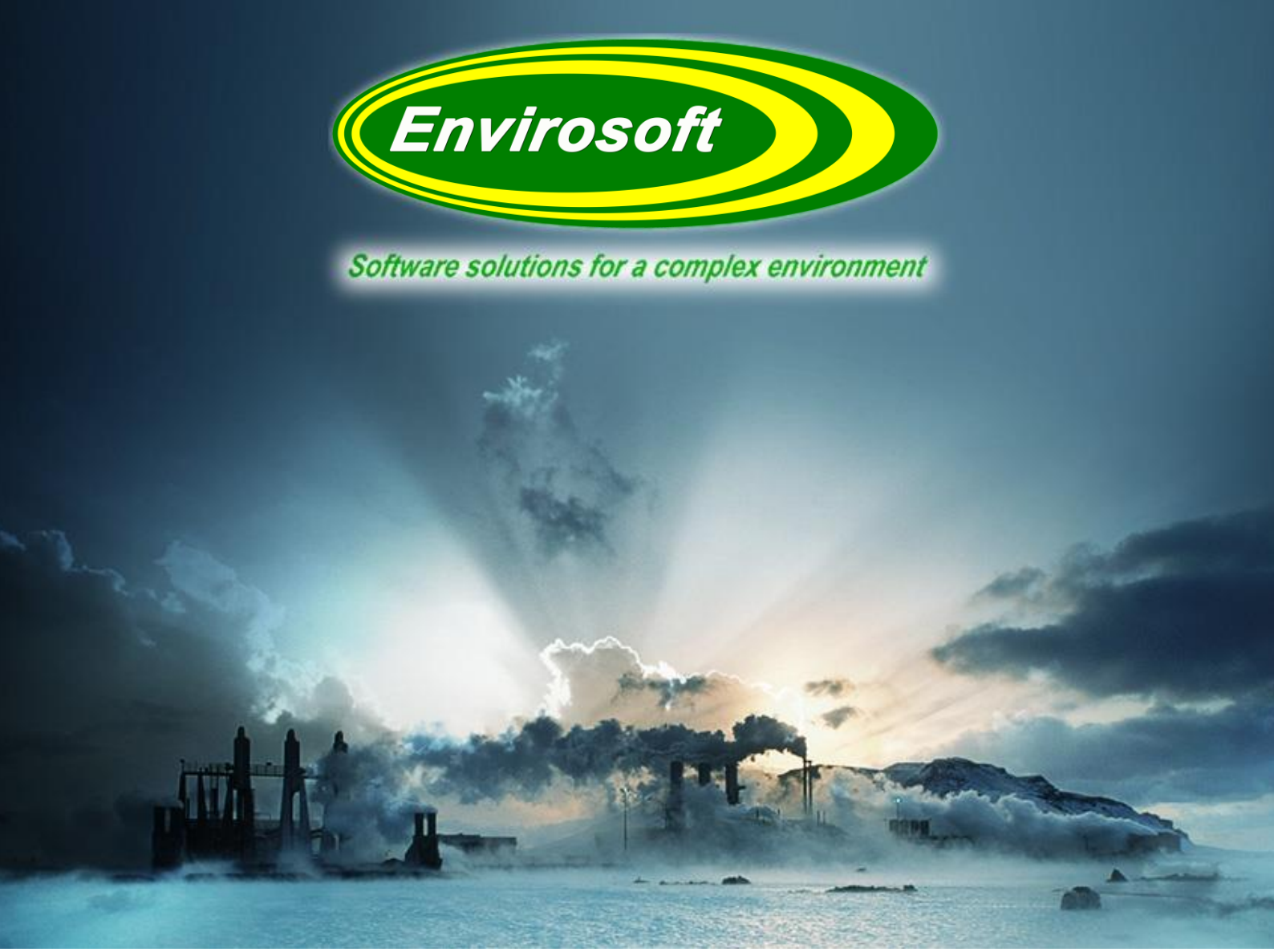


# CEMQual User Manual
# Ver. 1.21

DOC ID UM13

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# 2 INTRODUCTION

## 2.1 CEMQUAL

**CEMQual** is a PC based program, designed to operate under Windows operating systems. Operation is performed by using simple mouse instructions.

**CEMQual** forms part of an Envirosoft Ltd suite of environmental programs.
Envirosoft Ltd environmental programs are:

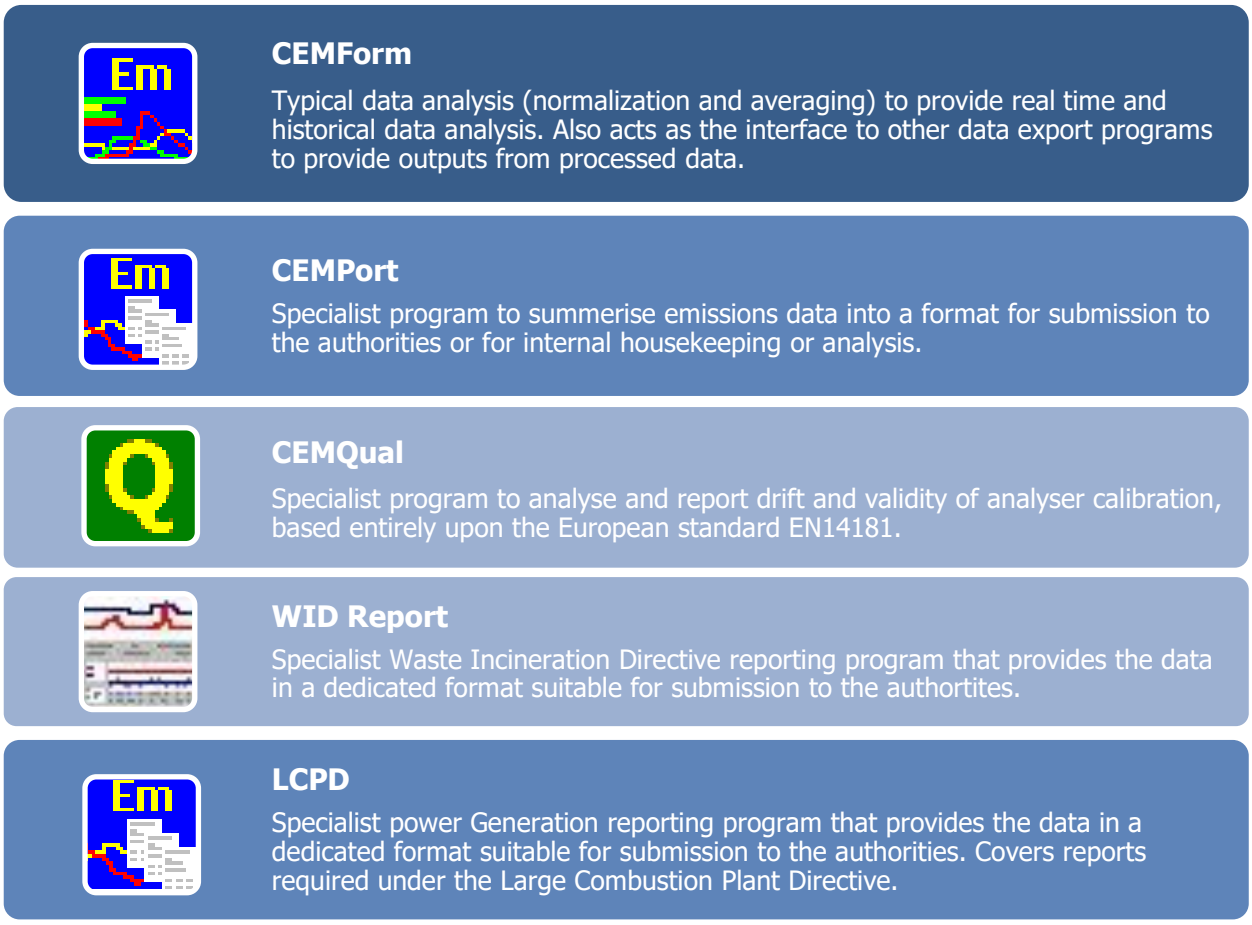



**Figure 1 Envirosoft Ltd - Environmental Programs**

## 2.2 THE CEMQUAL PROGRAM

CEMQual, a module of CEMSuite, is a specialist program that enables operators to make all the calculations, graphs and reports required to comply with the requirements of the European Standard EN 14181 – QAL3.

### 2.2.1 EN 14181

EN14181 is a European standard that was written to formalise the methods for assessing the quality of the measurements of stationary source emissions. There are three major parts of this standard:

1. QAL1; Quality during manufacture.
2. QAL2; Quality after initial installation.
3. QAL3; Routine, ongoing quality of the measurements.

QAL1 and QAL2 are usually outside of the plant operators' scope, and Envirosoft have concentrated on the QAL3 part of the standard – the ongoing assessment of the quality of these measurements. This is the most onerous part of the standard to assess as it is ongoing and requires the entry of data from the installed CEMS so that errors in drift and precision may be assessed. An extract from this standard is below:

*"QAL 3 is a procedure to check drift and precision to demonstrate that the AMS is in control during its operation so that it continues to function within the required specifications for uncertainty. This is achieved by conducting periodic zero and span checks of the AMS - based on those used in the procedure for zero and span repeatability tests according to EN ISO 14956 - and then evaluating the results obtained using control charts. Zero and span adjustments or maintenance of the AMS may be necessary depending on the results of this evaluation."*

QAL3 requires that both the drift and precision of measurements are checked using control charts. There are many interpretations of how the drift should be checked – CUSUM, EWMA, SHEWHART etc, but only one example of testing for precision, and this is another CUSUM-type check. The mathematics behind these checks are detailed within this manual.

### 2.2.2 MATHEMATICAL CALCULATION

All the mathematical formulae and calculations used within CEMQual are taken from:-

A) BS EN 14181 - Stationary source emissions - Quality assurance of automated measuring systems.

B) TGN M20 - Selection, installation, calibration and quality assurance of continuous emission monitoring systems (For the application of BS EN 14181 and BS EN 13284-2) published by the Environment Agency.

C) STATIONARY SOURCE EMISSIONS – GUIDANCE ON THE APPLICATION OF EN14181:2004, CEN/TC 264/WG 9N, dated 2008 – 12.

## 2.3 THE CEMQUAL MANUAL

This manual describes the operation and function of the CEMQual program and explains how to use the program to display the information as required.

In writing this software and manual, we have used the standard itself, the Environment Agency Technical Guidance Note (TGN) M20, and CEN/TC 264 – Guidance on the application of EN 14181.

For information concerning any of the other CEMSuite programs please refer to the relevant documentation.

# 3 SOFTWARE OPERATION

## 3.1 COMPUTER REQUIREMENTS

**PC Requirements (minimum)**

Processor: Intel i5
Memory: 4GB Ram
Graphics: Intel HD 3000
Display: 1920x1080 pixel resolution. 21" monitor or greater.
Hard disk: 250 GB
Modem/Dongle: Required for support
Operating system: Windows 7/8/10

The software will operate on PCs with lesser specifications. However, some operators involve lengthy calculations and the time taken to perform them may become tiresome.

## 3.2 INSTALLATION

Envirosoft will normally pre-install the necessary software. If not, the installation will be carried out on site by an Envirosoft Engineer. However, the software can be provided on CD-ROM. To install from the CD, open Windows explorer, or 'My Computer', select the relevant drive and run the setup program.

**Note:** If the CD drive has been set for 'Auto insert notification', the installation should start automatically.

Once started follow the instructions on the screen. The installation program creates files and folders and provides a shortcut to start the program from the Windows Start button.

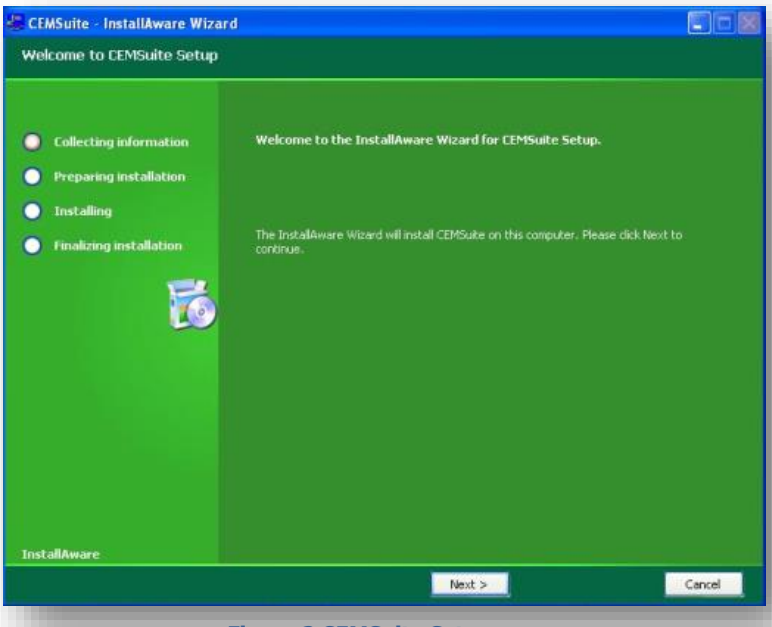



Figure 2 CEMSuite Setup

*Installation continued…*

**Note:** Once the installation has completed, the PC's Borland Database Engine will also need to be installed /updated. CEMSuite will start this process automatically.

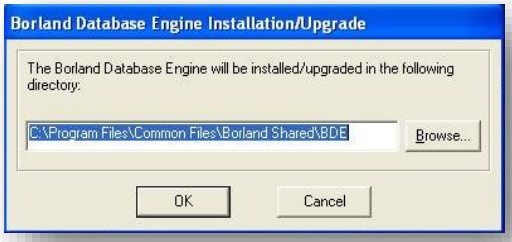



**Figure 3 Borland Database Engine**

### 3.2.1 USB INSTALLATION

The software may be supplied with a USB 'dongle' and will not function without it being present in a USB socket. To install the dongle drivers, use Windows Explorer to locate a sub-directory on the CD-Rom called 'Dongle driver' and open up this sub-directory. Double-click on the file called setupdrv.exe and this will install the dongle drivers. The CEMQual program will now operate normally.

## 3.3 ASSOCIATED PROGRAMS

A typical CEMSuite system will consist of one or more Data Storage Units (DSU) that will gather the CEMS data from various sources and store the data in a local database table; this storage is completely independent of the CEMSuite PC or Server operation. The CEMServer software will upload and process this raw data into minute average files on the CEMSuite PC.

CEMServer consists of the following programs:

### 3.3.1 CEMSYNC

Envirosoft's program CEMSync should be in operation to copy the historic and live data sets from the DSU(s). This may be seen in the taskbar as the following icon:

**Figure 4 CEMSync Icon**

The timing of the CEMSync program operations is:

- Between 5 and 10 seconds past each minute: copy the short term live data set from the DSU(s).
- Between 10 and 25 seconds past each minute: process the above data.
- At 20 past midnight, download the historic data for the previous day and completely refresh the rolling 24-hour data set.

### 3.3.2 CEMSOCKET

Should there be more than one DSU on the CEMSuite system, Envirosoft's program CEMSocket should be in operation on the taskbar; it has the following icon:

**Figure 5 CEMSocket Icon**

### 3.3.3 CEMCOMM

CEMComm is a windows based program that operates on the DSU in standard Envirosoft systems (CEMs PC in basic systems) and is designed to communicate with/collect data from analysers and data acquisition modules. CEMComm provides basic data gathering for all Envirosoft systems.

