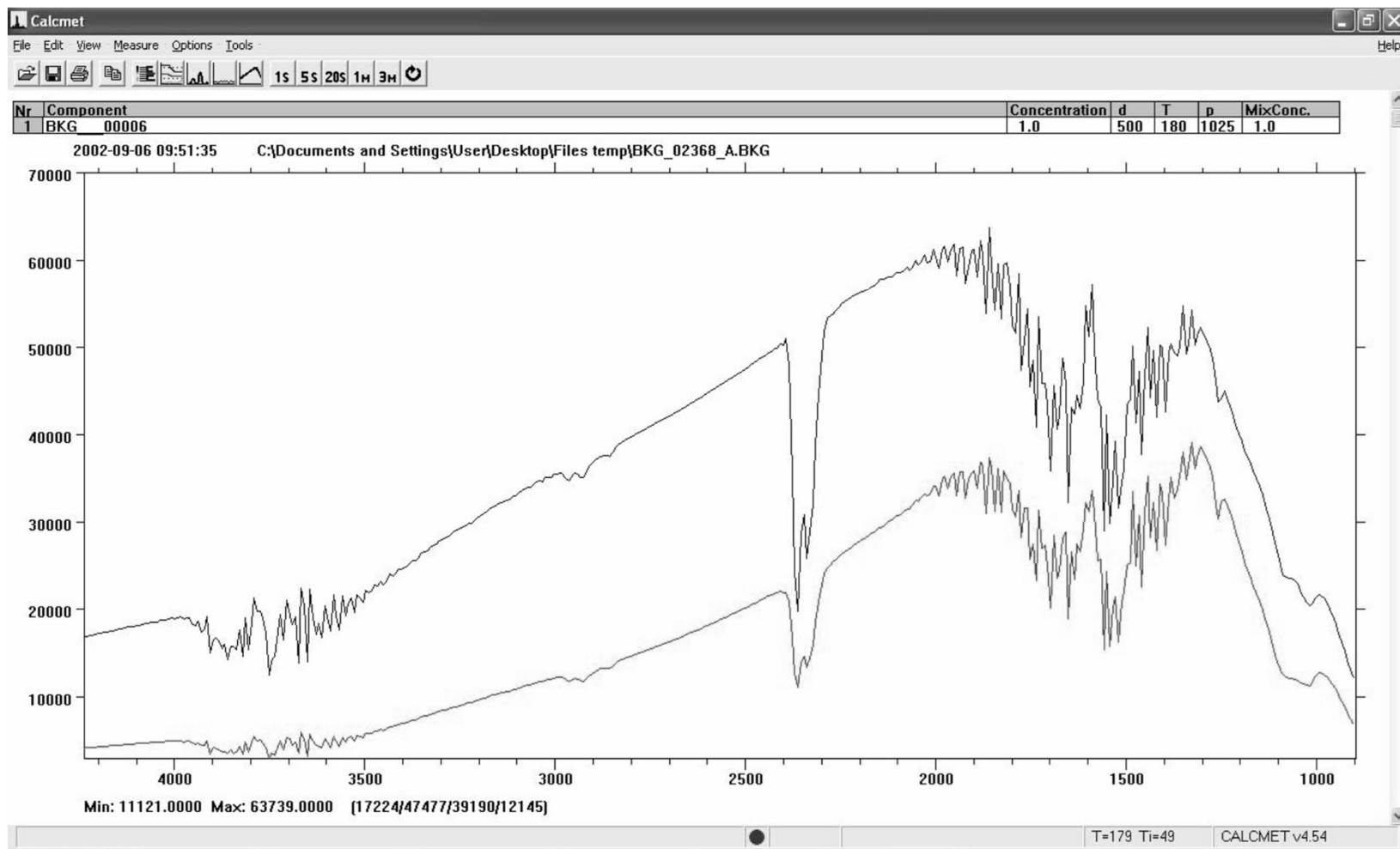
# Bad background



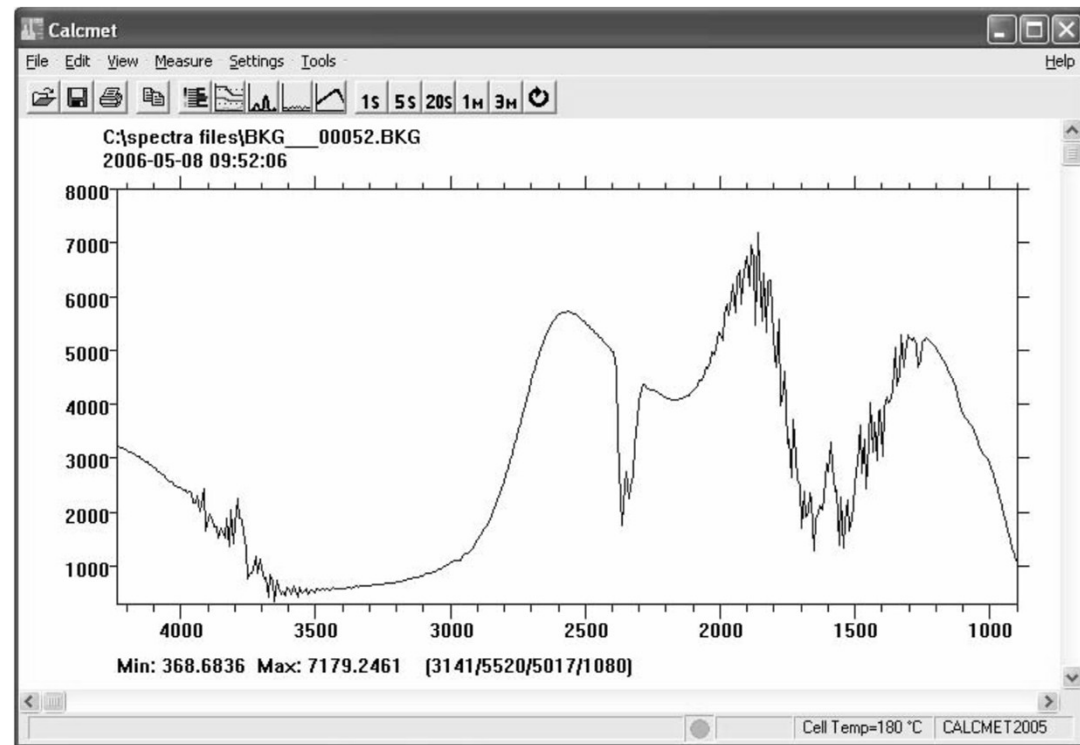
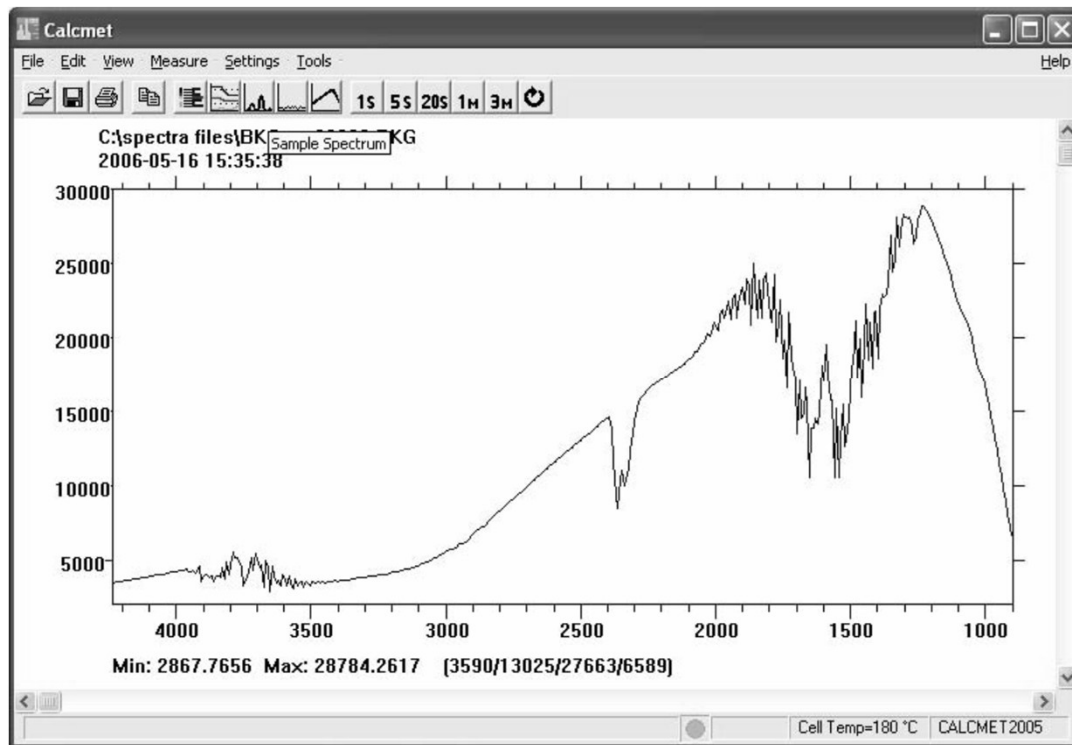
# Bad background