# 4 PROGRAM OPERATION

## 4.1 STARTING THE PROGRAM

Start the program by double-clicking the left-hand mouse button on the CEMQual icon; which should now reside on the PC desktop. Alternatively, it can also be started by pressing the Windows Start Button > Programs > Envirosoft > CEMQual.

**Figure 6 Desktop Shortcut to CEMQual**

## 4.2 INITIAL SCREEN

After the program has been started a 'tabbed notebook' style program provides access to the QAL3 analysis and the configuration pages.

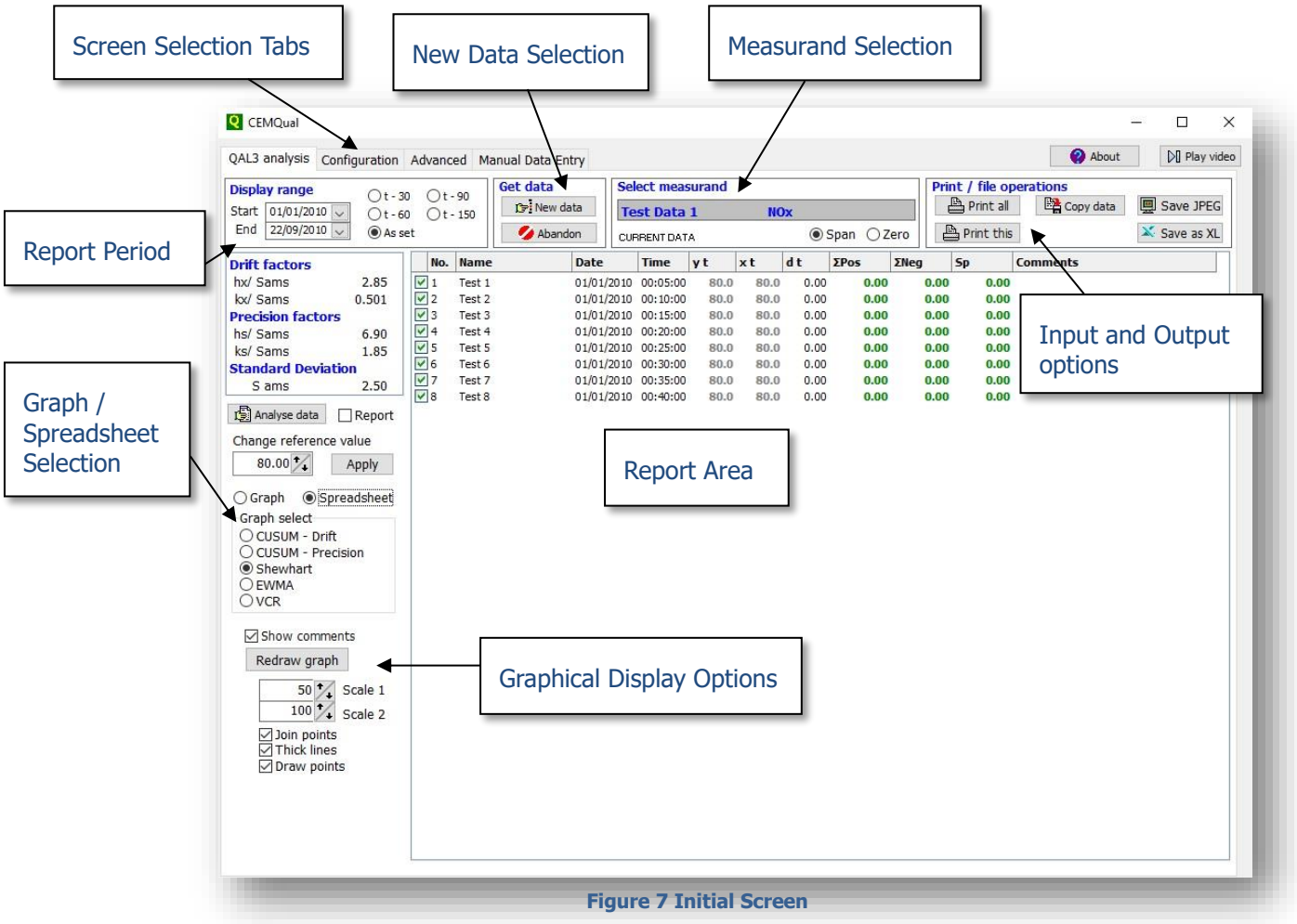



**Figure 7 Initial Screen**

On startup QAL3 data for the first measurand will be displayed as either as a spreadsheet style data grid or as a control chart.

A quick start guide is now described that should allow the operator to display the QAL3 data immediately.

# 5 QUICK START GUIDE

The program may be used to display the QAL3 data over a selected time period, for any appropriate measurement on the CEMSuite system. After it has been configured it is a simple matter to access the QAL3 data, and a step by step list follows:

1. Select the required group by clicking the drop down menu.
2. Once you have selected the group, a list of measurands is generated for that particular group.
3. Now select the time period over which to view the results for, as shown by 3 in the image below; period is expressed in days. Alternatively, enter the start and end dates for analysis manually.
4. To use a manual search, select the 'start' and 'end' dates then click the radio button 'As set' circled by 4A.
5. Data for either the span or zero analysis may be selected by pressing the labelled radio buttons.

**Figure 8 Quick Start Flow**

CEMQual will now recall the stored QAL3 and it will appear automatically in the grid area, along with the date/ time, gas bottle ID, and the calculated EN14181 parameters. (If selected, it will appear as a chart).

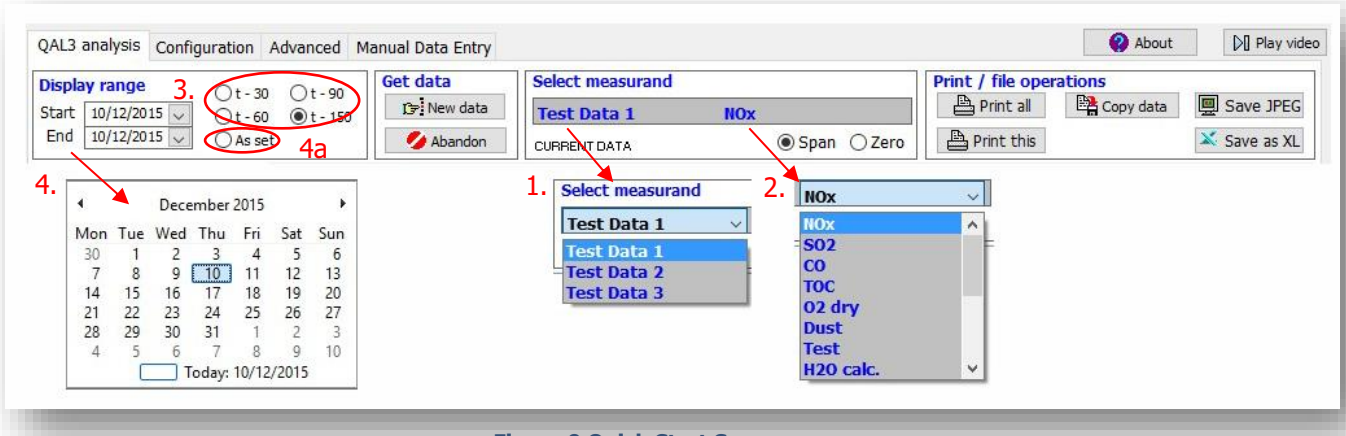



**Figure 9 Quick Start Screen**

## 5.1 CHARTS

After start up the program will access the current QAL3 data set for the first measurand and display it as a Shewhart chart – discussed later. The data is also available to view in different ways by simple mouse operations, these are described in this first section.

*(The factors shown here are used to determine limits for Drift and Precision. More information can be found in CUSUM drift calculation details).*

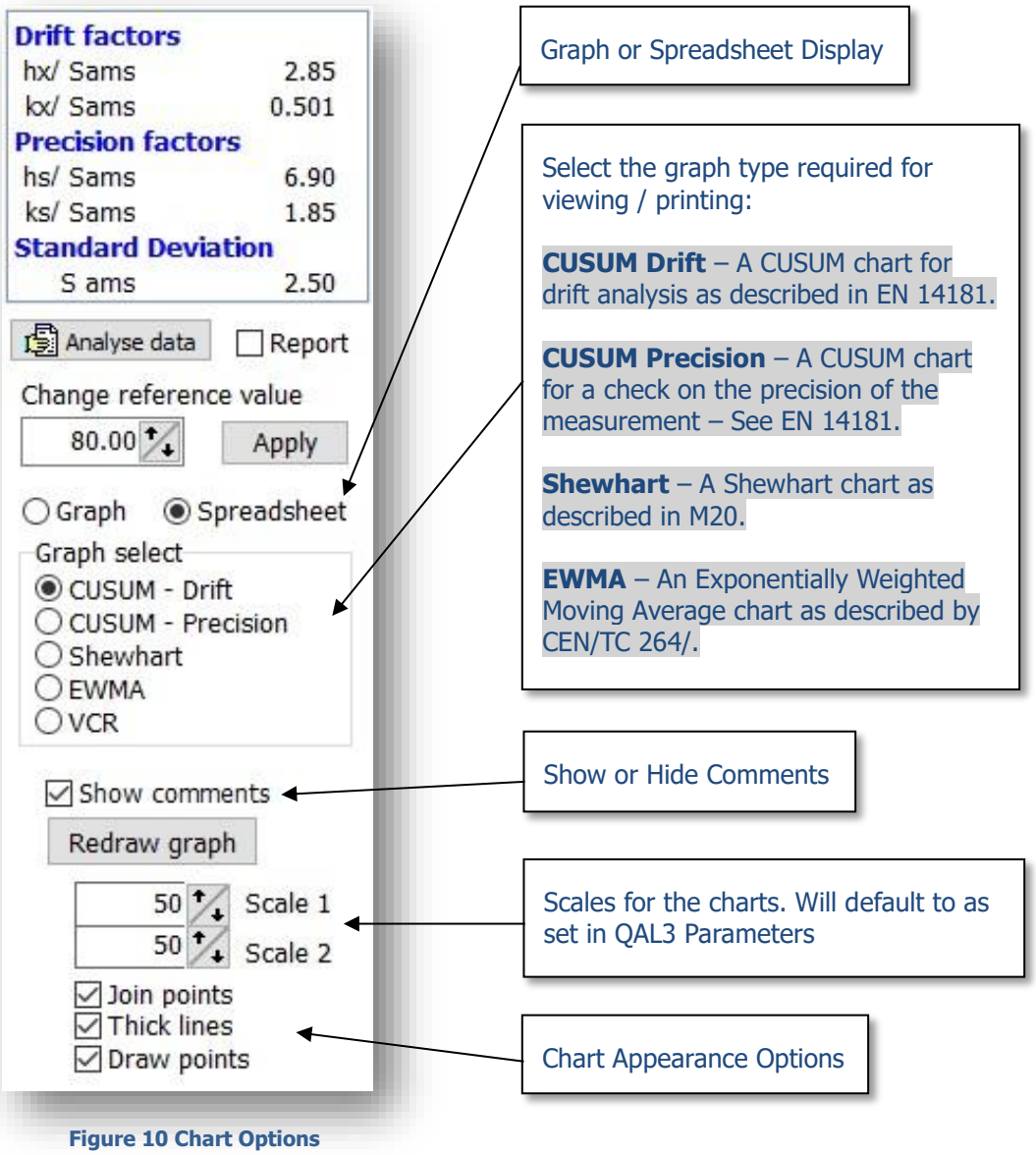



**Figure 10 Chart Options**

These spreadsheets and chart features are now described in more detail. They may be accessed quickly by checking the appropriate box or by individual selection from the top of the chart area.

## 5.1.1 CUSUM DRIFT

With CUSUM Drift selected, clicking on the 'Graph' radio button circled below will bring up a chart similar to the one shown here. Both positive and negative drift are displayed, along with the CUSUM drift limits. Looking at the example below, points have gradually declined past the negative drift limit.

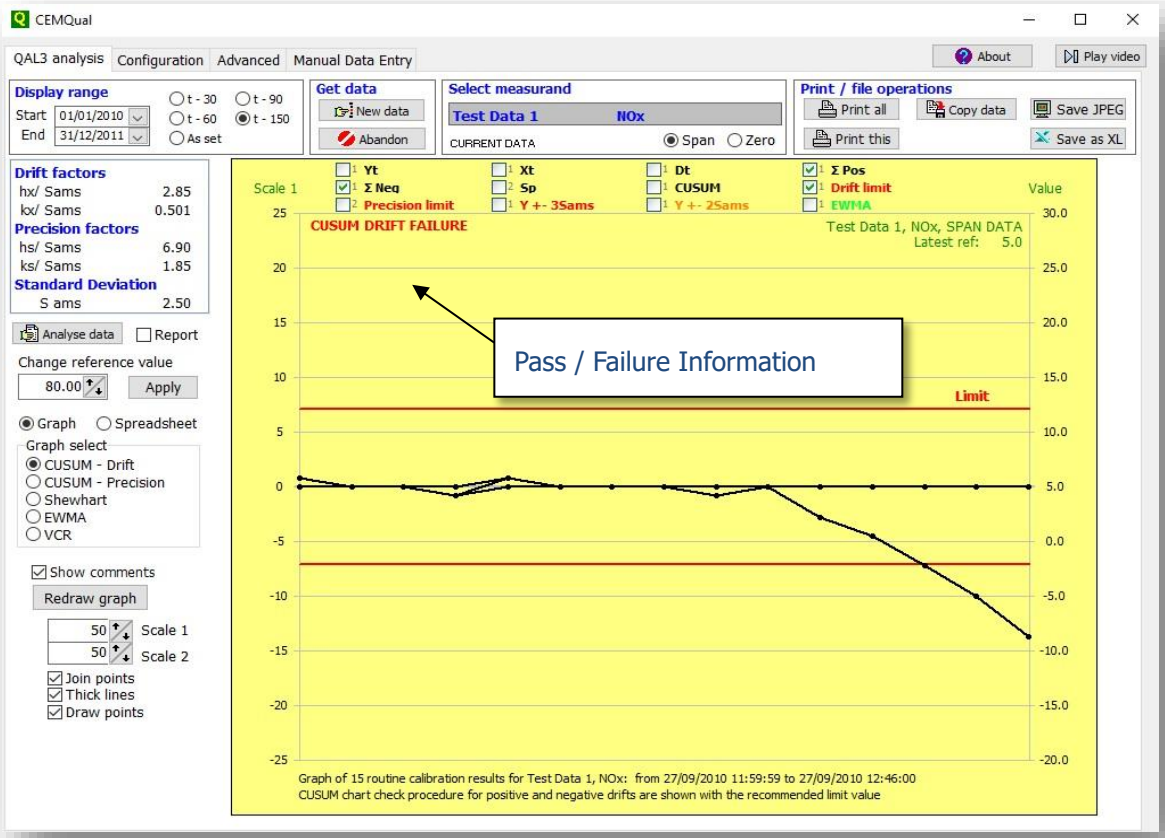



**Figure 11 CUSUM Drift Chart**

Below is how this graph would look in spreadsheet format. Looking at points 13, 14 and 15, they have declined below the drift limit as the text is highlighted red within the ∑Neg column.

| No. | Name | Date | Time | y t | x t | d t | ΣPos | ΣNeg | Sp |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Test 1 | 30/11/2007 | 13:39:00 | 82 | 80 | 2.00 | 0.75 | 0.00 | 0.00 |
| 2 | Test 2 | 30/11/2007 | 13:39:00 | 79 | 80 | -1.00 | 0.00 | 0.00 | 0.00 |
| 3 | Test 3 | 30/11/2007 | 13:39:00 | 80 | 80 | 0.00 | 0.00 | 0.00 | 0.00 |
| 4 | Test 4 | 30/11/2007 | 13:39:00 | 78 | 80 | -2.00 | 0.00 | 0.75 | 0.00 |
| 5 | Test 5 | 30/11/2007 | 13:39:00 | 82 | 80 | 2.00 | 0.75 | 0.00 | 0.00 |
| 6 | Test 6 | 30/11/2007 | 13:39:00 | 79 | 80 | -1.00 | 0.00 | 0.00 | 0.00 |
| 7 | Test 7 | 30/11/2007 | 13:39:00 | 80 | 80 | 0.00 | 0.00 | 0.00 | 0.00 |
| 8 | Test 8 | 30/11/2007 | 13:39:00 | 79 | 80 | -1.00 | 0.00 | 0.00 | 0.00 |
| 9 | Test 9 | 30/11/2007 | 13:39:00 | 78 | 80 | -2.00 | 0.00 | 0.75 | 0.00 |
| 10 | Test 10 | 30/11/2007 | 13:39:00 | 80 | 80 | 0.00 | 0.00 | 0.00 | 0.00 |
| 11 | Test 11 | 30/11/2007 | 13:39:00 | 76 | 80 | -4.00 | 0.00 | 2.75 | 0.00 |
| 12 | Test 12 | 30/11/2007 | 13:39:00 | 77 | 80 | -3.00 | 0.00 | 4.50 | 0.00 |
| 13 | Test 13 | 30/11/2007 | 13:39:00 | 76 | 80 | -4.00 | 0.00 | 7.24 | 0.00 |
| 14 | Test 14 | 30/11/2007 | 13:39:00 | 76 | 80 | -4.00 | 0.00 | 9.99 | 0.00 |
| 15 | Test 15 | 30/11/2007 | 13:39:00 | 75 | 80 | -5.00 | 0.00 | 13.74 | 0.00 |

**Figure 12 CUSUM Drift Spreadsheet**

## 5.1.2 CUSUM PRECISION

Selecting CUSUM – Precision will produce a chart similar to the one below.