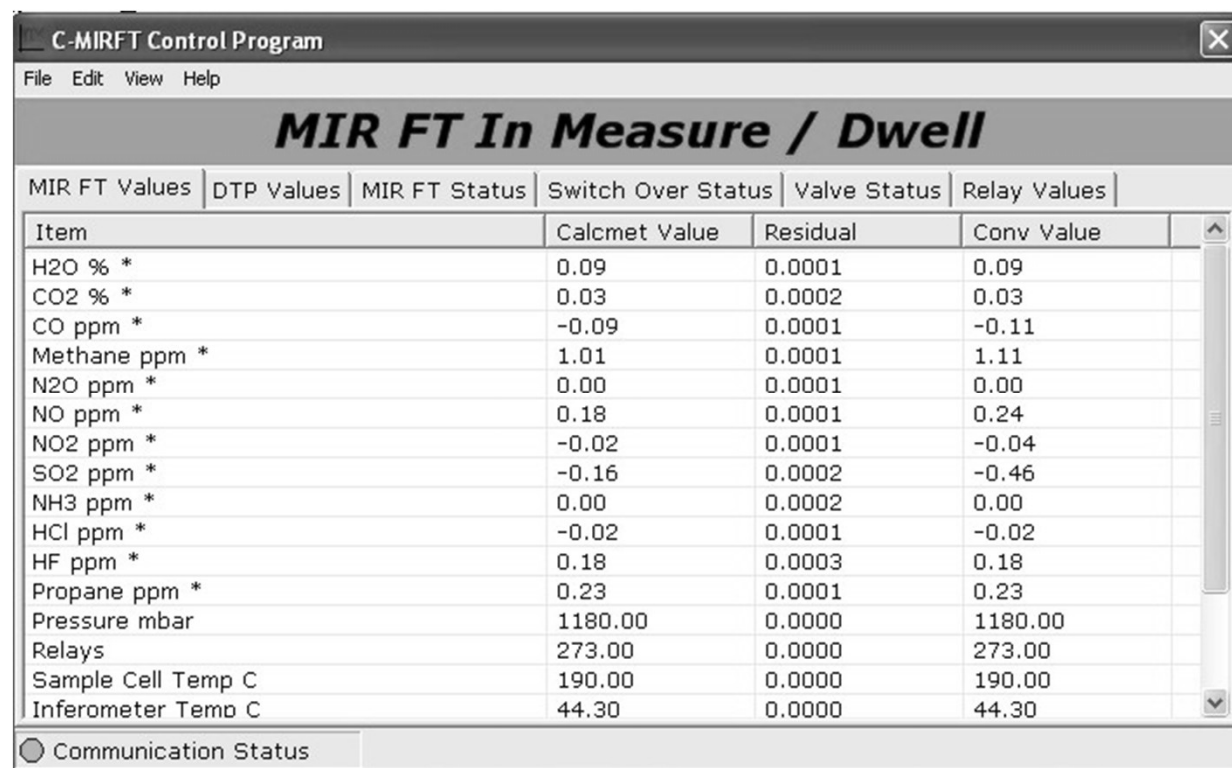
# Low background



# Icing on detector window



# C-MIRFT screen - MIRFT Values



**C-MIRFT Control Program**

File Edit View Help

**MIR FT In Measure / Dwell**

MIR FT Values | DTP Values | MIR FT Status | Switch Over Status | Valve Status | Relay Values

| Item               | Calcmet Value | Residual | Conv Value |
|--------------------|---------------|----------|------------|
| H2O % *            | 0.09          | 0.0001   | 0.09       |
| CO2 % *            | 0.03          | 0.0002   | 0.03       |
| CO ppm *           | -0.09         | 0.0001   | -0.11      |
| Methane ppm *      | 1.01          | 0.0001   | 1.11       |
| N2O ppm *          | 0.00          | 0.0001   | 0.00       |
| NO ppm *           | 0.18          | 0.0001   | 0.24       |
| NO2 ppm *          | -0.02         | 0.0001   | -0.04      |
| SO2 ppm *          | -0.16         | 0.0002   | -0.46      |
| NH3 ppm *          | 0.00          | 0.0002   | 0.00       |
| HCl ppm *          | -0.02         | 0.0001   | -0.02      |
| HF ppm *           | 0.18          | 0.0003   | 0.18       |
| Propane ppm *      | 0.23          | 0.0001   | 0.23       |
| Pressure mbar      | 1180.00       | 0.0000   | 1180.00    |
| Relays             | 273.00        | 0.0000   | 273.00     |
| Sample Cell Temp C | 190.00        | 0.0000   | 190.00     |
| Inferometer Temp C | 44.30         | 0.0000   | 44.30      |

☐ Communication Status



# C-MIRFT screen - DTP Values

C-MIRFT Control Program

File Edit View Help

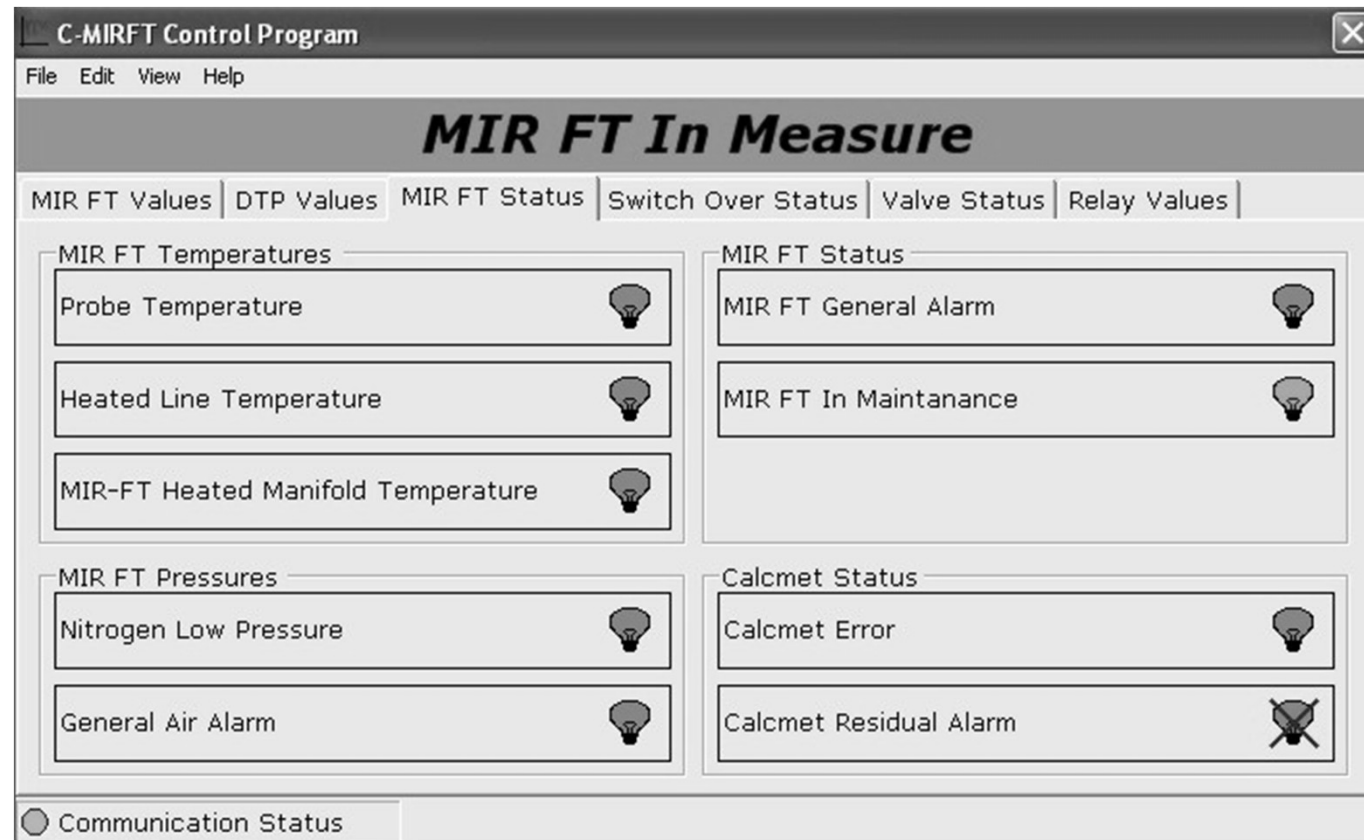
## MIR FT In Measure

| MIR FT Values                | DTP Values | MIR FT Status | Switch Over Status | Valve Status | Relay Values |
|------------------------------|------------|---------------|--------------------|--------------|--------------|
| Differential Pressure / mbar | 0.0006249  |               |                    |              |              |
| Atmospheric Pressure / mbar  | 1015.875   |               |                    |              |              |
| Stack Temperature / C        | 32.83125   |               |                    |              |              |
| Stack Pressure / mbar        | 1015.8756  |               |                    |              |              |
| Stack Velocity / m/s         | 0.2468178  |               |                    |              |              |
| Stack Flow / kNm3/hr         | 0.6247134  |               |                    |              |              |

☐ Communication Status



# C-MIRFT screen - MIR FT Status

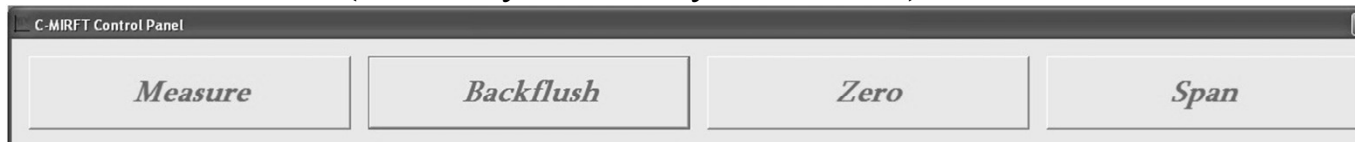


# C-MIRFT – Control Panel

Measure mode



Backflush mode (stand-by mode, system fault)



Zero mode (background, zero check)



Calibrate and zero



# Pressures and Flow

- ◆ Continuous Meas. 850 - 950mbar
- ◆ Daily Background (N<sub>2</sub>) 1050-1060mbar ~2.5-3.5l/min
- ◆ Span gas 1040 - 1050mbar ~ 3.5l/min
- ◆ Backflush(dry air) 1050 - 1100mbar >3.5l/min
- ◆ Interferometer Purge (dry air) ~ 0.2-0.3l/min (just above ambient)



# Common faults and alarms

- ◆ The HOFI box will alarm when either the temperature for the heated oven filter or the heated sample probe drops or rises above its set point by +/- 5 degrees C. There is one common alarm for both faults so you will have check inside the HOFI box to determine what the actual fault is.
- ◆ The MIR-FT and G52m FID analysers will automatically switch into Back flush mode if any alarms are activated, this is to protect the system from severe damage.
- ◆ Alarm for MIR-FT in control room, in the CEMS shelter the calcmet screen seems OK, but no measurement countdown timer visible. Press the 1 second single measurement button to update hardware settings. This will show if the thermal fuse (or any other internal analyser component) has failed as the MIR-FT cell temperature will update and be below 180 degrees C.
- ◆ If the temperature readings are erratic its possible that there is a faulty temperature controller or SSR within the system. Low temperature usually means a fuse has failed.



# Residual Alarm

- ▶ Residual alarms on MIR-FT analysers, caused by a bad zero background calibration (or water calibration needed). Check N2 supply, check background shape on calcmeter, start a new N2 Background calibration and re-start continuous measurement cycle.