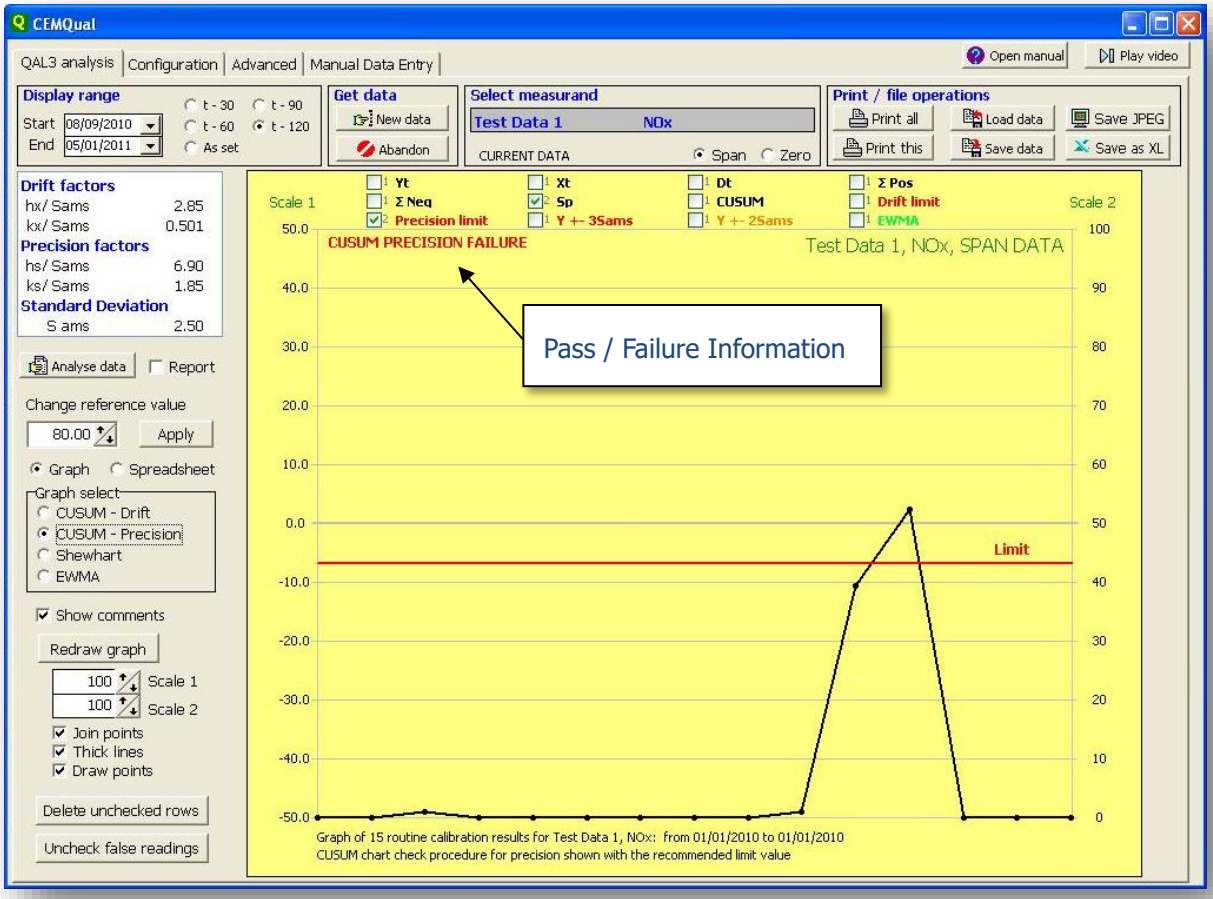



**Figure 13 CUSUM Precision Chart**

In this example, the 12th point has exceeded the Precision drift limit. These figures are also seen on the spreadsheet in the $S_D$ column.

| | No. | Name | Date | Time | y t | x t | d t | ΣPos | ΣNeg | Sp |
|---|---|---|---|---|---|---|---|---|---|---|
| ☑ | 1 | Test | 01/01/2010 | 00:05:00 | 80 | 80 | 0.00 | 0.00 | 0.00 | 0.00 |
| ☑ | 2 | Test | 01/01/2010 | 00:10:00 | 80 | 80 | 0.00 | 0.00 | 0.00 | 0.00 |
| ☑ | 3 | Test | 01/01/2010 | 00:15:00 | 85 | 80 | 5.00 | 3.75 | 0.00 | 0.94 |
| ☑ | 4 | Test | 01/01/2010 | 00:20:00 | 82 | 80 | 2.00 | 4.50 | 0.00 | 0.00 |
| ☑ | 5 | Test | 01/01/2010 | 00:25:00 | 80 | 80 | 0.00 | 0.00 | 0.00 | 0.00 |
| ☑ | 6 | Test | 01/01/2010 | 00:30:00 | 80 | 80 | 0.00 | 0.00 | 0.00 | 0.00 |
| ☑ | 7 | Test | 01/01/2010 | 00:35:00 | 82 | 80 | 2.00 | 0.75 | 0.00 | 0.00 |
| ☑ | 8 | Test | 01/01/2010 | 00:40:00 | 78 | 80 | -2.00 | 0.00 | 0.75 | 0.00 |
| ☑ | 9 | Test | 01/01/2010 | 00:45:00 | 80 | 80 | 0.00 | 0.00 | 0.00 | 0.00 |
| ☑ | 10 | Test | 01/01/2010 | 00:50:00 | 75 | 80 | -5.00 | 0.00 | 3.75 | 0.94 |
| ☑ | 11 | Test | 01/01/2010 | 00:55:00 | 85 | 80 | 5.00 | 3.75 | 0.00 | 39.38 |
| ☑ | 12 | Test | 01/01/2010 | 01:00:00 | 78 | 80 | -2.00 | 0.00 | 0.75 | 52.31 |
| ☑ | 13 | Test | 01/01/2010 | 01:05:00 | 80 | 80 | 0.00 | 0.00 | 0.00 | 0.00 |
| ☑ | 14 | Test | 01/01/2010 | 01:10:00 | 80 | 80 | 0.00 | 0.00 | 0.00 | 0.00 |
| ☑ | 15 | Test | 01/01/2010 | 01:15:00 | 80 | 80 | 0.00 | 0.00 | 0.00 | 0.00 |

**Figure 14 CUSUM Precision Spreadsheet**

## 5.1.3 SHEWHART

Selecting Shewhart will produce a chart similar to the example below:

**Figure 15 Shewhart Chart**

With Shewhart control charts, the operator has to analyse the chart to decide whether the AMS is still in control. There are five parameters that have to be met to show control, and these are detailed in the Environment Agencies Technical Guidance Note TGN-M20 and are when:

1. One or more data points are beyond one of the upper alarm limits;
2. Three consecutive data points are beyond one of the warning limits;
3. Four points among 5 consecutive ones are beyond +/- Sams (Standard deviation for the automated measurement system);
4. Eight consecutive points are on the same side of the mean (NOTE: the CEMQual program only considers samples that are outside of 0.5 x Sams);
5. Six consecutive points are either increasing or decreasing (NOTE: the CEMQual program only considers samples that are outside of 0.5 x Sams.)

The warning limits are set at +/- 2 x Sams, and the alarm limits at +/- 3 x Sams. These are drawn on the chart as illustrated above and are usually coloured in orange and red as seen here. These colours may be changed by the operator if required.

*Shewhart continued...*

On the Shewhart chart, each sample is checked for compliance with the 5 conditions above, and then either a PASS or FAIL is indicated by either a GREEN or RED bar, as indicated on the chart on the previous page. Holding the mouse over this bar will indicate the date and time of the check and which of the conditions has been breached.

Any point outside the limits automatically requires action, and is highlighted within the spreadsheet grid by both the check measurement and the reference measurement (xt and yt) being coloured RED; if all of these above conditions are met, the numbers are coloured in GREY. This can be seen in the example of the grid below.

| | No. | Name | Date | Time | y t | x t | d t | ΣPos | ΣNeg | Sp |
|---|---|---|---|---|---|---|---|---|---|---|
| ☑ | 1 | Test 1 | 30/11/2007 | 13:39:00 | 82 | 80 | 2.00 | 0.75 | 0.00 | 0.00 |
| ☑ | 2 | Test 2 | 30/11/2007 | 13:39:00 | 79 | 80 | -1.00 | 0.00 | 0.00 | 0.00 |
| ☑ | 3 | Test 3 | 30/11/2007 | 13:39:00 | 80 | 80 | 0.00 | 0.00 | 0.00 | 0.00 |
| ☑ | 4 | Test 4 | 30/11/2007 | 13:39:00 | 78 | 80 | -2.00 | 0.00 | 0.75 | 0.00 |
| ☑ | 5 | Test 5 | 30/11/2007 | 13:39:00 | 82 | 80 | 2.00 | 0.75 | 0.00 | 0.00 |
| ☑ | 6 | Test 6 | 30/11/2007 | 13:39:00 | 79 | 80 | -1.00 | 0.00 | 0.00 | 0.00 |
| ☑ | 7 | Test 7 | 30/11/2007 | 13:39:00 | 80 | 80 | 0.00 | 0.00 | 0.00 | 0.00 |
| ☑ | 8 | Test 8 | 30/11/2007 | 13:39:00 | 79 | 80 | -1.00 | 0.00 | 0.00 | 0.00 |
| ☑ | 9 | Test 9 | 30/11/2007 | 13:39:00 | 78 | 80 | -2.00 | 0.00 | 0.75 | 0.00 |
| ☑ | 10 | Test 10 | 30/11/2007 | 13:39:00 | 80 | 80 | 0.00 | 0.00 | 0.00 | 0.00 |
| ☑ | 11 | Test 11 | 30/11/2007 | 13:39:00 | 76 | 80 | -4.00 | 0.00 | 2.75 | 0.00 |
| ☑ | 12 | Test 12 | 30/11/2007 | 13:39:00 | 77 | 80 | -3.00 | 0.00 | 4.50 | 0.00 |
| ☑ | 13 | Test 13 | 30/11/2007 | 13:39:00 | 76 | 80 | -4.00 | 0.00 | 7.24 | 0.00 |
| ☑ | 14 | Test 14 | 30/11/2007 | 13:39:00 | 76 | 80 | -4.00 | 0.00 | 9.99 | 0.00 |
| ☑ | 15 | Test 15 | 30/11/2007 | 13:39:00 | 75 | 80 | -5.00 | 0.00 | 13.74 | 0.00 |

**Figure 16 Shewhart Spreadsheet**

## 5.1.4 EWMA

Selecting EWMA will produce a chart similar to the one below:

**Figure 17 EWMA Chart**

Looking at the example above, points have gradually declined past the negative drift limit. Below is how this graph would look in spreadsheet format.

| No. | Name | Date | Time | y t | x t | d t | ΣPos | ΣNeg | Sp |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Test 1 | 01/01/2010 | 00:05:00 | 200.0 | 200.0 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | Test 2 | 01/01/2010 | 00:10:00 | 202.0 | 200.0 | 2.00 | 0.00 | 0.00 | 0.00 |
| 3 | Test 3 | 01/01/2010 | 00:15:00 | 199.0 | 200.0 | -1.00 | 0.00 | 0.00 | 0.00 |
| 4 | Test 4 | 01/01/2010 | 00:20:00 | 202.0 | 200.0 | 2.00 | 0.00 | 0.00 | 0.00 |
| 5 | Test 5 | 01/01/2010 | 00:25:00 | 203.0 | 200.0 | 3.00 | 0.49 | 0.00 | 0.00 |
| 6 | Test 6 | 01/01/2010 | 00:30:00 | 200.0 | 200.0 | 0.00 | 0.00 | 0.00 | 0.00 |
| 7 | Test 7 | 01/01/2010 | 00:35:00 | 199.0 | 200.0 | -1.00 | 0.00 | 0.00 | 0.00 |
| 8 | Test 8 | 01/01/2010 | 00:40:00 | 198.0 | 200.0 | -2.00 | 0.00 | 0.00 | 0.00 |
| 9 | Test 9 | 01/01/2010 | 00:45:00 | 196.0 | 200.0 | -4.00 | 0.00 | 1.50 | 0.00 |
| 10 | Test 10 | 01/01/2010 | 00:50:00 | 195.0 | 200.0 | -5.00 | 0.00 | 3.99 | 0.00 |
| 11 | Test 11 | 01/01/2010 | 00:55:00 | 194.0 | 200.0 | -6.00 | 0.00 | 7.49 | 0.00 |
| 12 | Test 12 | 01/01/2010 | 01:00:00 | 192.0 | 200.0 | -8.00 | 0.00 | 12.98 | 0.00 |
| 13 | Test 13 | 01/01/2010 | 01:05:00 | 190.0 | 200.0 | -10.00 | 0.00 | 20.48 | 0.00 |
| 14 | Test 14 | 01/01/2010 | 01:10:00 | 190.0 | 200.0 | -10.00 | 0.00 | 27.97 | 0.00 |
| 15 | Test 15 | 01/01/2010 | 01:15:00 | 188.0 | 200.0 | -12.00 | 0.00 | 37.47 | 0.00 |
| 16 | Test 16 | 01/01/2010 | 01:15:00 | 187.0 | 200.0 | -13.00 | 0.00 | 47.96 | 0.00 |
| 17 | Test 17 | 01/01/2010 | 01:15:00 | 186.0 | 200.0 | -14.00 | 0.00 | 59.45 | 0.00 |
| 18 | Test 18 | 01/01/2010 | 01:15:00 | 185.0 | 200.0 | -15.00 | 0.00 | 71.95 | 0.00 |
| 19 | Test 19 | 01/01/2010 | 01:15:00 | 184.0 | 200.0 | -16.00 | 0.00 | 85.45 | 0.00 |
| 20 | Test 20 | 01/01/2010 | 01:15:00 | 182.0 | 200.0 | -18.00 | 0.00 | 100.94 | 0.00 |

**Figure 18 EWMA Spreadsheet**

## 5.2 ANALYSE DATA

Users also have the option to generate an analysis report for the latest QAL3 data, enabling them to easily check QAL3 compliance.

Selecting 'Analyse data' will produce a report similar to the one below:

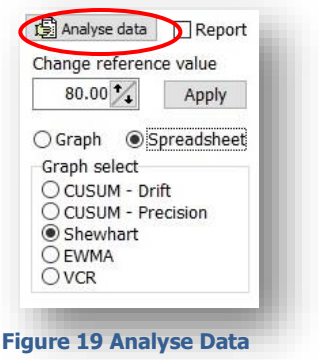



**Figure 19 Analyse Data**

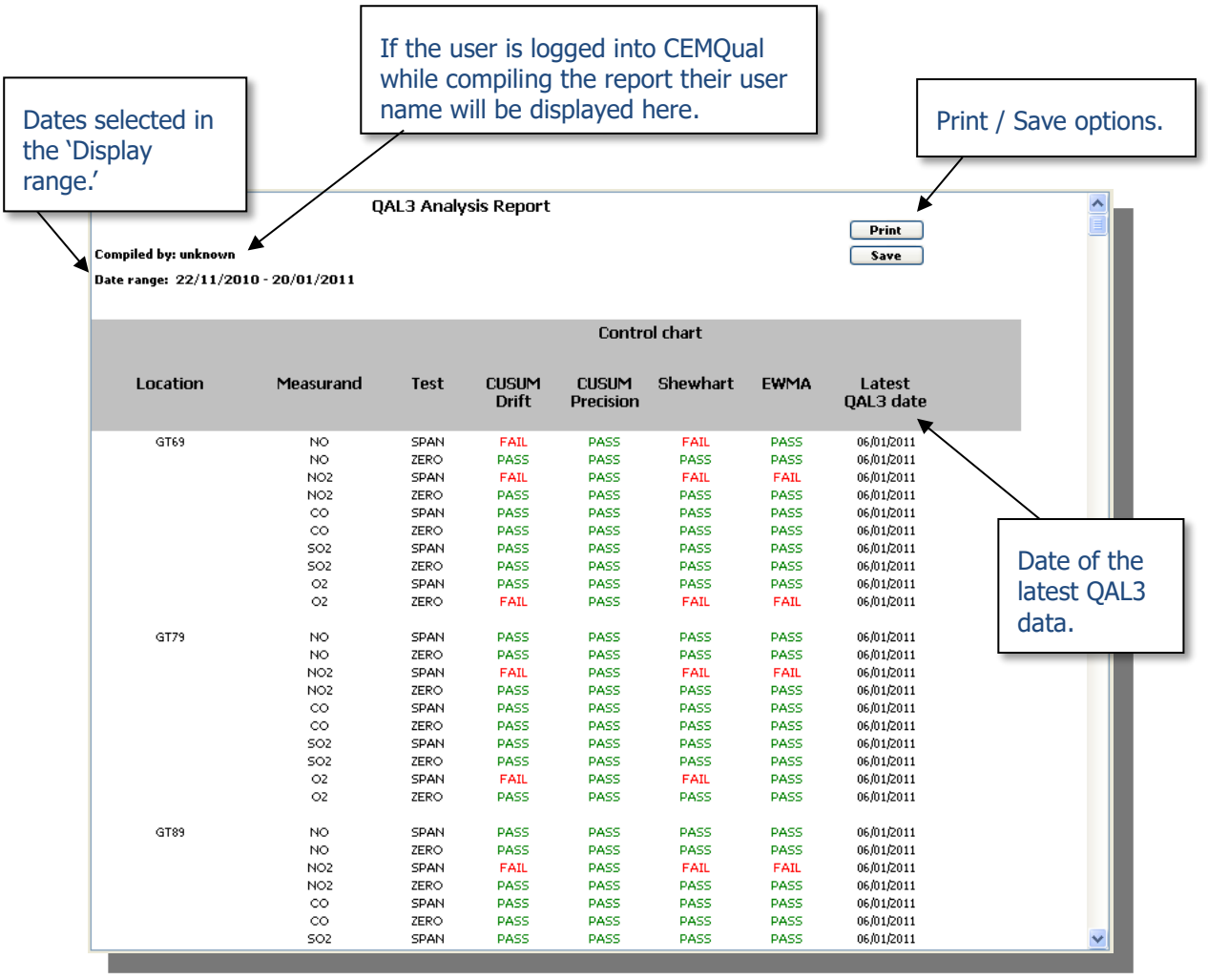



**Figure 20 QAL3 Analysis Report**

Looking at the above example and taking just one measurand; '*GT69 – NO – SPAN*' it has failed both CUSUM Drift and Shewhart but passed CUSUM Precision and EWMA.

*Analyse Data continued…*

Below is how the selected measurand would look in spreadsheet format.

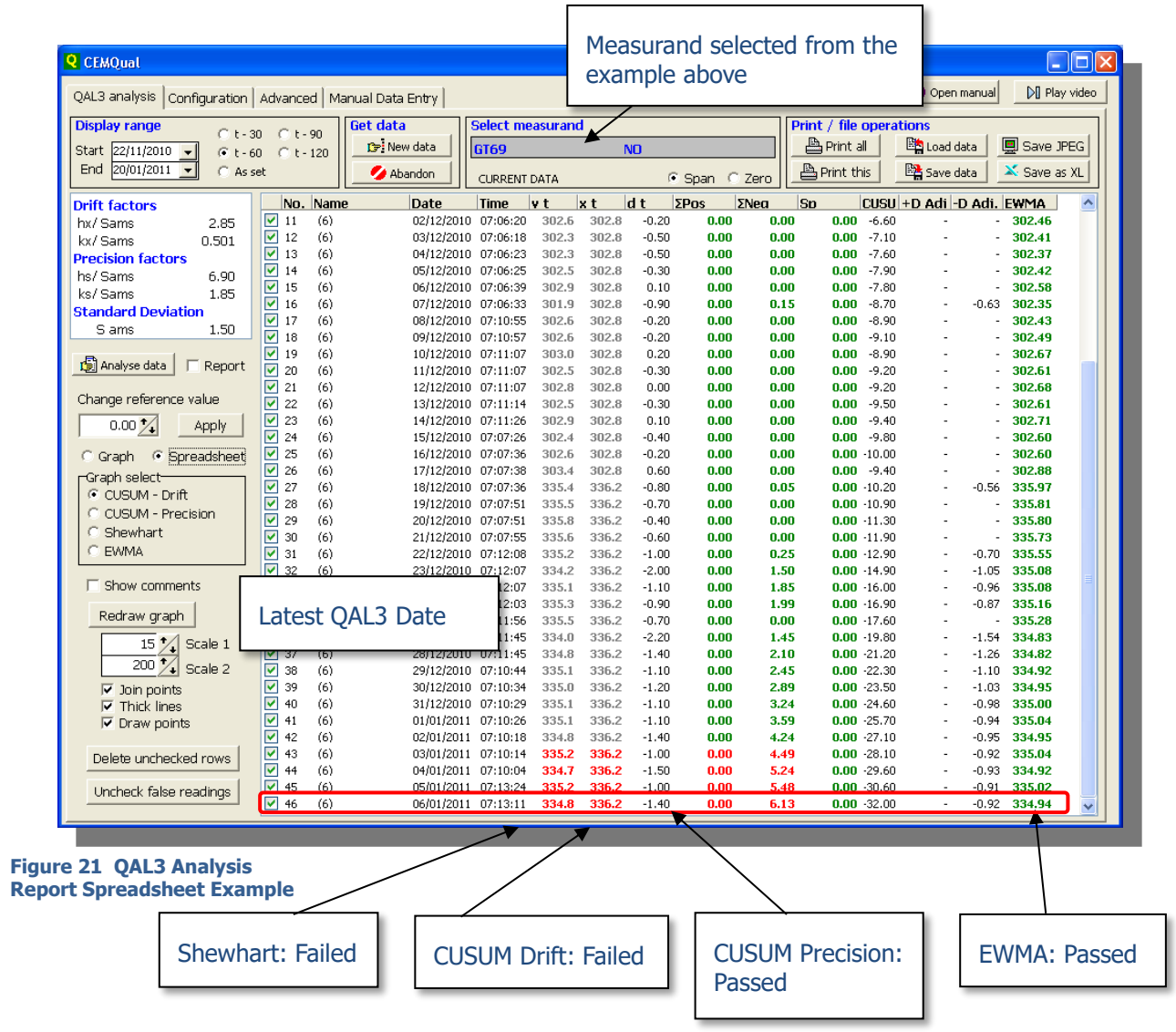



**Figure 21 QAL3 Analysis Report Spreadsheet Example**

## 5.3 MANUAL SELECTION OF CHART LINES

When displaying a graph, at the top of the chart there are 12 checkboxes available to select or deselect the individual trend lines. After selecting one of the preset options (CUSUM Drift, CUSUM Precision, Shewhart or EWMA) the lines are selected automatically and the data is checked for meeting the limits for each analysis.

It is also possible to select or deselect individual trend lines by clicking on their relevant check boxes.

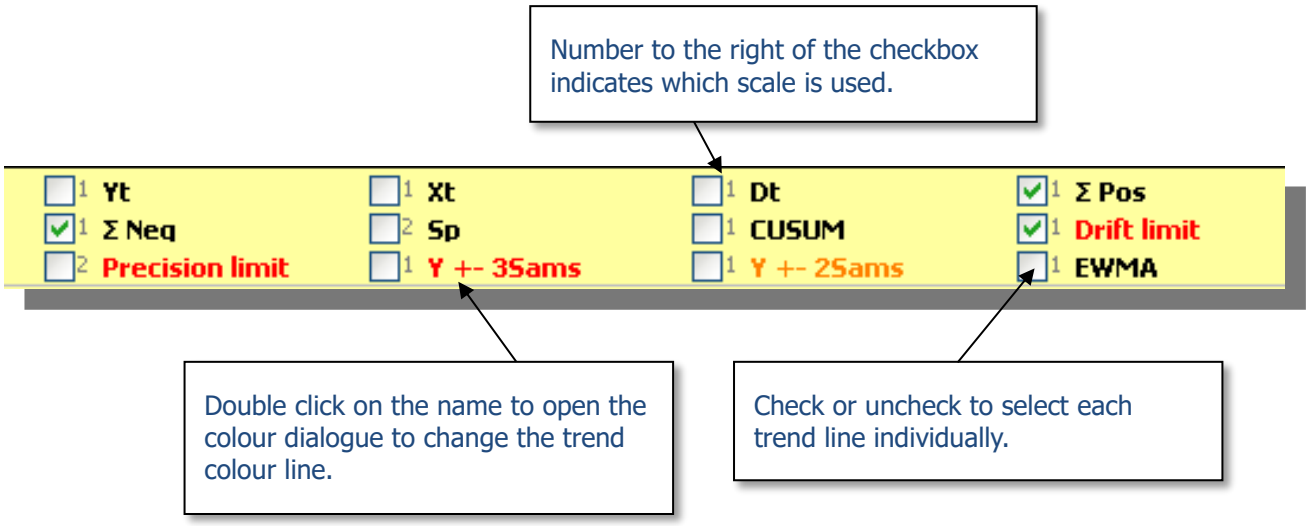



**Figure 22 Chart Line Selection**

For each preset condition the following lines are selected automatically:

| Chart Selection | Trend lines selected |
|---|---|
| CUSUM Drift | ∑Pos – Positive drift<br>∑Neg – Negative drift<br>Drift limits (+/–) |
| CUSUM Precision | Sp<br>Precision limit |
| Shewhart | Dt<br>Y +/– 2 sams<br>Y +/– 3 sams |
| EWMA | EWMA<br>Drift limits (+/–) |

**Table 1 Preset Trend Lines**

## 5.4 FINDING NEW QAL3 DATAPOINTS

If new QAL3 check data points are available and are required to be added to the analysis, press the 'New data' button as shown below:

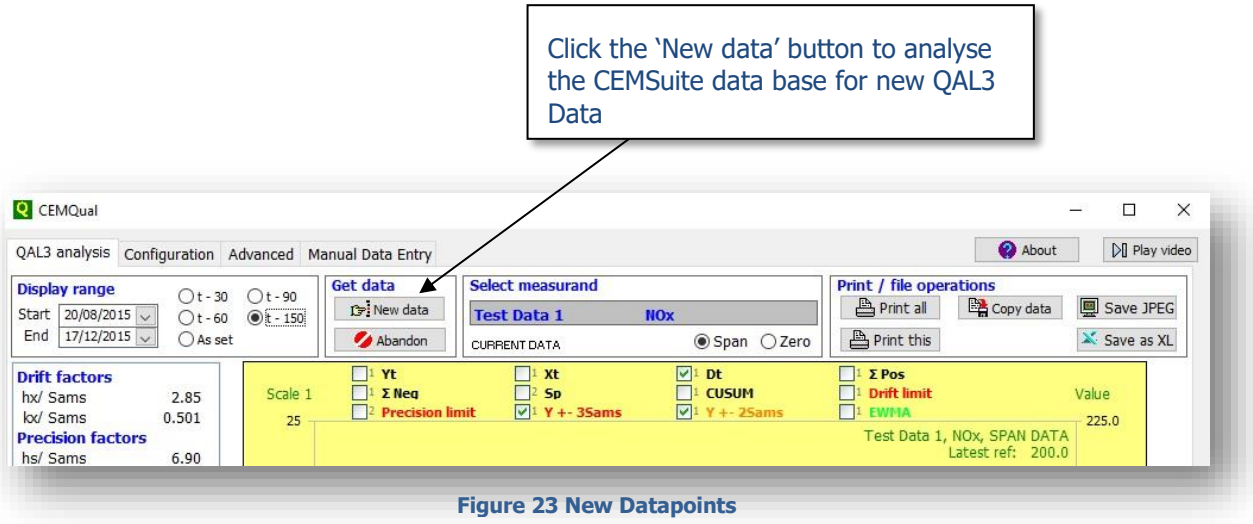



**Figure 23 New Datapoints**

Data will now be gathered for all selected measurands, for both zero and span since the last search, the data will be analysed and entered into the QAL3 databases for each of the measurands. During this operation, the analysis date will be seen to count up and the measurand being analysed displayed just below the 'Select measurand' area. On completion, the grid data or chart will update automatically – provided the new data falls within the display dates – this may not be so if the chart has been set to 'As set'.

Should it have been some time since the data was last analysed, this operation might take a few minutes. The operation may be abandoned by pressing the 'Abandon' button – the analysis will be stopped after the current day has been completed.

To re-analyse earlier QAL3 analysis, perhaps using different criteria, use the options provided on the 'Advanced' tab, see page 70.