In case of 'Residual Alarm' the following action should be taken:

- ◆ Check Nitrogen inlet pressure on the gas regulator. If it's zero connect a new bottle. (set outlet pressure to 2 bar). You can expect problems with Residual Alarm usually after unsuccessful zero calibration – Empty N2 bottle, bottle turned off or faulty solenoid valve.
- ◆ Perform zero calibration (Background) – Stop measurement (Click Cancel, then Yes), Click Measure, then Background.
- ◆ The system will then inject nitrogen to produce a 'zero' reference graph.
- ◆ Remember to place CEMS system back into sample mode and start continuous measurement on Calcmeter software.



# Plant maintenance

1. Check compressed air supply to MDS driers.
2. Check hydrogen H<sub>2</sub>He supply and connect new cylinders when low.
3. Check nitrogen pressure (min 15 bar) and connect new cylinders, set outlet pressure to 2 bar.
4. Clean air conditioner filters.
5. Clean analysers inlet filters.
6. Keep room free of dust.
7. Carry out QAL3 procedures



**Questions?**

**End of part one**



# **CDAS Software**



# What is CDAS?

**CDAS is a data collection package aimed at the needs of the waste incineration and power industries.**

- Collect data from instruments
- Process data to reportable conditions as per permit
- Store data for future reporting
- Produce reports to Agency/Site requirements
- Allow site to monitor their current emissions to enable compliance with permit limits.



# CDAS Legislative Compliance

## Main data collection program

- CDAS Advanced
  - EN14181 – QAL 2
- CDAS Elite
  - EN14181 – QAL 3

## Separate Report Package

- CDAS Report
  - EN14181 support as per main program



# CDAS Main Program

## Three Programs

### Data Collection

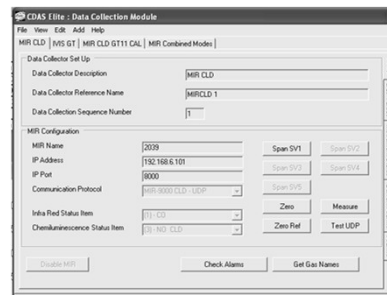
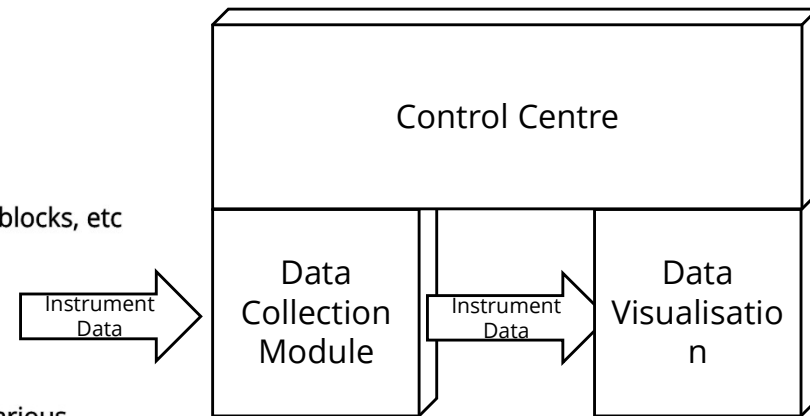
- Collects data from instruments, I/O, DCS, etc
- Used to configure QAL2 factors, QAL3 Settings, comms settings, function blocks, etc

### Data Visualisation

- Displays data in useable format – Raw, Calibrated, Corrected, Adjusted, Various averages, Graphical data, Tabular data, Gauges

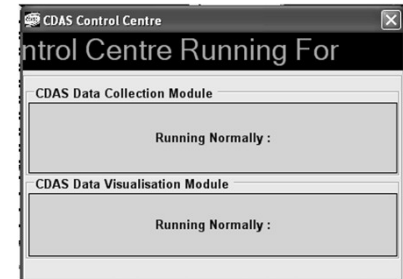
### Control Centre

- Ensures continuous running of DCM & DV

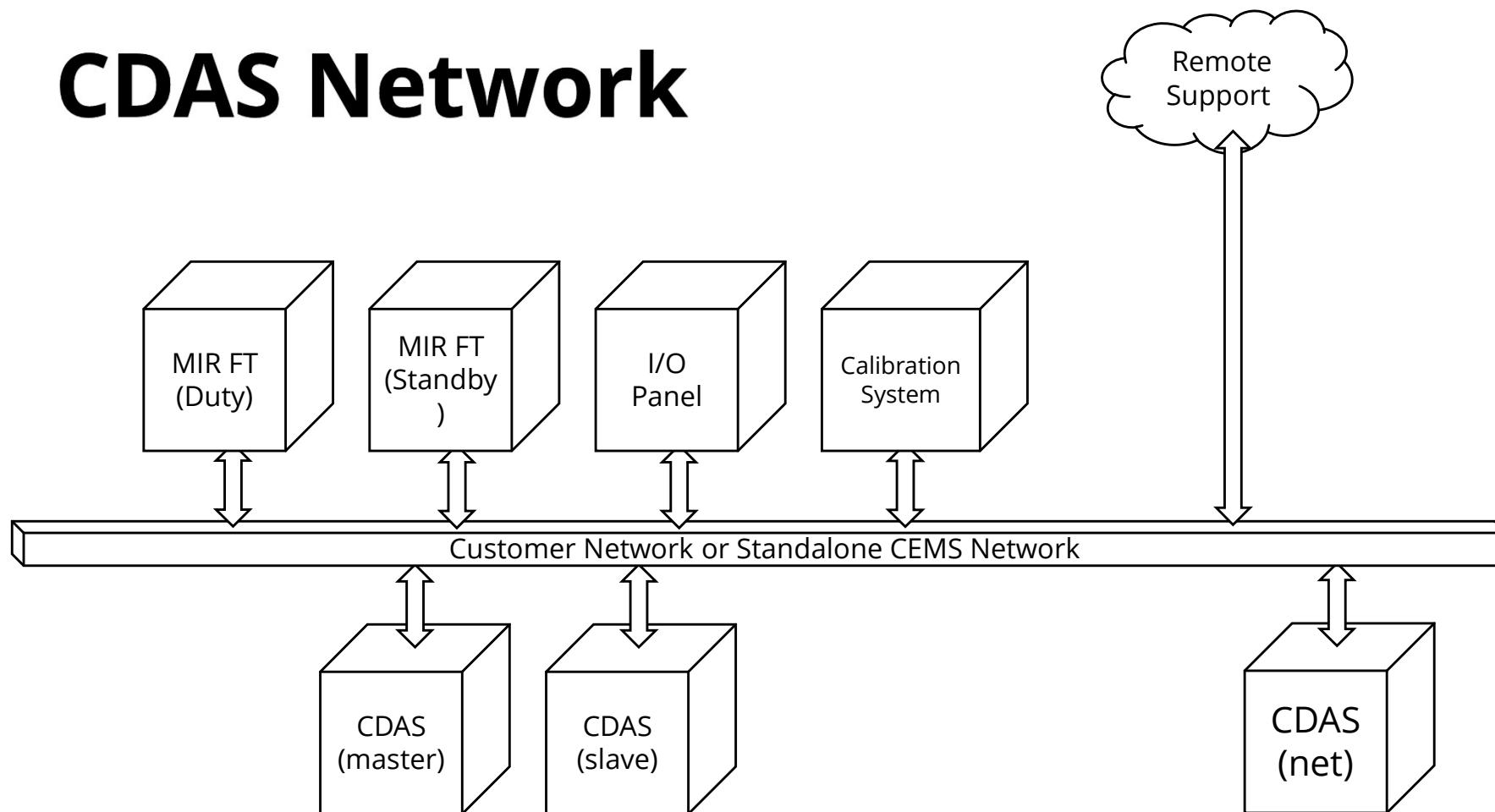


The screenshot shows the 'CDAS Elite - Service Dangle - Eleven' window. It displays a table with columns: Raw Data, Calibrated Data, Corrected Data, Adjusted Data, and One Minute Average. The rows show data for NO (CLD) mg/m3, NO2 (CLD) mg/m3, NOx (CLD) mg/m3, CO mg/m3, O2 %, and H2O ppm. All data values are 'N/A'.

|                 | Raw Data | Calibrated Data | Corrected Data | Adjusted Data | One Minute Average |
|-----------------|----------|-----------------|----------------|---------------|--------------------|
| NO (CLD) mg/m3  | N/A      | N/A             | N/A            | N/A           | N/A                |
| NO2 (CLD) mg/m3 | N/A      | N/A             | N/A            | N/A           | N/A                |
| NOx (CLD) mg/m3 | N/A      | N/A             | N/A            | N/A           | N/A                |
| CO mg/m3        | N/A      | N/A             | N/A            | N/A           | N/A                |
| O2 %            | N/A      | N/A             | N/A            | N/A           | N/A                |
| H2O ppm         | N/A      | N/A             | N/A            | N/A           | N/A                |



# CDAS Network



# CDAS Redundancy



# Data Collection & Processing

## Data Collectors

- Talk to Instruments
- Communicate with Remote I/O
- Apply QAL 2 Functions

## Data Processors

- Data Switches
- Relay Logic
- Maths
- Standard Formulae
- Calibration
- Bit to Word Convertors
- Limiters
- Latching Digitals
- Digital Combining



# Data Collection & Processing

## Channels

Collection of values, normally all linked in some way

- No Software Limit on the number of Channels
- Each Channel can contain any number of items
- Each Channel can be set to use a digital as a “Plant On” signal

## Items

- Individual Correction and Alarm Settings
- Can take data from any Data Collector or Processor



# Data Collection & Processing

## Standard Conditions

The Environmental Permit requires all gas concentrations to be standardised to the following conditions:

- Ambient pressure 1013 mbar
- Temperature 0°C
- Dry gas
- Reference oxygen level



# Data Collection & Processing

## Data Stages & File Types

CDAS stores data at various stages. They are generated in the following sequence:

- Raw Data Files (.CRAW)

Raw data files contain the raw data as read directly from the instruments.

- Calibrated Data Files (.CCAL)

Calibrated data files contain the data after any EN 14181 calibration adjustments have been made to the data.  $Y=AX+C$

- Corrected Data Files (.CCOR)

Corrected data files contain data after the values have been corrected to standard conditions.

- Adjusted Data Files (.CADJ)

Adjusted Data files contain the final data after the confidence interval has been applied to any items that require it.



# Data Collection & Processing

## Long Term Averages

Averages calculated for five pre-set time periods:

- 10 minute
- 15 minute
- 30 minute
- 1 hour\*
- 1 day\*

Three types of average are available for each one.

- Rolling Averages
- Current Fixed Average
- Last Fixed Average



# CDAS Security

## Access to CDAS

There are four levels of access to CDAS:

- CDAS Default User

Default User Logged in When Program Starts

- User

Lowest level of named user access

- Operator

Access to all areas, except system critical settings

- Administrator

Full access to all settings



# CDAS Security

## Data Security

CDAS Data Files

- Stored on Main PC
- Never Deleted
- One File per day per calculated value
- Encrypted (Triple DES) and flagged as read only
- Automatic back up on the PC in second data folder
- Options to back up to other locations



# Data Visualisation

## On Screen Elements

### Grids

- Current Values of Averages

### Graphs

- Trend Historical Data (up to 2 days)

### Gauges

- Customisable view of one average

### Digital Indicators

- Status of Digitals

### Screen Configurations

- Method of saving current screen layout



# Data Visualisation

## On Screen Elements

CDAS Elite 2.1.4.4 - Ferrybridge

File Edit View Users Create Window Help

Load Save

Standby Data

|                                        | Raw Data | Calibrated Data | Corrected Data | Adjusted Data | One Minute Average |
|----------------------------------------|----------|-----------------|----------------|---------------|--------------------|
| Standby Analyser - NO mg/m3            | 0.0      | 0.0             | 0.0            | 0.0           | 0.0                |
| Standby Analyser - NO2 mg/m3           | -0.2     | -0.2            | -0.2           | -0.2          | -0.2               |
| Standby Analyser - NOx mg/m3           | 0.0      | 0.0             | 0.0            | 0.0           | 0.2                |
| Standby Analyser - CO mg/m3            | -0.7     | -0.7            | -0.7           | -0.7          | -0.9               |
| Standby Analyser - SO2 mg/m3           | -4.5     | -4.5            | -4.5           | -4.5          | -4.8               |
| Standby Analyser - HCl mg/m3           | 0.0      | 0.0             | 0.0            | 0.0           | 0.0                |
| Standby Analyser - NH3 mg/m3           | 0.0      | 0.0             | 0.0            | 0.0           | 0.0                |
| Standby Analyser - VOC mg/m3           | 1        | 1               | 1              | 1             | 1                  |
| Standby Analyser - Dust mg/m3          | 0.2      | 0.2             | 0.3            | 0.3           | 0.3                |
| Standby Analyser - N2O mg/m3           | 0.3      | 0.3             | 0.3            | 0.3           | 0.3                |
| Standby Analyser - O2 Dry %            | N/A      | 17.4            | 17.4           | 17.4          | 17.4               |
| Standby Analyser - Stack Temperature C | 102.4    | 102.4           | 102.4          | 102.4         | 102.2              |
| Standby Analyser - Stack Pressure mbar | 1014.4   | 1014.4          | 1014.4         | 1014.4        | 1014.3             |
| Standby Analyser - Stack Flow kNm3/hr  | 0.0      | 0.0             | 0.0            | 0.0           | 0.0                |
| Standby Analyser - Moisture %          | 0.06     | 0.06            | 0.06           | 0.06          | 0.06               |
| Standby Analyser - O2 Wet %            | 17.35    | 17.35           | 17.35          | 17.35         | 17.35              |
| Standby Analyser - CO2 %               | 0.05     | 0.05            | 0.05           | 0.05          | 0.04               |

Digital Indicator

CMIRFT in Alarm

CMIRFT in Measure

CMIRFT In Zero Reference

CMIRFT in Zero

CMIRFT in No Measure

CMIRFT in Span

CMIRFT in Maintenance

Digital Indicator

FID in Alarm

FID in Measure

FID in Zero Reference

FID in Zero

FID in No Measure

FID in Span

Measuring

Time left: 12.0

Cancel

Data Received 25 March 2015 10:31:01

CBSS Service Engineer



# Data Visualisation

## On Screen Elements

CDAS Elite: 2.1.4.4 - Ferrybridge

File Edit View Users Create Window Help

Load Save Print Refresh Help

### Standby Data

|                              | Raw Data | Calibrated Data | Corrected Data | Adjusted Data | One Minute Average |
|------------------------------|----------|-----------------|----------------|---------------|--------------------|
| Standby Analyser - NO mg/m3  | -0.3     | -0.3            | -0.3           | -0.3          | -0.1               |
| Standby Analyser - NO2 mg/m3 | 0.1      | 0.1             | 0.1            | 0.1           | -0.4               |
| Standby Analyser - NOx mg/m3 | 0.1      | 0.1             | 0.1            | 0.1           | 0.2                |
| Standby Analyser - CO mg/m3  | -0.9     | -0.9            | -0.9           | -0.9          | -0.8               |
| Standby Analyser - SO2 mg/m3 | -4.7     | -4.7            | -4.7           | -4.7          | -4.7               |
| Standby Analyser - HCl mg/m3 | -0.1     | -0.1            | -0.1           | -0.1          | 0.0                |

### Configure Grid

Select Items for the Grid Rows

Standby Analyser NO mg/m3

Add Row Delete Selected Rows

Select Items For the Grid Columns

General Date

Add Column Delete Selected Columns

Raw Data  
Calibrated Data  
Corrected Data  
Adjusted Data  
One Minute Average

Standby Analyser - NO mg/m3  
Standby Analyser - NO2 mg/m3  
Standby Analyser - NOx mg/m3  
Standby Analyser - CO mg/m3  
Standby Analyser - SO2 mg/m3  
Standby Analyser - HCl mg/m3  
Standby Analyser - NH3 mg/m3  
Standby Analyser - VOC mg/m3  
Standby Analyser - Dust mg/m3  
Standby Analyser - N2O mg/m3  
Standby Analyser - O2 Dry %  
Standby Analyser - Stack Temperature C  
Standby Analyser - Stack Pressure mbar