## 5.5 PRINTING THE DATA

The grids and charts may be printed either as a print all command or using the current display – either a chart or spreadsheet for the selected measurand, for either ZERO or SPAN. The printer to be used is defined from the advanced tabbed page, please refer to page 72.

**NOTE**: Take care when using the 'Print all' feature, depending upon the selection and the quantity of data, many pages may be printed.

Spreadsheet data will always be printed in Portrait orientation, and graphs in Landscape orientation, regardless of the printer set up.

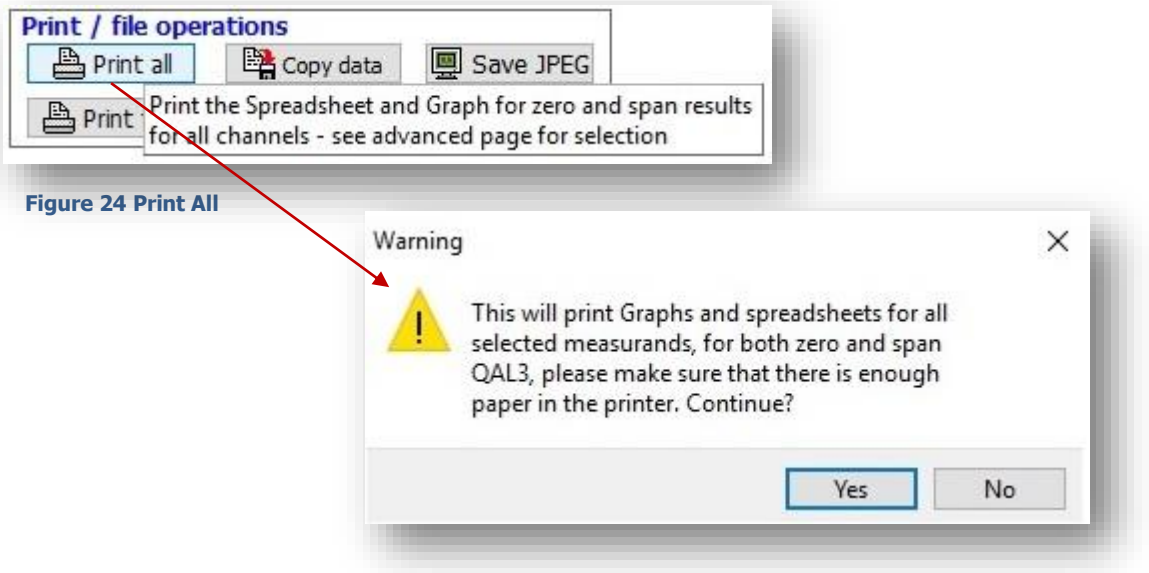



Figure 24 Print All

If you wish to print just the current graph or spreadsheet for the specific measurand, then click the 'Print this' button as indicated in the image below.

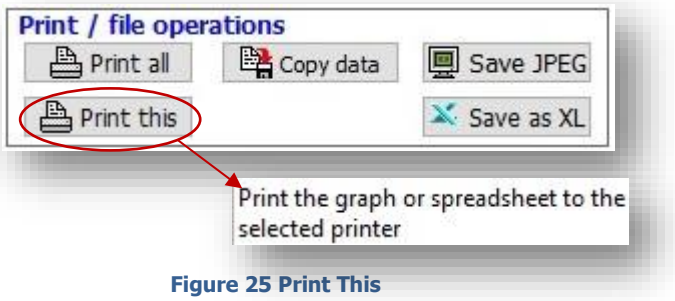



Figure 25 Print This

# 6 CONFIGURATION

## 6.1 PASSWORD ENTRY

For the security of the operator and to ensure complete integrity of the process, the "Configuration" section is password protected. The Username and password will be provided to you by Envirosoft, you should keep a copy in a safe and secure place. We will supply as many usernames/passwords as you request.

Enter your username and password and click on the "Log in" button.

Before performing any operations with CEMQual, certain data are required to enable the calculations to be performed. Click on the "Configuration" tab at the top of the page. In the configuration menu, there is a two level login system with the following sections accessible for each login type.

### 6.1.1 OPERATOR (LEVEL 1)

If your name and password are set as an operator, the only option available to you is the entry of the calibration gas bottle data.

### 6.1.2 ENGINEER (LEVEL 2)

Should your name and password be set as an engineer, the following options are available:

- Channel Selection
- Calibration gas bottle data
- QAL3 Parameters
- CEMQual/EN14181 Data

When a user clicks any of the locked panels in the configuration area then they will be presented with the following message.

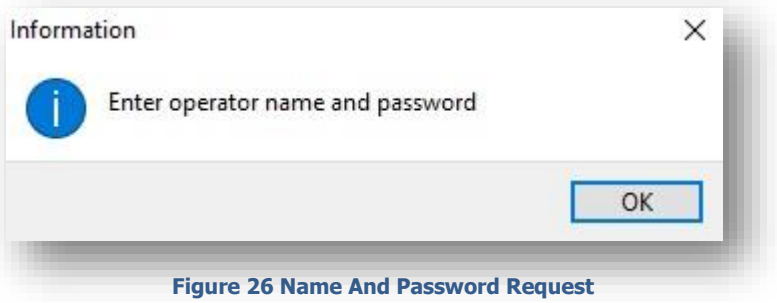



**Figure 26 Name And Password Request**

*Password Entry continued…*

To log in, the user needs to enter the username and password provided by Envirosoft (if new passwords are required then please contact Envirosoft for details)

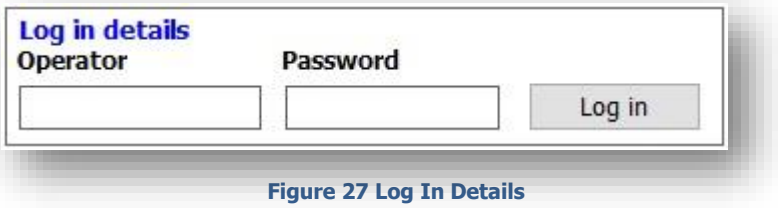



**Figure 27 Log In Details**

If this is the first time the system is run or somebody has deleted the previous password data then the following box will appear after a successful login.

**Figure 28 Password Data Error**

After a successful login, if there were unauthorised or incorrect logins since the last successful login, then the following box will appear detailing all the previous failed login attempts.

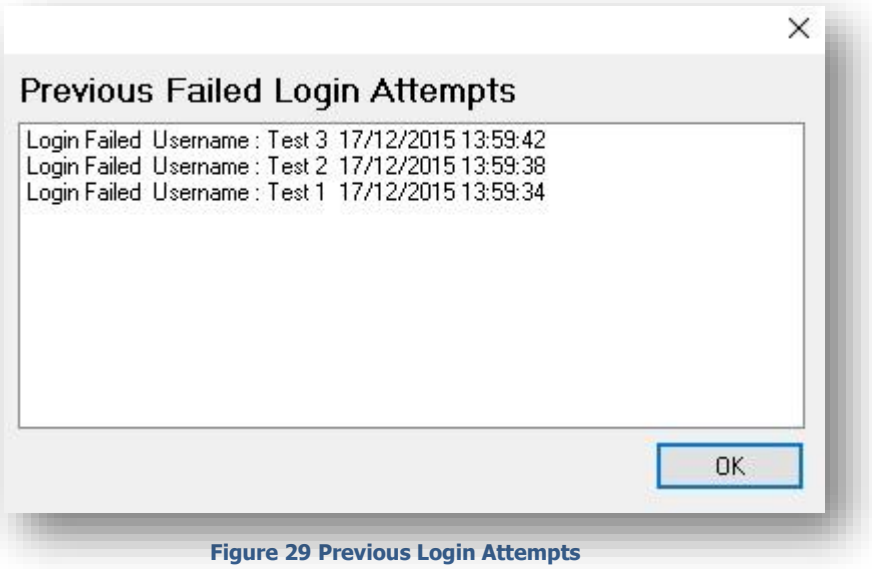



**Figure 29 Previous Login Attempts**

*Password Entry continued…*

If an operator level user or an excluded user clicks a panel that is engineer level only then the following box will appear.

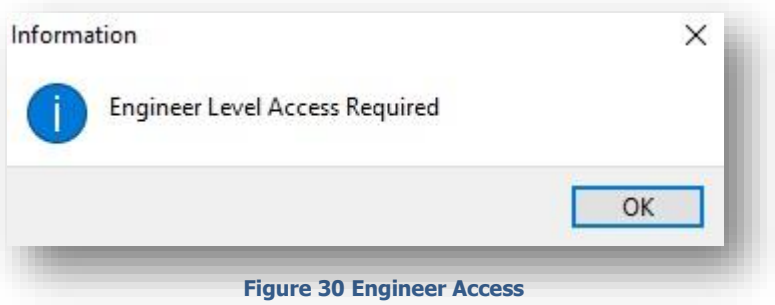



**Figure 30 Engineer Access**

Finally, the user must remember to log out when they have finished editing in the configuration section.

## 6.2 QAL3 MEASURAND PARAMETERS

Firstly select the stack and the measurand to configure from the list in the top left corner.

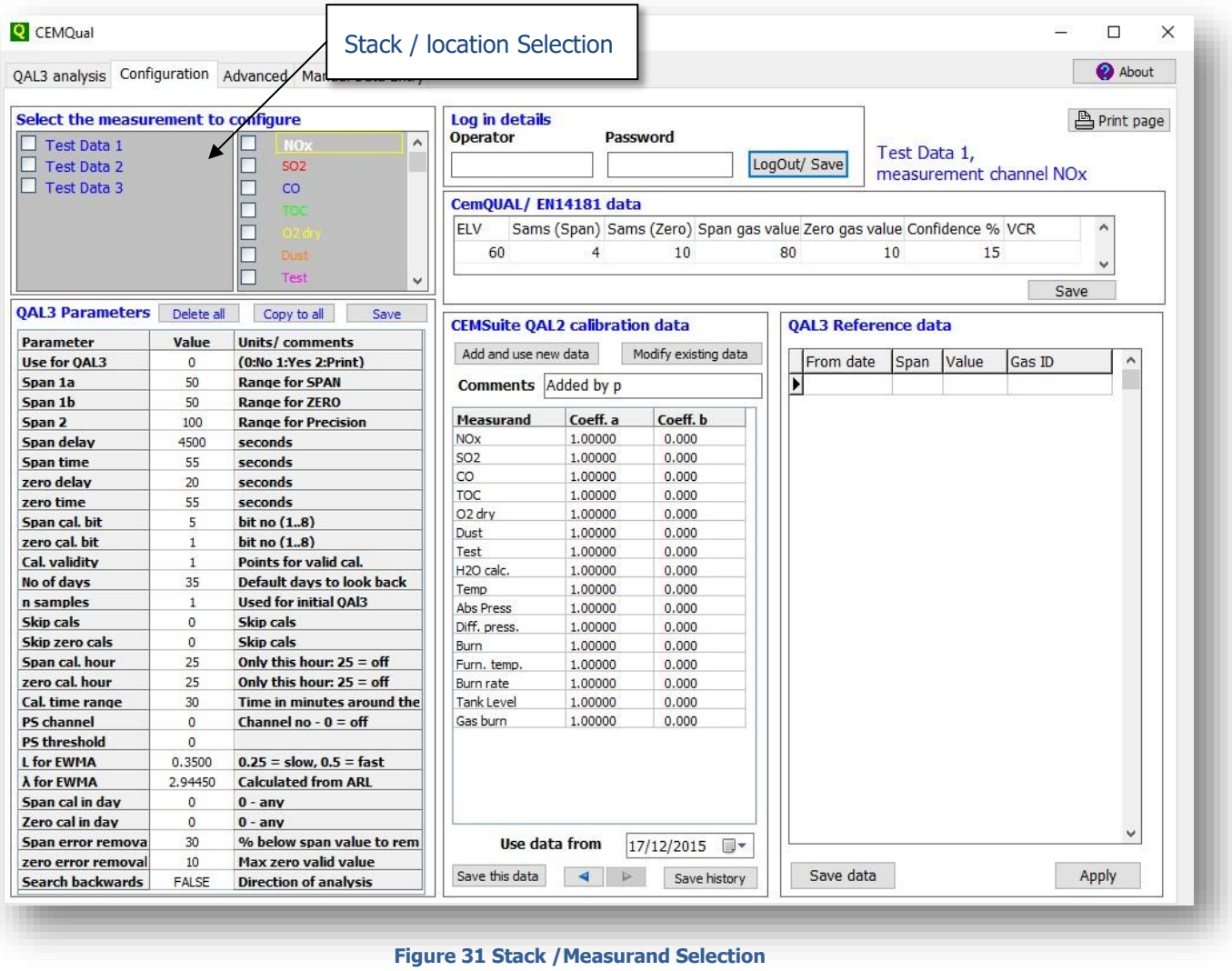



**Figure 31 Stack /Measurand Selection**

From this page the settings for each measurand and the parameters to acquire the QAL3 data are entered. This data is now examined:

## 6.3 QAL3 PARAMETER DETAILS

After selecting the required measurand by clicking on its name, the QAL3 parameter data may be changed as required. This affects how the CEMQual program analyses the CEMSuite database to access the QAL3 information.

Envirosoft engineers will normally have set this up, and this is provided as a reference. Please be careful when changing data here as it might have undesired effects when analysing the data. Should there be any doubts, please consult Envirosoft.

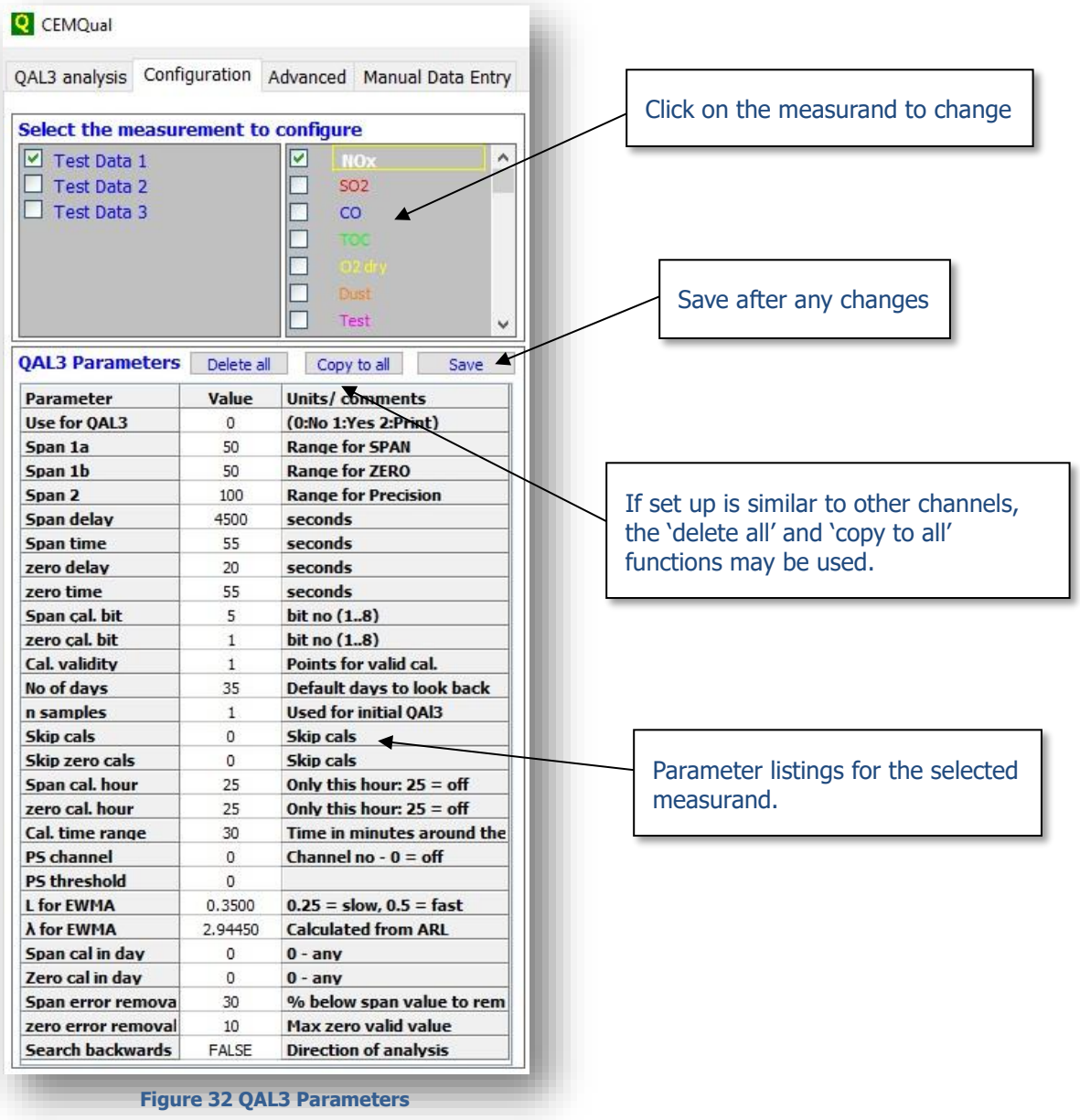



**Figure 32 QAL3 Parameters**

A discussion of these parameters now follows. **Note:** That after making any changes here, they should be saved by pressing the 'Save' button.

| Parameter | Typical Value | Comments |
|---|---|---|
| Use for QAL3 | 0, 1 or 2 | The following applies:<br><br>0: Not used for QAL3<br>1: Used for QAL3 analysis<br>2: Used for QAL3 analysis and printed during the 'Print all' function. |
| Span 1a | 20 – 1000 | The range of the Chart for CUSUM Drift, Shewhart and EWMA for the span data analysis for the SPAN data. |
| Span 1b | 20 – 200 | The range of the Chart for CUSUM Drift, Shewhart and EWMA for the span data analysis for the ZERO data. |
| Span 2 | 200 – 5000 | The range for CUSUM precision check chart. |
| Span delay | 0 – 2000 | Time in seconds from the SPAN calibration start to when the data should be analysed. Note that this can be negative to allow for a time before a calibration bit is set. |
| Span time | 10 – 120 | Time in seconds to average the SPAN data. **Note:** Should the time be too long, data from outside of the actual span data may be used. |
| Zero delay | 0 – 2000 | Time in seconds from the ZERO calibration start to when the data should be analysed. |
| Zero time | 10 – 120 | Time in seconds to average the ZERO data. |
| Span cal bit | 1..8 | Bit of the validity byte that indicates the start of the SPAN calibration. Has a 1 not 0 base, i.e.:<br><br>Hex 01 = Bit 1<br>Hex 02 = Bit 2 ...<br><br>Hex 40 = Bit 7<br>Hex 80 = Bit 8 |
| Zero cal bit | 1..8 | Bit of the validity byte that indicates the start of the ZERO calibration. Same as above. |
| Cal validity | 1 – 10 | Number of averages required to consider the calibration valid. Depends on the Span and Zero times above. |
| No of days | 30 – 365 | Historic setting – how far should CEMQual look back through the data. |

| Parameter | Typical Value | Comments |
|---|---|---|
| N samples | 1 | May be used to change the factors for the initial QAL3 analysis. In normal operation, this should be set to 1. |
| Skip cals (SPAN) | 0 – 6 | Normally, calibrations are conducted relatively infrequently (every day). Some measurements, however, have very frequent internal calibration routines (hourly) and to plot them all would be undesirable. This value will skip n-1 calibrations before using the analysed data. |
| Skip zero cals | 0 – 6 | As above, some analysers have regular zero n=but not span calibrations. |
| Span cal. Hour | 1..25 | To prevent spurious data being entered into the QAL3 database, CEMQual can only use data from a particular hour (24 hr clock). Set to 25 to use all data, anything else for the hour. |
| Zero cal. Hour | 1..25 | As above but for zero calibration checks. Set to 25 to remove this filter from the QAL3 analysis, |
| Cal. Time range | 20..120 | Time in minutes around the cal hour (above) over which the cals should be used. |
| PS Channel | 0..16 | It is possible to use plant shutdowns to acquire zero data. This selects which channel to use as an indicator of plant operation – please speak to Envirosoft before changing this. |
| PS Threshold | 0 - 1000 | Threshold over which the plant is considered shut down, please note the above. |
| L for EWMA | 2 – 5 | L factor for the EWMA chart – see EA guidance. |
| l for EWMA | 0.2 .. 1.0 | Factor EWMA chart – see EA guidance. |
| Span error removal | 10 .. 80 | Determines when to remove span calibrations with massive errors. This avoids false data from being used in the QAL3 analysis – units are %age of the span. |
| Zero error removal | 1 .. 10 | As above but for zero data. |
| Span cal Day | 0-any | Will only consider the nth calibration for each day. |
| Zero cal. Day | 0-any | Will only consider the nth calibration for each day. |

**Table 2 QAL3 Parameter Details**

To avoid problems in the data analysis, please speak to Envirosoft before changing any of the settings here.

## 6.4 SAVING AND COPYING THE QAL3 PARAMETERS

Within the QAL 3 parameters, there are three buttons; 'Delete all', 'Copy to all', and 'Save', as seen in the image below. Clicking the 'Delete all' button will delete all measurement configurations, apart from the current one in use. Clicking the 'Copy to all' button will copy the current measurement configurations to all other channels. If the measurement configurations are permanent, click the 'Save' button for future use.

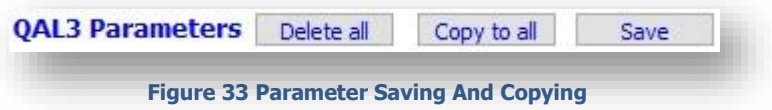



**Figure 33 Parameter Saving And Copying**

During initial commissioning, these operations may be used to speed up the set up of the QAL3 parameters for all measurands. Once commissioned, however, they should be used with caution to avoid incorrect settings.

## 6.5 A NOTE ABOUT MEASUREMENT UNITS

The CEMQual program is independent of the units of measurement – usually ppm or mg/m3 for gas data. The program always uses the raw data stored by the analysers – contact Envirosoft should there be any doubt here. However, the measurement units ***do*** have an effect when entering the calibration gas data and the standard deviation information. The units of these items must match the stored analyser data, and may need to be adjusted.

## 6.6 DETERMINING SPAN AND ZERO DELAY TIMES

To determine the delay times for Span and zero, we first of all need to know two things; the date and time of a calibration audit and the validity bit that is set during the audit. The easiest way of finding these is to use the Trend page in CEMForm (see below).

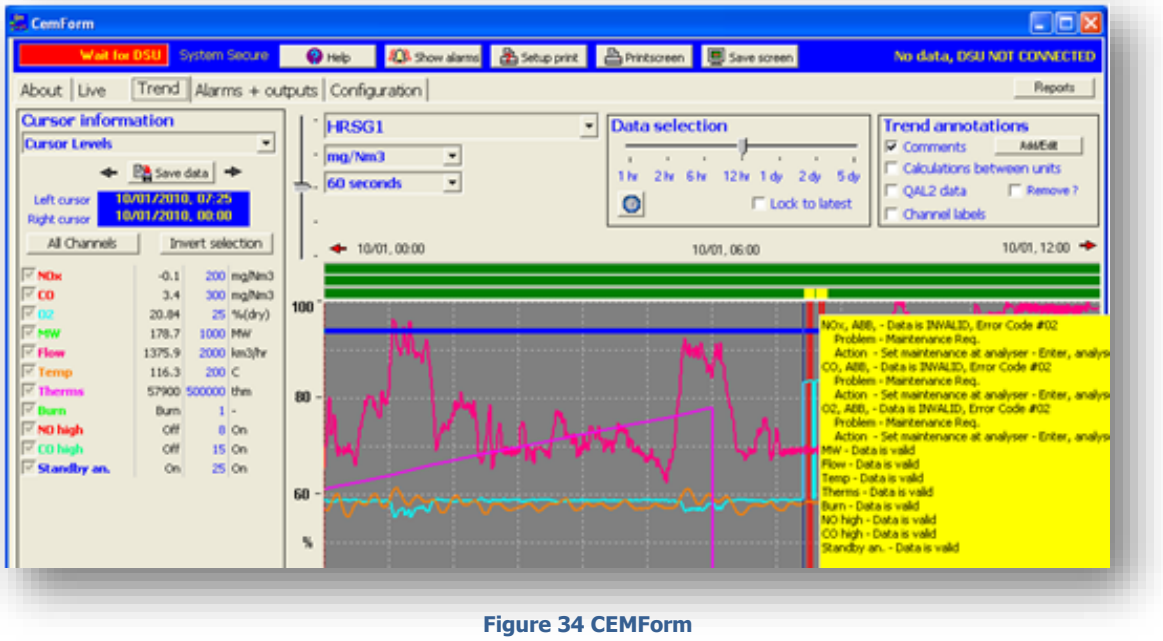



**Figure 34 CEMForm**

In this example, the audit is carried out just before 07:30 on the 10th January and the validity code 02 has been set. From section 6.6.1, we know that this is bit 2, and this parameter has to be entered in the QAL 3 parameter table (in this example, the same bit is set for Span and Zero, but with other instruments, they might be different for Span and Zero, and also different for each measurand).

## 6.6.1 RAW DATA EXAMPLE

The next step is to run a Raw Data report using CEMPort for the date in question, and scroll down to the start of the calibration audit, i.e. 07:23:39.

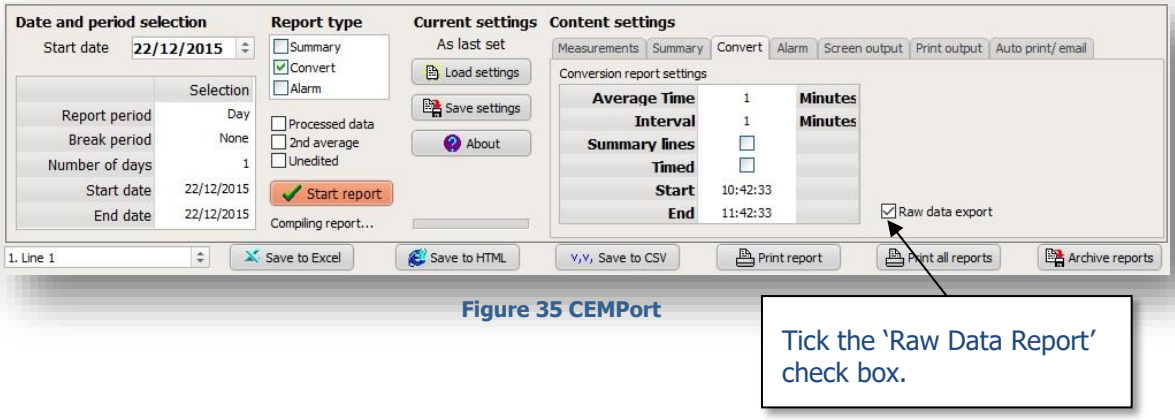



Figure 35 CEMPort

We will see that the Validity code changes state – this will normally be from a 00 to the code seen on the Trend, but could potentially be non-zero if the analyser has an invalid state, such as a fault or maintenance being carried out.

| | NOx | | CO | |
|---|---|---|---|---|
| | Valid | Data | Valid | Data |
| 10/01/2010 07:23:33 | 00 | 52.3 | 00 | 5.4 |
| 10/01/2010 07:23:34 | 00 | 52.3 | 00 | 5.4 |
| 10/01/2010 07:23:39 | 02 | 51.6 | 02 | 5.4 |
| 10/01/2010 07:23:41 | 02 | 51.6 | 02 | 5.4 |
| 10/01/2010 07:23:46 | 02 | 52.0 | 02 | 5.6 |

Figure 36 Raw Data 1

We note the time that the audit begins and scroll down the report until we see each measurand stabilise its Span and Zero readings.

In this example, both the NOx and the CO zeros settle out around zero, sometime around 07:25:00. By looking for a change in reading, as seen with the NOx channel below, we can choose a time somewhere between 07:25:00 and 0729:36, for QAL3 Zero, points for each of the measurands. It is advisable to pick a time closer to the end of the zero phase of the audit, rather than the beginning, as this will ensure that the measurements have truly stabilised. Remember that we also have to average the readings for the "Span time" and "Zero time", so this must be taken into account.
So, in our example, we would probably take a zero reading for NOx and CO at 07:27:39 and average the readings for 30 seconds. This gives us a Zero delay of 240 seconds (07:27:39 - 07:23:39) and a Zero Time of 30 seconds.

| | NOx | | CO | |
|---|---|---|---|---|
| | Valid | Data | Valid | Data |
| 10/01/2010 07:29:29 | 02 | -0.3 | 02 | -0.3 |
| 10/01/2010 07:29:30 | 02 | -0.3 | 02 | -0.3 |
| 10/01/2010 07:29:36 | 02 | 306.6 | 02 | -0.3 |
| 10/01/2010 07:29:37 | 02 | 306.6 | 02 | -0.3 |
| 10/01/2010 07:29:42 | 02 | 330.0 | 02 | -0.3 |

Figure 37 Raw Data 2

*Raw Data Example continued...*

Following the same method, we can determine the Span delay times for each measurand.

| | NOx | | CO | |
|---|---|---|---|---|
| | Valid | Data | Valid | Data |
| 10/01/2010 07:32:15 | 02 | 332.0 | 02 | -0.3 |
| 10/01/2010 07:32:21 | 02 | 331.0 | 02 | -0.2 |
| 10/01/2010 07:32:22 | 02 | 331.0 | 02 | -0.2 |
| 10/01/2010 07:32:28 | 02 | 89.0 | 02 | -0.4 |
| 10/01/2010 07:32:29 | 02 | 89.0 | 02 | -0.4 |
| 10/01/2010 07:32:34 | 02 | 4.0 | 02 | -0.4 |

**Figure 38 Raw Data 3**

NOx Span delay = 480 seconds; Span time = 30 seconds. (07:31:39 - 07:23:39)
CO Span delay = 1140 seconds; Span time = 30 seconds. (07:42:39 - 07:23:39)

| | NOx | | CO | |
|---|---|---|---|---|
| | Valid | Data | Valid | Data |
| 10/01/2010 07:43:33 | 02 | -0.3 | 02 | 444.3 |
| 10/01/2010 07:43:39 | 02 | -0.1 | 02 | 444.5 |
| 10/01/2010 07:43:40 | 02 | -0.1 | 02 | 444.5 |
| 10/01/2010 07:43:46 | 02 | -0.4 | 02 | 130.0 |
| 10/01/2010 07:43:47 | 02 | -0.4 | 02 | 130.0 |
| 10/01/2010 07:43:52 | 02 | -0.4 | 02 | 5.7 |

**Figure 39 Raw Data 4**

Once these times have been established, they may be entered into the configuration table as described earlier in this section.