☒ Show Channel Names on the Grid  
☒ Show Item Name on the Grid

Window Caption: Standby Data

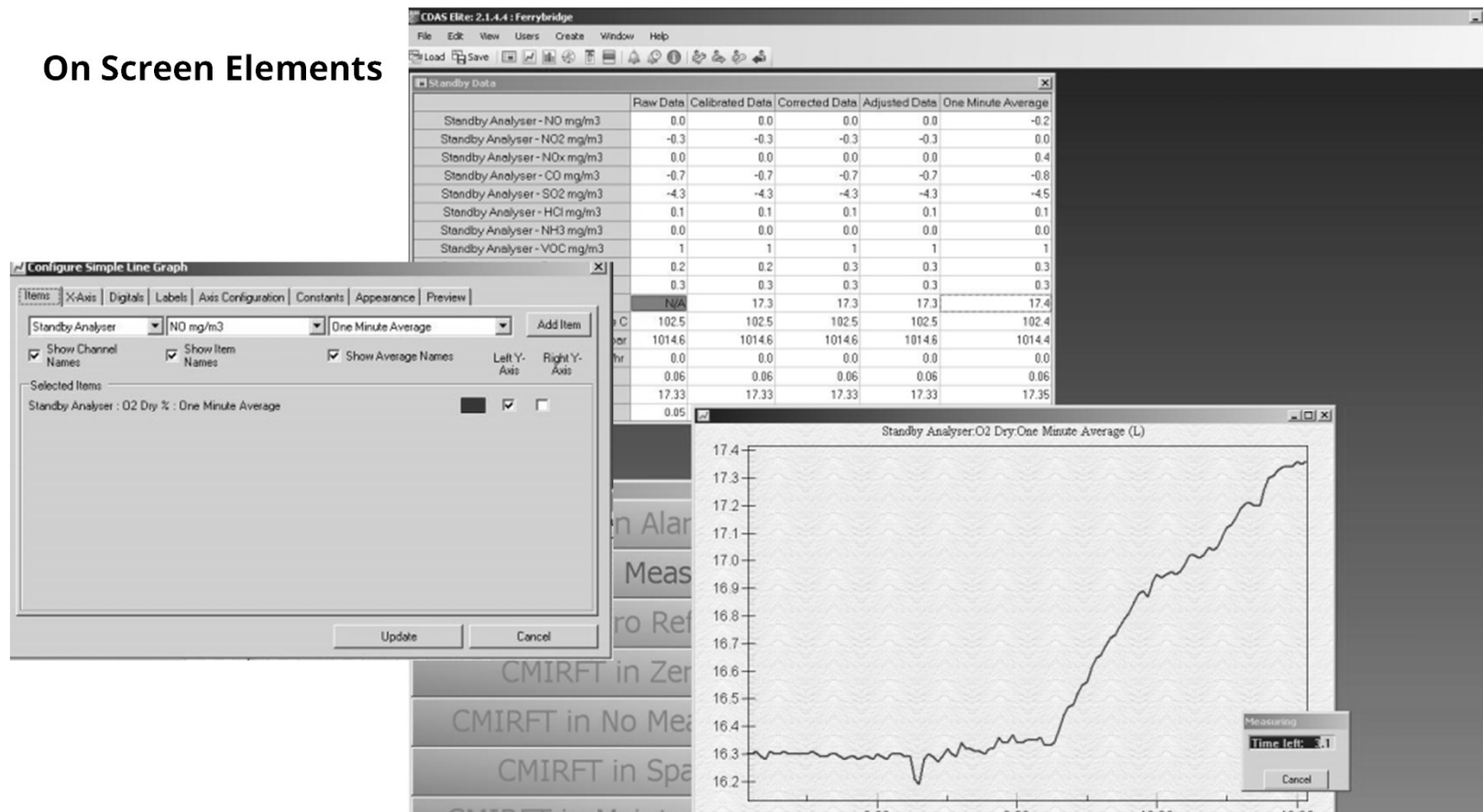
Select Font Update Grid Cancel

Example Font Text



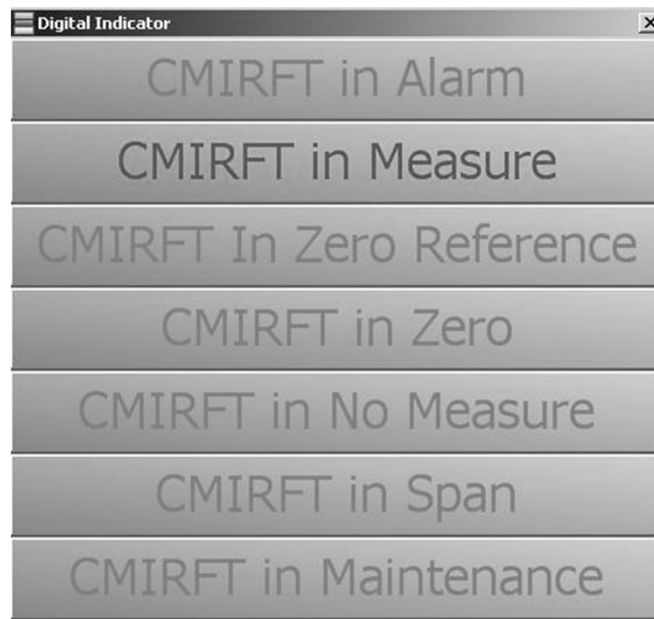
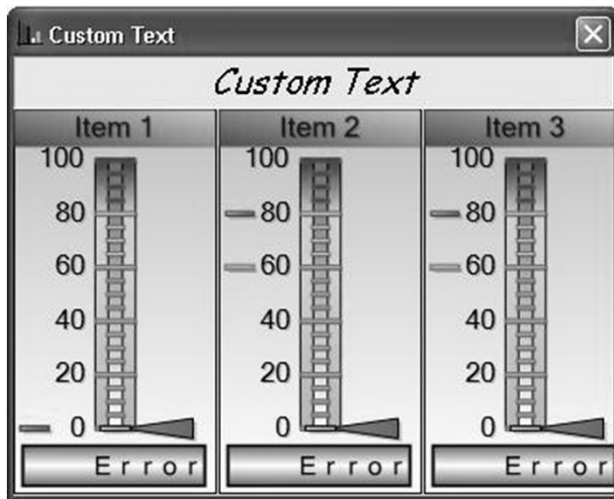
# Data Visualisation

## On Screen Elements



# Data Visualisation

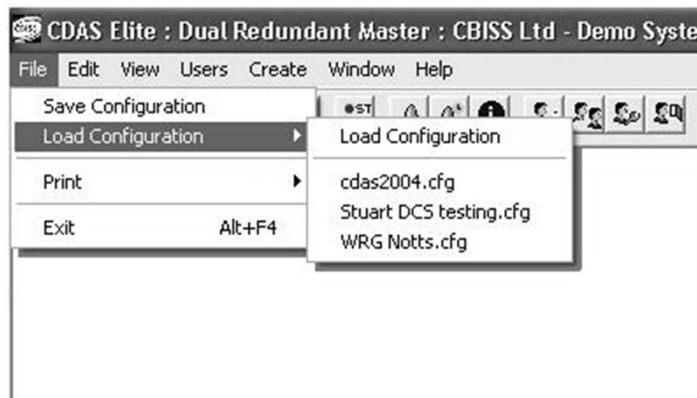
## On Screen Elements



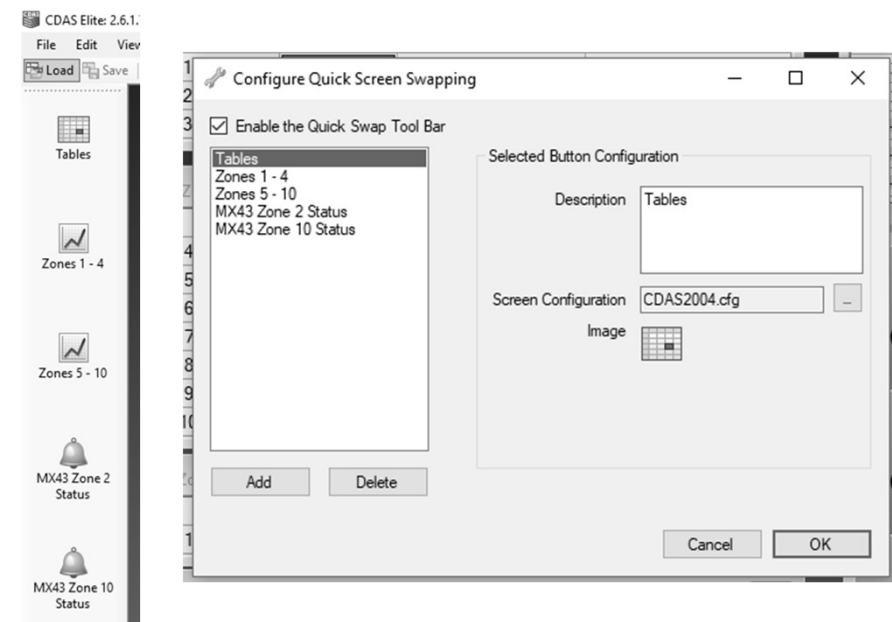
# Data Visualisation

## Screen Configurations

### The Old Way



### The New Way



# Alarms

**For each average on each measured value**

- High High Alarm
- High Alarm
- Low Alarm
- Low Low Alarm

## **Effects of alarms**

- Entry in the Alarm Log
- Audible
- Energise a relay
- Cell changes colour on Grid
- Send SMS Messages



# Alarms

## Current Alarms

CDAS Elite : Current Analogue Alarms (2 Alarms) : Current Digital Alarms (No Alarms)

Active Alarm

Ignored Alarm

Accepted Alarm

Accept All Alarms

| Channel Name : | Item Name : | Alarm Type :                       | Limit : | Current Value : | High / Low : | Time Of Alarm : | Time of Acceptance : |
|----------------|-------------|------------------------------------|---------|-----------------|--------------|-----------------|----------------------|
| System One     | NOx         | One Minute Average - HH            | 50.00   | 100.00          | 100.00       | 26 Feb 14:36:22 |                      |
| System One     | NOx         | Rolling Thirty Minute Average - HH | 50.00   | 100.00          | 100.00       | 26 Feb 14:36:01 |                      |

Digital Description :

Alarm Message :

Current Digital State :

Time Of Alarm :

Time of Acceptance :

## Historical Alarms

Alarm History : Displaying 2 Alarms.

DateUsersDigital AlarmsSystem OneSystem TwoOther Inputs

Date Filter

Start Date25 February 2008

End Date26 February 2008

Apply Filter

Reset Filter

Print

Exit

| Alarm Description                        | Time of Alarm         | Alarm Accepted | Alarm Cleared | Acc... | User When Cleared | User When Occurred     | Reason | High/L... |
|------------------------------------------|-----------------------|----------------|---------------|--------|-------------------|------------------------|--------|-----------|
| System One NOx One Minute Average ...    | Tue 26 Feb 2008 14:36 | ---            | ---           | ---    | ---               | CBISS Software Engi... |        | N/A       |
| System One NOx Rolling Thirty Minute ... | Tue 26 Feb 2008 14:36 | ---            | ---           | ---    | ---               | CBISS Software Engi... |        | N/A       |



# Reports

## Reports From Main CDAS Program

### Daily reports

- Print automatically
- Preview today's report
- Reprint yesterday's report

### Period reports

- Print automatically
- Based on CDAS Report Templates
- Available for Reporting intervals other than Daily

## Reports From CDAS Report

### Variety of pre defined reports

- Day Reports
- Month Reports
- Annual Reports
- Mass Reports
- Percentile Reports

### Agency Reports

- EA/SEPA WID Monthly
- EN 14181 QAL 2 Weekly Distribution
- EN 14181 QAL 3 Shewart/CUSUM



# Reports

## Running a new report

Select The Dates For the Report To Run Between (1 of 6)

 Monitoring & control for your environment

**CDAS Elite Report**

**Daily Report Wizard**

**Please Select the Dates for the Report**

Start Date of Report: 01 January 2008

End Date of Report: 31 January 2008

Same Day As Start Date

|             |                            |             |
|-------------|----------------------------|-------------|
| - One Week  | One Week After Start Date  | + One Week  |
| - One Month | One Month After Start Date | + One Month |
| - 3 Months  | 3 Months After Start Date  | + 3 Months  |
| - One Year  | One Year After Start Date  | + One Year  |

Cancel < Back Next > Finish



# Reports

## Running a new report

The image shows two overlapping windows from the CDAS Elite Report Wizard. The background window is titled "Select The Dates For the Report To Run Between (1 of 6)". It features the CBISS logo and a sidebar with the text "Monitoring & control for your environment", "CDAS Elite Report", "Daily Report Wizard", and "Please Select the Dates for the Report". The main area has a "Start Date of Report" dropdown set to "01 January 2008" and an "End Date of Report" dropdown.

The foreground window is titled "Select The Data Files to Used For The Report (2 of 6)". It also features the CBISS logo and the same sidebar. The main area includes a checkbox for "Include Data When Channel Is Off Line", a "Type of Data File to Use" dropdown set to "Adjusted Data", and a text box explaining: "Adjusted data files contain data that has been completely adjusted to the conditions and corrections required for reporting purposes." Below this is an "Output Data Type" dropdown set to "Ddoc Print Previewer". At the bottom are buttons for "Cancel", "< Back", "Next >", and "Finish".



# Reports

## Running a new report

The image displays three overlapping screenshots of the CBISS report wizard interface, showing the first three steps of the process.