## 6.7 CEMQUAL / EN 14181 DATA

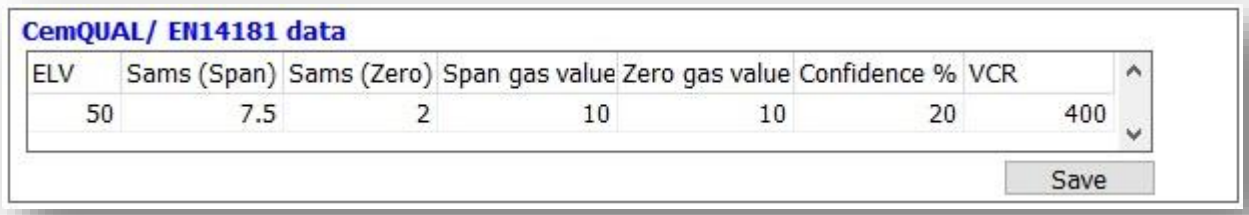



**Figure 40 CEMQual / EN 14181**

After selecting the measurand to be edited, the following data should be entered:

1. ELV (Emission Limit Value) refer to the site environmental permit.
2. Standard deviation values for span and zero assessments – Sams (Span) and Sams (Zero).
3. Zero and Span gas values. These values are only used in the QAL3 assessment should no gas bottle data be available for this measurand.
4. Confidence value; this data is currently not used by the program but will reflect the confidence as recognised by the authorities, these values are normally: CO (10%), NOx, SO2 (20%), dust (30%) etc.
5. VCR – Sets the Validated Calibrated Range.

After the table is set up as required, press the 'Save and apply' button to store this data and apply it, should QAL3 data exist in the spreadsheet.

## 6.8 CALIBRATION GAS / REFERENCE DATA

An important part of the QAL3 assessment process is to use the calibration gas data that was used as the reference material for each measurand at the time of each calibration check. This is performed in the Calibration gas data section; firstly click on a date in the "From date" column and press the "INS" Key on your keyboard. This should create a new row in the grid. Enter the date the bottle is first used, if it is a span gas enter True or Zero enter False, enter the value in mg/m3 and the bottle identifier. The latter is required to show a clear quality assurance chain. It is very important that this information is updated every time a gas bottle is changed or errors will be introduced into the calculations.

To add a new bottle, select the latest date and press the INSERT key. Edit the new line as required and finish with the 'Save data' button below. Records may be deleted by pressing CTRL + DEL together - use caution. Although not essential, we recommend that the latest gas information is at the top of this list – it makes it easier to read.

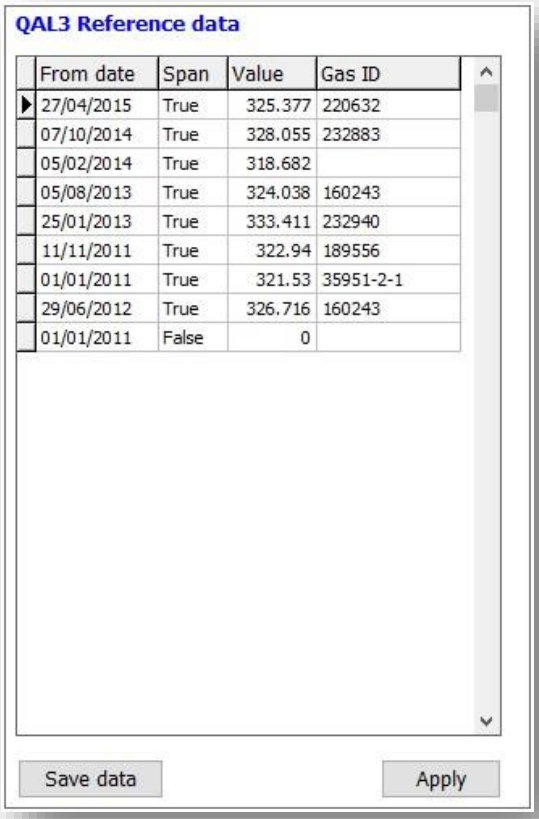



Figure 41 QAL3 Reference Data

**From date;** Enter here the date from which the gas is to be used; it assumes that this will be used from midnight that day (00:00). During the automatic data find operation, the program will look up the appropriate verification gas to relate to the span reading found at the analyser.

**Span;** Enter 'true' here if the gas entered is a SPAN gas and 'false' if the gas is a zero gas.

**Value;** Enter the concentration of the calibration gas in the same units as the raw measurements.

**Gas ID;** Enter here an appropriate name for the reference. For gas bottle data, it is recommended that the bottle ID or calibration certificate be used to provide an audit trail.

Once the gas data has been entered and saved, if data has already been collected for QAL3, the new reference data may be applied to the stored QAL3 information. To conduct this, press the 'Apply' button here. This will re-enter the span ***and*** zero gas data for all collected QAL3 data for the selected measurand.

## 6.9 QAL2 PARAMETERS

Also from the configuration page, the QAL2 factors may be examined, changed and added to; these operations require a login and password. Firstly, select the location that the measurands(s) are made in the top left-hand corner. The QAL2 factors currently applied to the data are now displayed, along with the date that these factors are to be applied from. The left and right arrows will take the user back and forward in time if there are multiple sets of QAL2 data; the factors are applied from the date including that date.

The two factors are entered so the result is Coeff. a x value + Coeff. b and the default values are 1 and 0 (no correction applied).

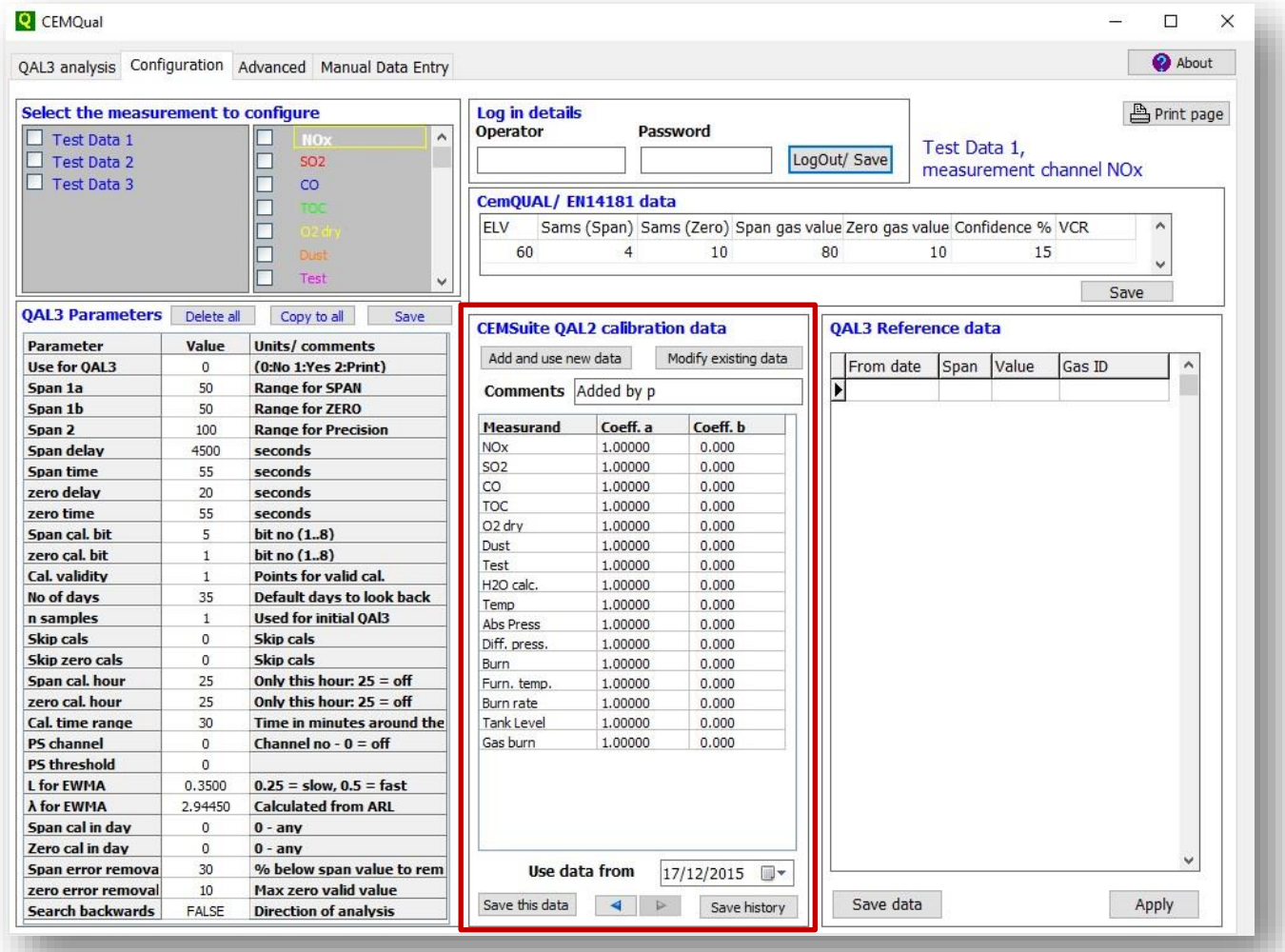



**Figure 42 QAL2 Data Section**

### 6.9.1 HOW TO ADD A NEW QAL2 DATA SET

To enter a new set of QAL2 data for a group of measurements on a common stack, conduct the following:

1. Select the location from the list in the top left-hand corner (e.g., Unit 1 stack).
2. Press the 'Add and use new data' button. This will make a copy of the existing QAL2 dataset, and open it for editing.
3. Edit the QAL2 data for each measurand until they are as required.
4. Add a suitable comment to identify why the changes have been made.
5. Select the date from which the new factors should be applied.
6. Press the 'Save this data' button.
7. If the date from which the new factors are to be applied is sometime in the past, the data will require reprocessing from this time. This is conducted from the CEMForm program – see this manual for details.

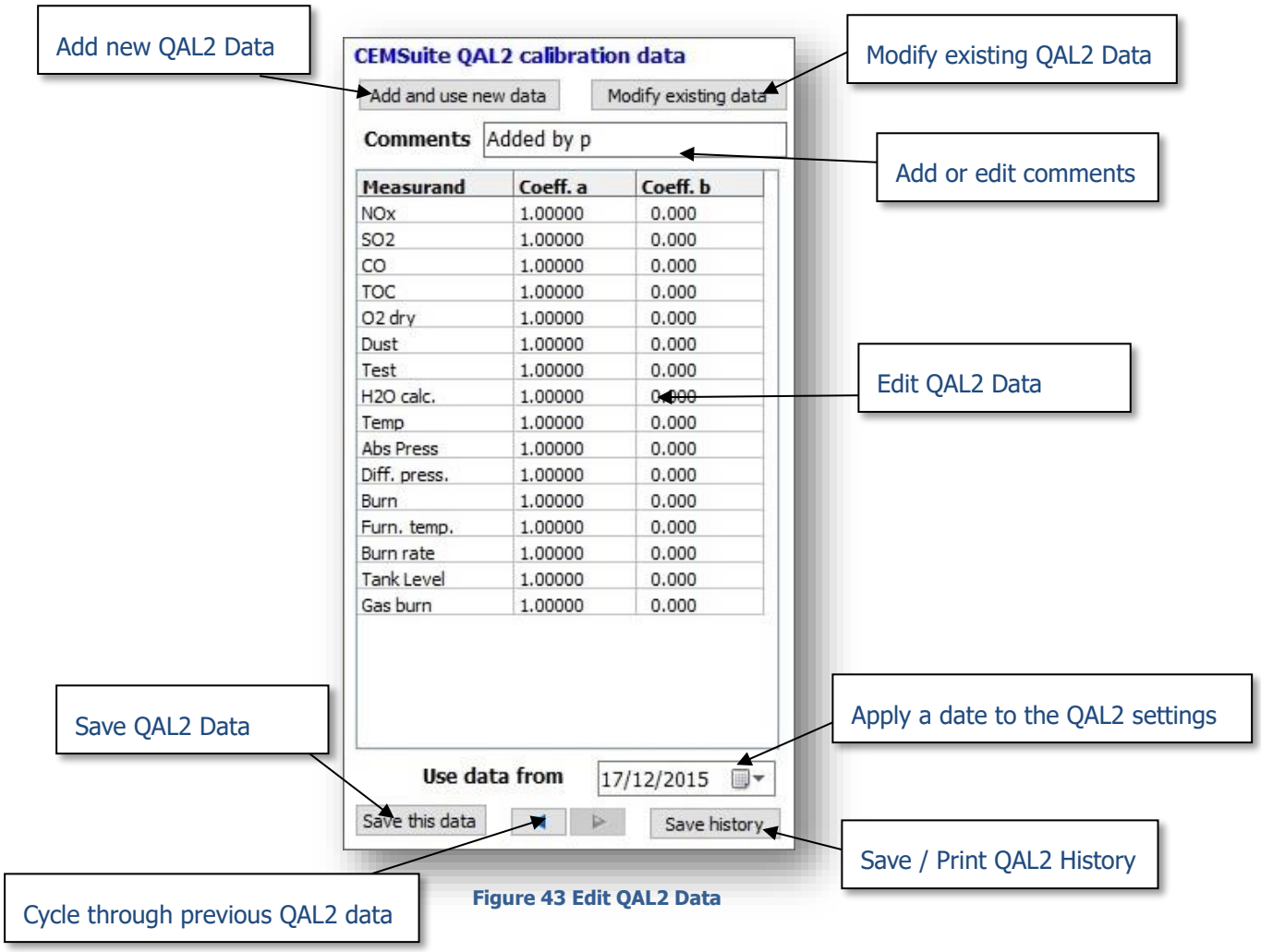



**Figure 43 Edit QAL2 Data**

### 6.9.2 HOW TO EDIT AN EXISTING QAL2 DATA SET

To enter a new set of QAL2 data for a group of measurements on a common stack, conduct the following:

1. Select the location from the list in the top left-hand corner (e.g., Unit 1 stack).
2. Press the 'Modify existing data' button. This will open the dataset for editing.
3. Edit the QAL2 data for each measurand until they are as required.

Then continue as in 6.9.1 above.

### 6.9.3 NOTES ON QAL2 DATA ENTRY

Please note the following when entering QAL2 data:

1. The QAL2 factors should be in the raw terms of the measurement. For gas measurements, this is usually mg/m3, but may occasionally be ppm.
2. Be cautious when applying QAL2 factors to dust measurements; if the basis of the measurement is the optical transmission, then particular care must be used. Please consult Envirosoft if there are any doubts.
3. The effect of the QAL2 factors may be checked on the CEMForm program using the trends page; there is an option to remove them and check the effect is as required.
4. Don't forget to reprocess the data from CEMForm from the date required, if the QAL2 is entered retrospectively.

### 6.9.4 PRINT / SAVE QAL2 HISTORY

Users have the ability to print the QAL2 data history by selecting 'Print history'. This will print all QAL2 data from the point of installation in a spreadsheet style format. Operators and Engineers, once logged in, have the ability to save the QAL2 data history to a .xls spreadsheet file.

## 6.10 MULTIPLE QAL3 DATASETS

Occasionally, an analyser may have two sets of QAL3 data; for example, one from the results after admitting bottled gas into the measurement chamber, and the other using an inferred technique such as a filter wheel. The CEMQual program may be set up for this by adding the following lines to the CEMQual.ini file (in the Config folder).