**Step 1: Select The Dates For the Report To Run Between (1 of 6)**

Start Date of Report: 01 January 2008

End Date of Report: [Empty]

**Step 2: Select The Data Files to Used For The Report (2 of 6)**

☐ Include Data When Channel Is Off Line

Type of Data File to Use: Adjusted Data

**Step 3: Select and Configure the Averages to Report for Each Month (3 of 7)**

**CDAS Elite Report**

**EA Monthly Report Wizard**

Please Select The Averages For The Report

Configure Average to Use

Base Period Average: Half Hourly

No of Valid Data Points Per Base Average: 20

Average to Report: Daily

No of Valid Data Points Per Average: 43

Report Configuration

Show Report Issue Date: ☒ 01 January 2008

Font Size: 7

Title Position: Centre

Grid Style: EA Standard 2006+

Configure Graph Styles

Period ELV Colour: [Black]

Daily ELV Colour: [Black]

Period Average Colour: [Black]

Bar Width: 75

Period ELV Line Dashed: ☐

Daily ELV Line Dashed: ☐

Daily Average Colour: [Black]

Show Graph Border: ☐

Buttons: Cancel, < Back, Next >, Finish



# Reports

## Running a new report

The image shows three overlapping screenshots of the CBISS report wizard, illustrating the steps to run a new report:

- Step 1: Select The Dates For the Report To Run Between (1 of 6)**
  - Start Date of Report: 01 January 2008
  - End Date of Report: (empty)
- Step 2: Select The Data Files to Used For The Report (2 of 6)**
  - Include Data When Channel Is Off Line: ☐
  - Type of Data File to Use: Adjusted Data
- Step 3: Select and Configure the Averages to Report for Each Month (3 of 7)**
  - Configure Average to Use**
    - Base Period Average: Half Hourly
    - No of Valid Data Points Per Base Average: 20
    - Average to Report: Daily
    - No of Valid Data Points Per Average: 43
  - Report Configuration**
    - Show Report Issue Date: ☒
    - Font Size: 7
    - Title Position: Centre
    - Grid Style: EA Standard 2006+
  - Configure Graph Styles**
    - Period ELV Colour: (dark grey)
    - Daily ELV Colour: (dark grey)
    - Period Average Colour: (dark grey)
    - Bar Width: 75
    - Period ELV Line Dashed: ☐
    - Daily ELV Line Dashed: ☐
    - Daily Average Colour: (black)
    - Show Graph Border: ☐

## Templates

- Templates can be used to store settings from a wizard
- Templates are specific to their Wizard
- More than one template can be saved for each report type

The image shows the final step of the CBISS report wizard:

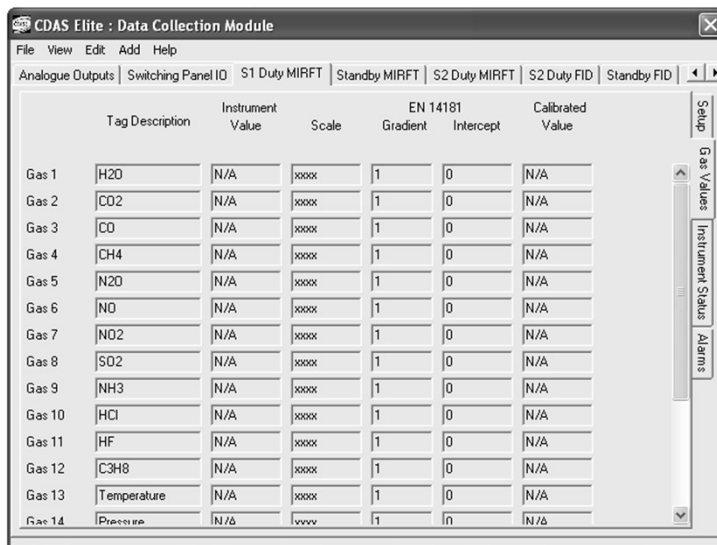
- Step 6: Select a File Name for The Template Report (6 of 6)**
  - Message: "You have now completed the configuration of this report. Should you wish to save this configuration for future use, click on the Save button below."
  - Message: "Saving the report configuration will allow users to rerun this report for other date ranges without the need to reselect all the configuration options."
  - Buttons: Cancel, < Back, Next >, Finish, Save Configuration



# EN14181

## QAL2

- Calibration of Instrument to SRM instrument
- Each Species on each analyser gives a calibration formulae in the form  $y = mx + c$
- Within CDAS m and c values are entered.



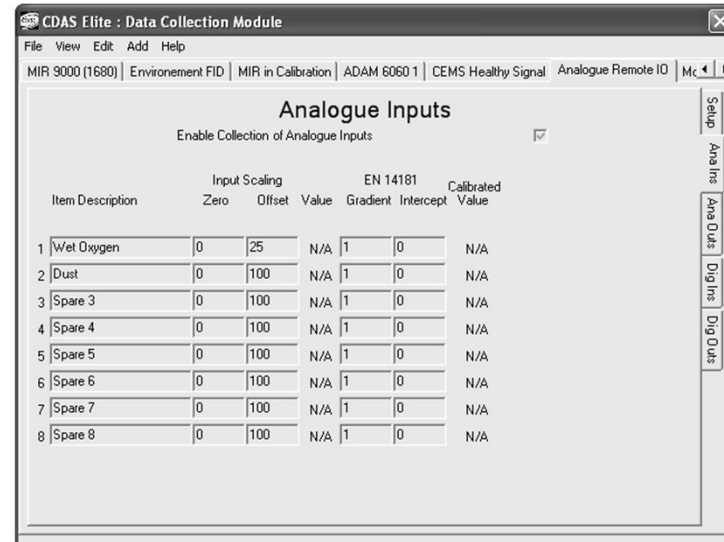
CDAS Elite : Data Collection Module

File View Edit Add Help

Analogue Outputs | Switching Panel ID | S1 Duty MIRFT | Standby MIRFT | S2 Duty MIRFT | S2 Duty FID | Standby FID

|        | Tag Description | Instrument Value | Scale | EN 14181 |           | Calibrated Value |
|--------|-----------------|------------------|-------|----------|-----------|------------------|
|        |                 |                  |       | Gradient | Intercept |                  |
| Gas 1  | H2O             | N/A              | xxxx  | 1        | 0         | N/A              |
| Gas 2  | CO2             | N/A              | xxxx  | 1        | 0         | N/A              |
| Gas 3  | CO              | N/A              | xxxx  | 1        | 0         | N/A              |
| Gas 4  | CH4             | N/A              | xxxx  | 1        | 0         | N/A              |
| Gas 5  | N2O             | N/A              | xxxx  | 1        | 0         | N/A              |
| Gas 6  | NO              | N/A              | xxxx  | 1        | 0         | N/A              |
| Gas 7  | NO2             | N/A              | xxxx  | 1        | 0         | N/A              |
| Gas 8  | SO2             | N/A              | xxxx  | 1        | 0         | N/A              |
| Gas 9  | NH3             | N/A              | xxxx  | 1        | 0         | N/A              |
| Gas 10 | HCl             | N/A              | xxxx  | 1        | 0         | N/A              |
| Gas 11 | HF              | N/A              | xxxx  | 1        | 0         | N/A              |
| Gas 12 | C3H8            | N/A              | xxxx  | 1        | 0         | N/A              |
| Gas 13 | Temperature     | N/A              | xxxx  | 1        | 0         | N/A              |
| Gas 14 | Pressure        | N/A              | xxxx  | 1        | 0         | N/A              |

Setup | Gas Values | Instrument Status | Alarms



CDAS Elite : Data Collection Module

File View Edit Add Help

MIR 9000 (1680) | Environment FID | MIR in Calibration | ADAM 6060 1 | CEMS Healthy Signal | Analogue Remote ID | M...

### Analogue Inputs

Enable Collection of Analogue Inputs ☒

| Item Description | Input Scaling |        | Value | EN 14181 |           | Calibrated Value |
|------------------|---------------|--------|-------|----------|-----------|------------------|
|                  | Zero          | Offset |       | Gradient | Intercept |                  |
| 1 Wet Oxygen     | 0             | 25     | N/A   | 1        | 0         | N/A              |
| 2 Dust           | 0             | 100    | N/A   | 1        | 0         | N/A              |
| 3 Spare 3        | 0             | 100    | N/A   | 1        | 0         | N/A              |
| 4 Spare 4        | 0             | 100    | N/A   | 1        | 0         | N/A              |
| 5 Spare 5        | 0             | 100    | N/A   | 1        | 0         | N/A              |
| 6 Spare 6        | 0             | 100    | N/A   | 1        | 0         | N/A              |
| 7 Spare 7        | 0             | 100    | N/A   | 1        | 0         | N/A              |
| 8 Spare 8        | 0             | 100    | N/A   | 1        | 0         | N/A              |

Setup | Ana Ins | Ana Outs | Dig Ins | Dig Outs



# EN14181

## QAL3

A check to ensure analysers are still working as intended

### For each gas on an analyser

- Perform a Zero Check
- Perform a Span Check
- Produce a control chart to check if gas is out of control
- If out of control, take correcting action

## QAL3 Report Types

- Shewhart
- CUSUM (Cumulative Sum)
- Summary of Zero and Span Results
- EWMA (Exponentially Weighted Moving Average)



# EN14181

## Computer Controlled QAL3

- Software is configured to run a test at fixed intervals
- Instructs instrument to span and zero each gas in turn
- Records the Zero and Span values to file
- Generates Control Charts to determine if instrument remains within Control Parameters



# EN14181

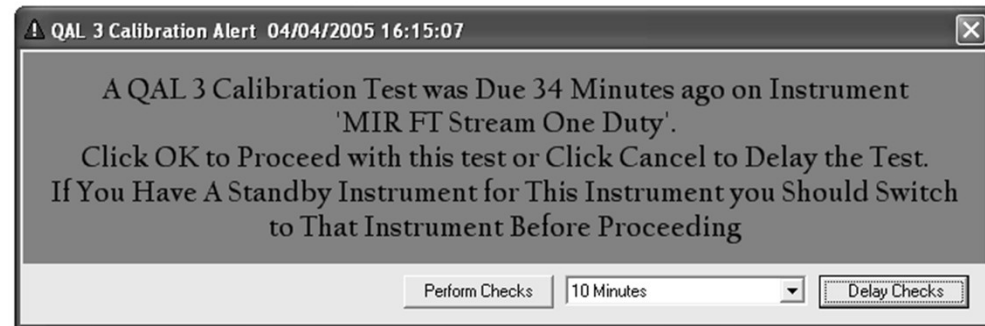
## QAL3 Span & Zero Check

### Software control of the QAL 3 process

- Fully Automatic
- Semi Automatic
- Manual
- Automatic Report Generated

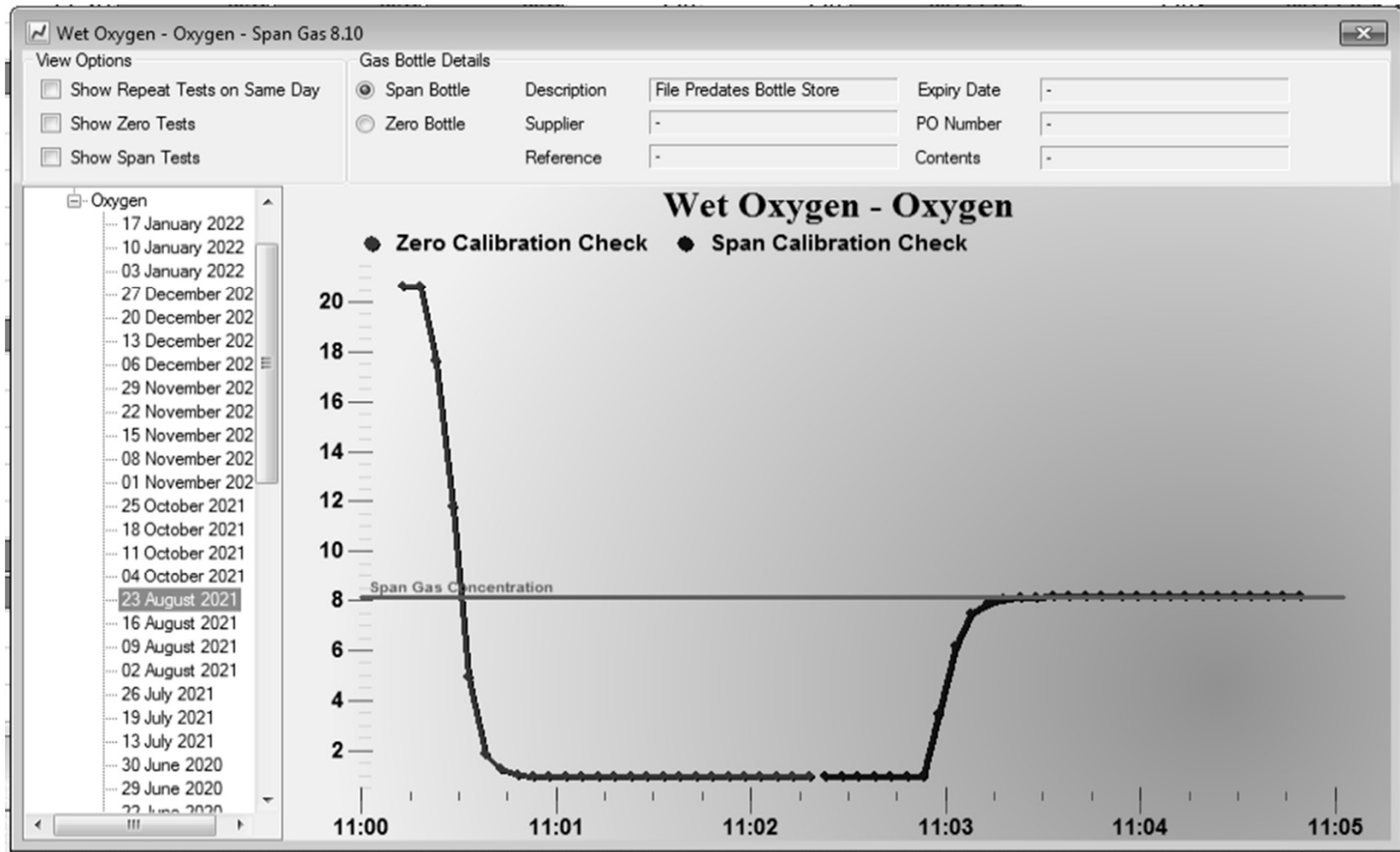
### End of Test Determination

- Statistical Analysis of Data Points to Determine if Plateau has been reached
- Not Dependant on Expected Span Value
- All the Tests Data is logged to a Separate File

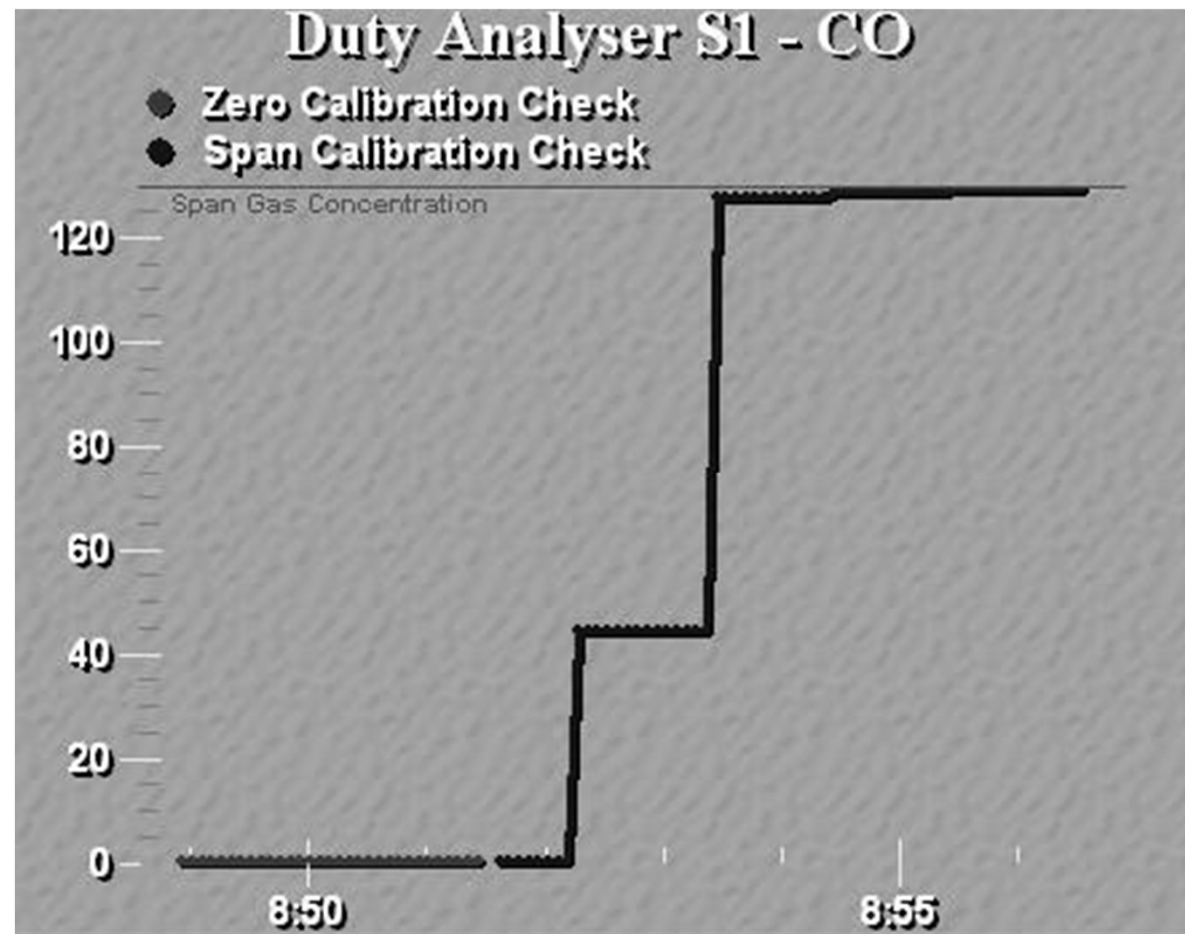


# EN14181

## QAL3 Span & Zero Check



# EN14181

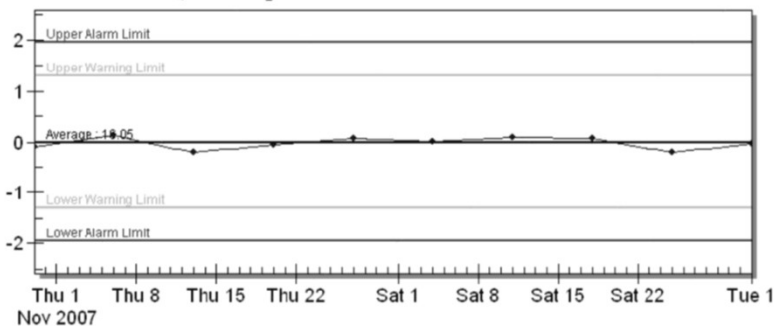


# EN14181

## QAL3 – Shewhart Chart Examples

QAL3 Report For CO2 from 30 October 2007 to 01 January 2008  
Report printed at 09:58 on the 14 February 2008

EN14181 QAL 3 Span Shewhart Chart for FLUE U2 : CO2

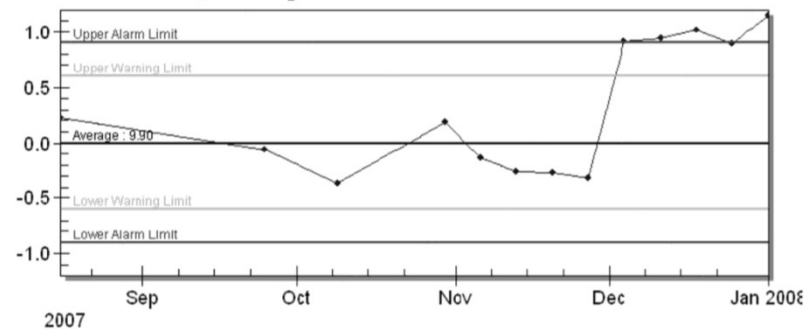


FLUE U2 CO2 Sams Value = 0.65

Pass - FLUE U2 CO2 - No Intervention Conditions Met.

QAL3 Report For O2 from 16 August 2007 to 01 January 2008  
Report printed at 09:58 on the 14 February 2008

EN14181 QAL 3 Span Shewhart Chart for FLUE U2 : O2



FLUE U2 O2 Sams Value = 0.30

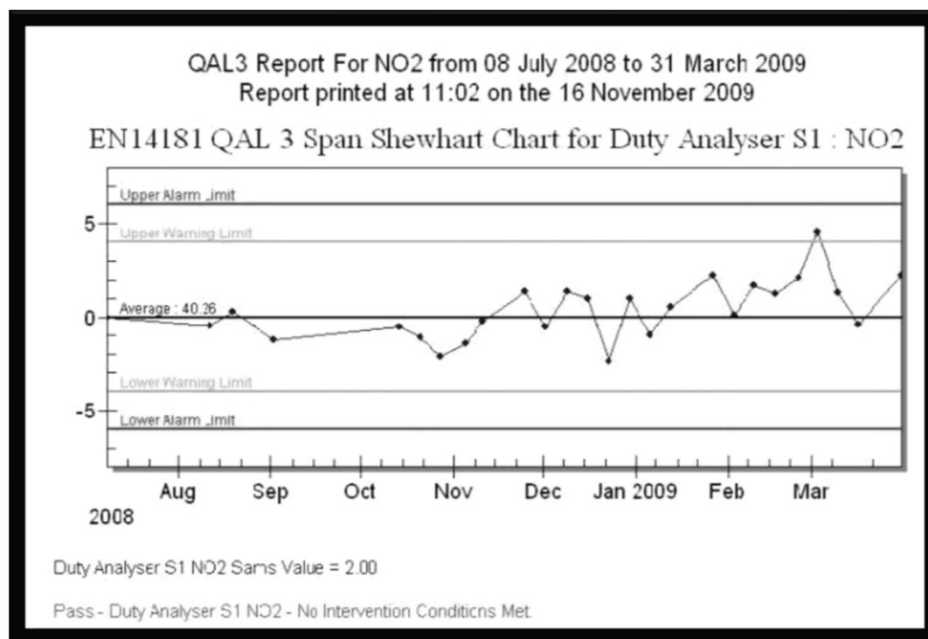
Failure - FLUE U2 O2 - Single Point Outside of Alarm Limit.

Failure - FLUE U2 O2 - Three Consecutive Points Above Warning Level.



# EN14181

## QAL3 – Shewhart Chart Examples

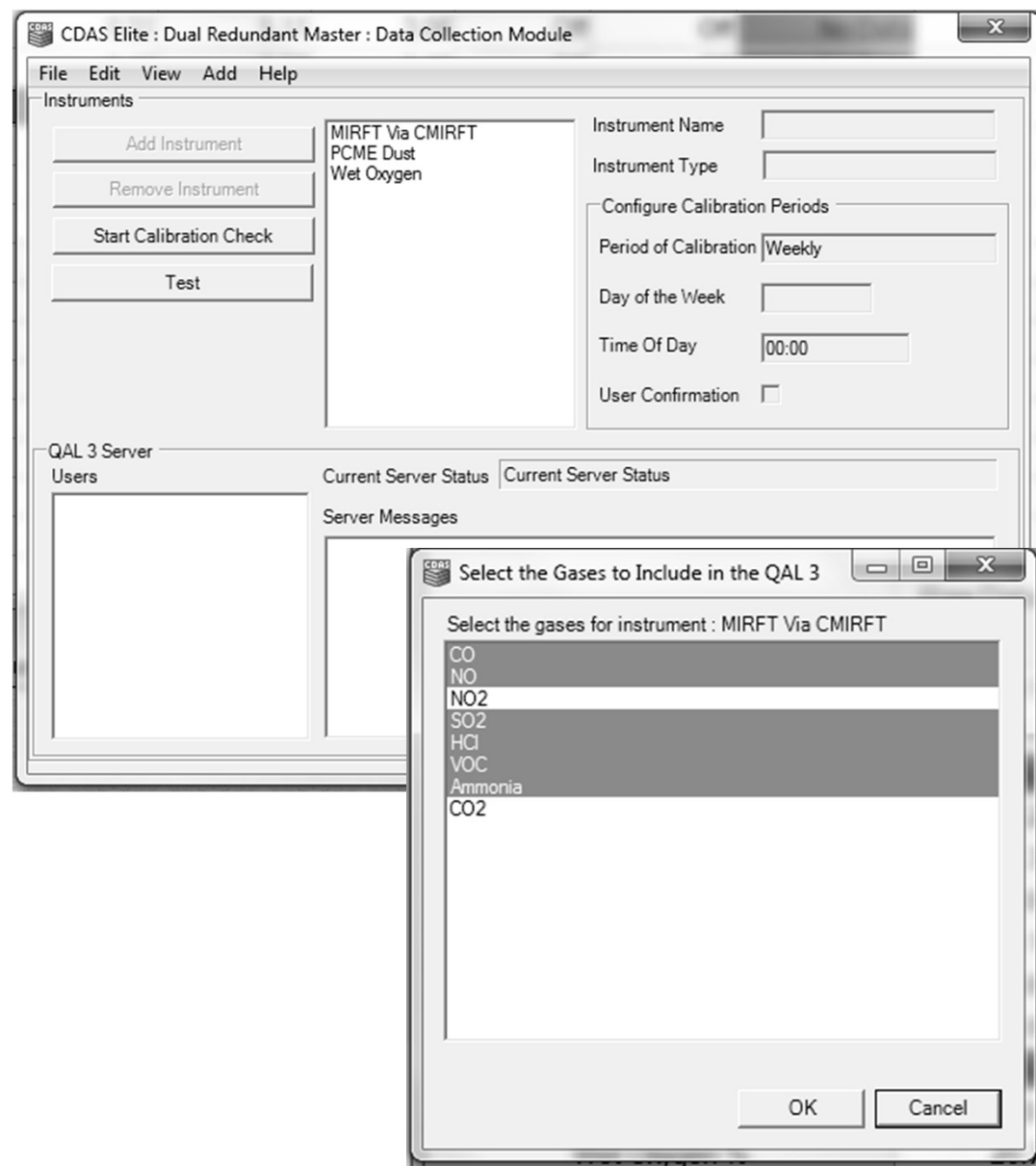


# EN14181

## Starting a Manual Test

To start a Manual test follow the following steps.

- Log into CDAS as an administrator
- Select View – DCS
- When the DCS Window appears select View – Instruments \
- Click on the instrument in the list you want to run a test for
- Click on the Run Calibration Now button, this will cause the normal window to appear on the main copy of CDAS Elite to confirm the start of a test.
- Click on Perform Tests on the confirmation window



# EN14181

## QAL3 Settings

The screenshot shows the 'CDAS Elite: Dual Redundant Master: Data Collection Module' window. It features a menu bar with 'File', 'Edit', 'View', 'Add', and 'Help'. The main interface is divided into several sections:

- Instruments:** A list on the left contains 'MIRFT Via CMIRFT', 'PCME Dust', and 'Wet Oxygen'. To the right of this list are four buttons: 'Add Instrument', 'Remove Instrument', 'Start Calibration Check', and 'Test'.
- Instrument Configuration:** On the right side, there are input fields for 'Instrument Name' and 'Instrument Type'. Below these is a section titled 'Configure Calibration Periods' which includes a dropdown for 'Period of Calibration' (set to 'Weekly'), a text field for 'Day of the Week', a text field for 'Time Of Day' (set to '00:00'), and a 'User Confirmation' checkbox.
- QAL 3 Server:** At the bottom, there is a section for 'QAL 3 Server' which includes a 'Users' list (currently empty), a 'Current Server Status' field (displaying 'Current Server Status'), and a 'Server Messages' area (currently empty).

# EN14181

## QAL3 Settings

**Edit Instrument Settings :**

**Configure Calibration Periods**

Period of Calibration: Weekly Day of the Week: Monday

Time Of Day: 09:00 User Confirmation: ☐

**CMIRFT Controlled MIRFT Analyser**

Instrument Settings | Gas Settings

Instrument Fault Interlock Digital: Duty MIR FT (1) - MIR In Measurement Mc

Digital to Indicate Instrument In Calibration: CDAS System Outputs (1) - QAL3 in Progress

Data Collector For the MIR Instrument: Duty MIR FT

OK Cancel

# EN14181

## QAL3 Settings

**Edit Instrument Settings :**

Configure Calibration Periods

Period of Calibration: Weekly Day of the Week: Monday

Time Of Day: 09:00 User Confirmation: ☐

CMIRFT Controlled MIRFT Analyser

Instrument Settings Gas Settings

Add Gas Delete Gas

Current Gas: CO

Gas Name: CO ☒ Include Gas ☐ Send Gas Via Probe

Gas Item: Duty MIR FT (3) - CO

Zero Value: 0.00 Zero Sams: 1.41 Zero Gas Valve No: 1

Zero Gas Bottle: Nitrogen (Nitrogen 99.99 %)

Span Value: 102.60 Span Sams: 2.46 Span Gas Valve No: 4

Span Gas Bottle: mixed gas (CO 80.3 ppm, NO 195.5 ppm, SO2 70 ppm)

Number of Data Points For Stats: 21.0

Maximum Time For Test (s): 300.0

Start Date: 28 September 2021

Reset Baseline

OK Cancel

# EN14181

## **Replacing gas cylinders or other surrogates**

When replacing gas cylinders, differences in the concentrations of cylinders may mislead an operative into believing that the CEMS has drifted. This is because 2 gas cylinders with seemingly identical contents can produce different readings in a CEMS because of the uncertainty of the concentrations. This results in a step change in the CEMS readings when a cylinder is changed for another. Hence it is important to differentiate and account for such step changes instead of mistaking such changes for drift. Therefore, when changing gas cylinders, the following steps are recommended:

Take at least 5 span readings with the current gas cylinder and then take an average of the readings.

If the span readings using the current gas cylinder show that the CEMS has not drifted beyond the action limits since the last span readings, then go to step 4.

If the CEMS has drifted, then carry out any necessary actions to remedy this; then proceed to step 4.

Take at least 5 span measurements using the replacement span-gas cylinder and then set a new baseline for the control-chart span-level using an average of the 5 measurements.

Sets of readings with an existing cylinder, followed by an equal number of readings with a second cylinder, will establish the magnitude of any step-changes.

# EN14181

## What to do if a QAL3 fails.....

### Don't panic!

A failed QAL3 does not mean you have to come offline/shutdown

Check the basics – Were the gas bottles connected correctly? Correct outlet pressure? (2 bar)

Sufficient flow to analyser? (3lpm)

Have you recently changed bottles?

Has maintenance recently been carried out?

If none of the above solve the issue call the service provider and ask them to investigate.

The QAL3 failure may indicate that a part is failing or that maintenance is required.

**Questions?**

**End of part two**