[Datasets]
Number of datasets=2
Name 1=Bottled gas (or any name)
Name 2=Gas wheel

Copies should also be made of the following folder from the QAL data folder: Config, Comments and Current. To each of these, the number 1 should be added to the end of the name, e.g., QAL Data\Config1 etc. If there were three sets, another copy of these three folders should be made with the suffix '2', and so on. Note that the program will update the folder structure from earlier versions (v4.53 and earlier), and so removing the need for the Group1, Group2 etc folders. Run the program first to create the Config and Comments folders.

The contents of the Comments1 and Current1 folders should be deleted as these will be populated by the new analysis and subsequent comments to the data. The Config folder may be left alone as a starting point in the configuration, or its contents deleted if the user starts the configuration of the new dataset afresh. Note that if the new dataset is selected, all changes made to the configuration will be to only to this dataset, not all datasets.

If more than one dataset is defined, a new selection box is revealed on the config page. From here the operator may select the QAL3 data to be examined. It is suggested that the most commonly used data is set to the default settings (no suffix), as it will be these that are visible when the program starts.

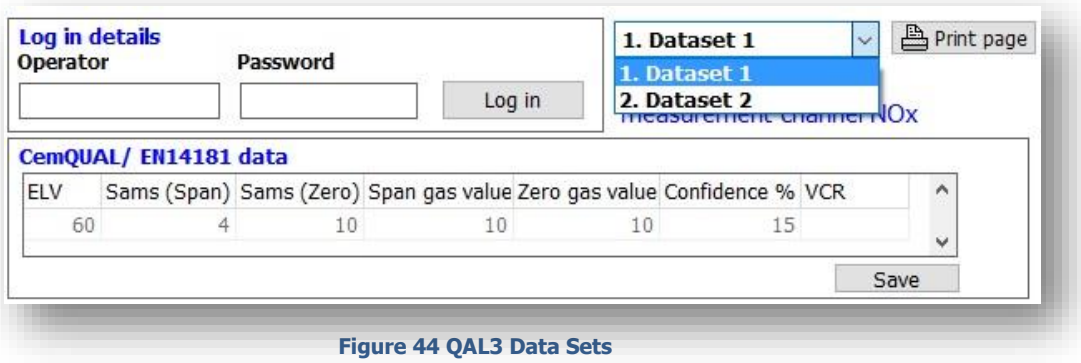



Figure 44 QAL3 Data Sets

If multiple datasets are used, these are indicated on all control chart plots in the top right-hand corner; bottled gas being indicated below.

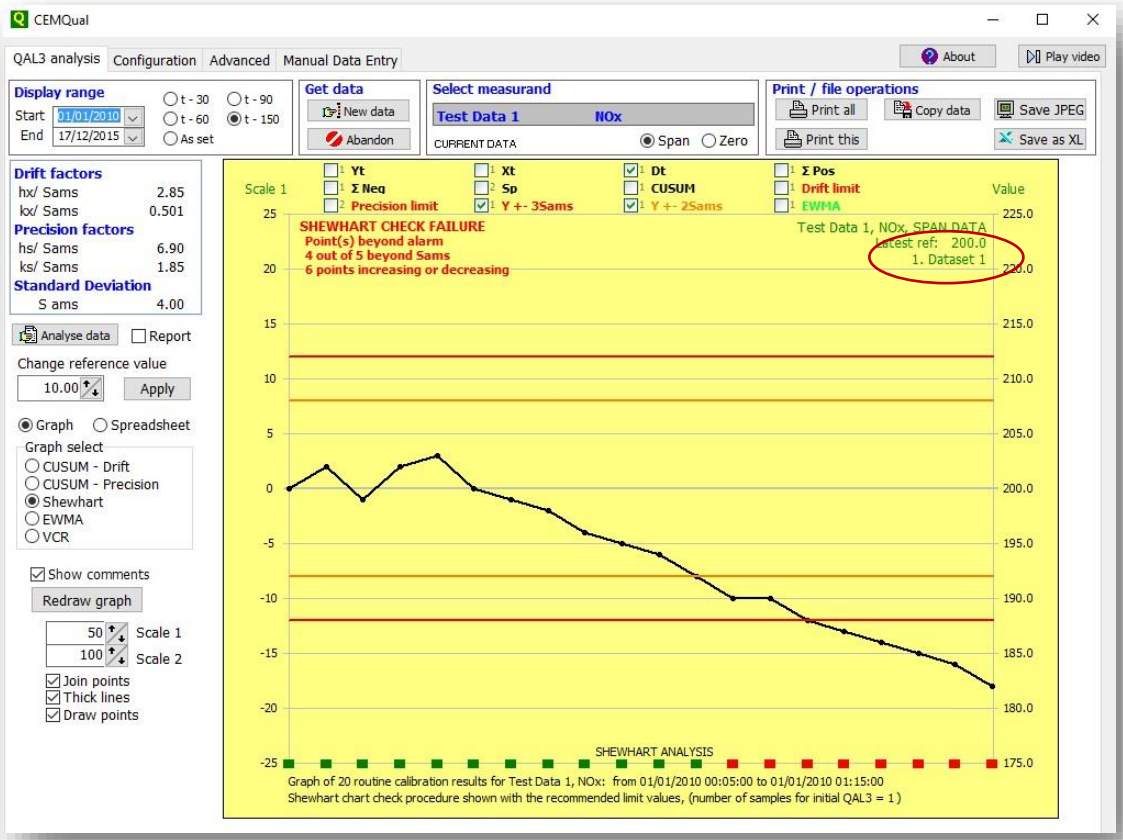



**Figure 45 Control Chart Data Sets**

# 7 MANUAL DATA ENTRY

After opening the 'Manual Data Entry' page, the screen below will be displayed. Details of how to select and enter data are now provided.

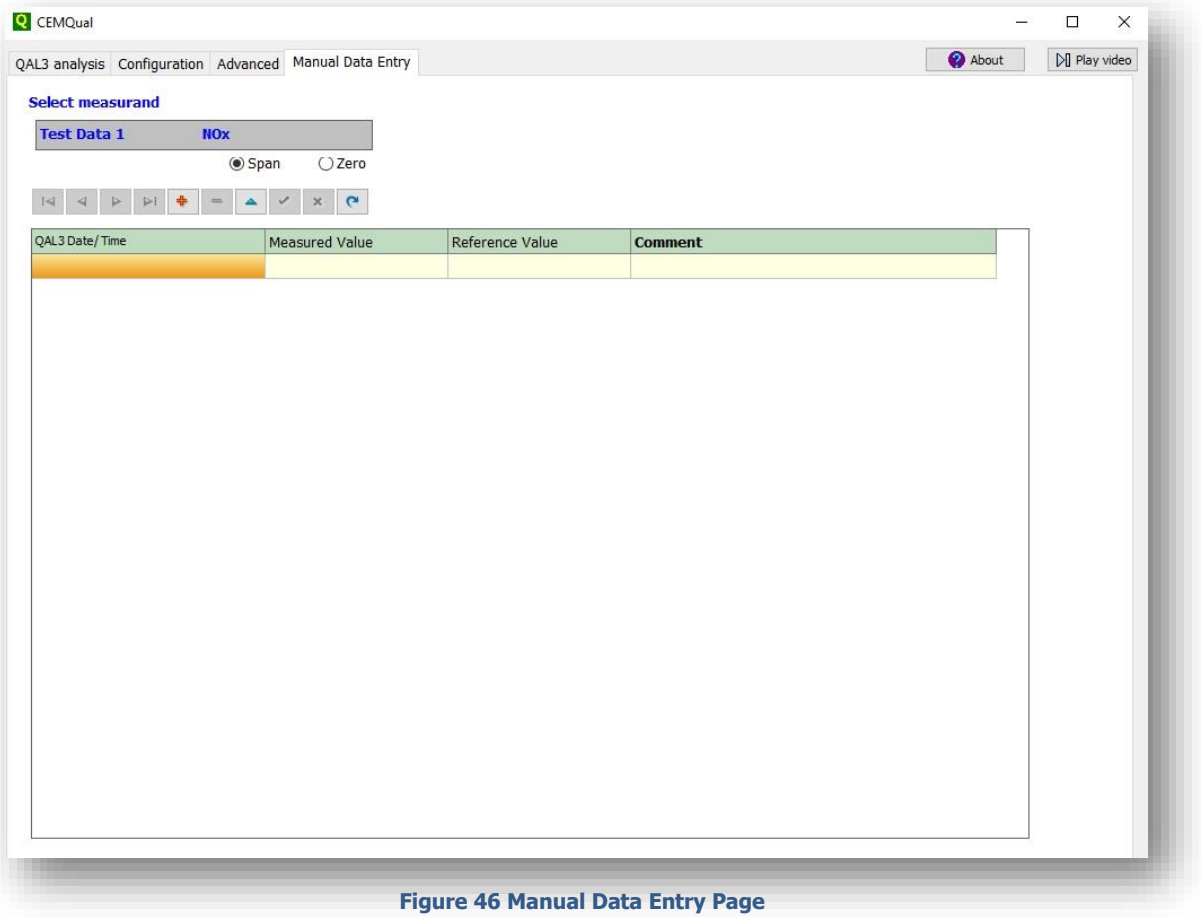



**Figure 46 Manual Data Entry Page**

This facility is provided so that data may be entered manually into the program and checked alongside automatic readings. It is envisaged that this will be used for systems where automatic calibration is not possible, or for sites where supplementary calibrations are conducted and not marked by the data logging system. Although the data here exists in the main database, it is always marked as MANUAL to indicate its source.

## 7.1 SELECTING MEASURAND

Before configuring any information on the Manual Data Entry tab, the correct measurand must be selected. To select the measurand, double click the group and channel, as shown below and select the appropriate measurement.

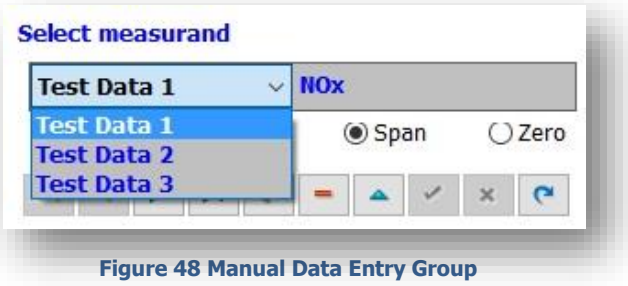



Figure 48 Manual Data Entry Group

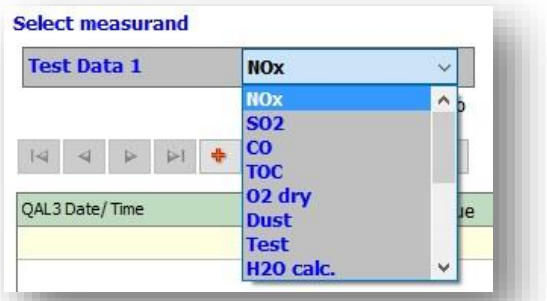



Figure 48 Manual Data Entry Channel

## 7.2 SELECTING SPAN OR ZERO

Once the correct group and channel have been selected, the calibration type must be selected. Click either 'Span' or 'Zero' as appropriate.

Figure 49 Manual Data Entry Span/Zero

## 7.3 ENTERING QAL3 DATA

To enter a new data point, either press the insert key or press the 'Plus' button to start a new record.

**Note**: It doesn't matter what date and time order the data is entered, the charts will be sorted correctly. However, for ease of record-keeping and control, it is advised that the latest data be put at the top of the grid.

### 7.3.1 QAL3 DATE / TIME

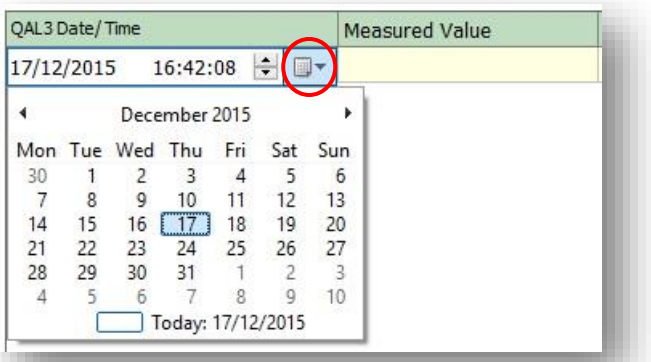



**Figure 50 Manual Data Entry Date/Time**

Specific dates can be selected under the 'QAL3 date/ time' column by double clicking the cell then clicking the arrow circled in the image above. Once the calendar appears, a relevant date can be selected, as shown above.

### 7.3.2 MEASURED VALUE

Enter the value recorded by the analyser for this span or zero measurement. The units used reflect that of the reference material.

### 7.3.3 REFERENCE VALUE

Enter the value recorded by the analyser for this span or zero measurement. The units used must reflect that of the reference material.

## 7.4 KEY FOR BUTTONS

The functions of the navigation buttons are detailed below:

Figure 51 Navigation Buttons

1. Navigates back to the very first record of data.
2. Selects previous record up.
3. Selects next record down.
4. Navigates to the last record of data.
5. Adds a new manual record, as shown by the red arrow.
6. Deletes record, as shown by the red arrow.
7. Click this button to edit record currently selected, which enables buttons 8 and 9.
8. Saves changes made.
9. Abandons changes made.
10. Refresh records.

Specific dates can be selected under the 'QAL3 date/ time' column by double clicking the cell then clicking the arrow circled in the image above. Once the calendar appears, a relevant date can be selected, as shown above.

## 7.5 MANUAL AND AUTOMATIC DATA ENTRY

Relevant comments can be added to every record within the 'Comments' column. Once the manual record is saved, it will appear in the 'QAL CUSUM Analysis' tab along with all automatic records. Manual records are identified by having the name 'MANUAL' unlike automatic records, which are named according to the gas bottle data.

**Note:** That records obtained automatically are not available for editing.

**Manual Data Entry:**

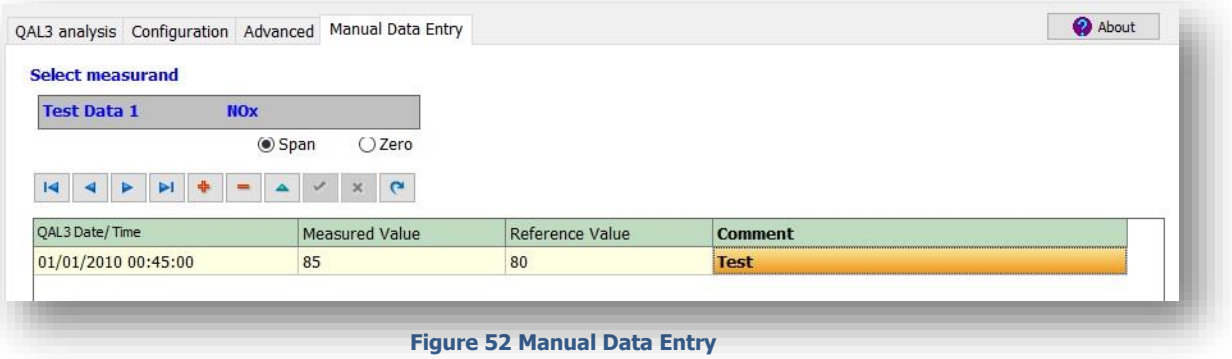



Figure 52 Manual Data Entry

*Manual And Automatic Data Entry continued…*

### QAL3 Analysis:

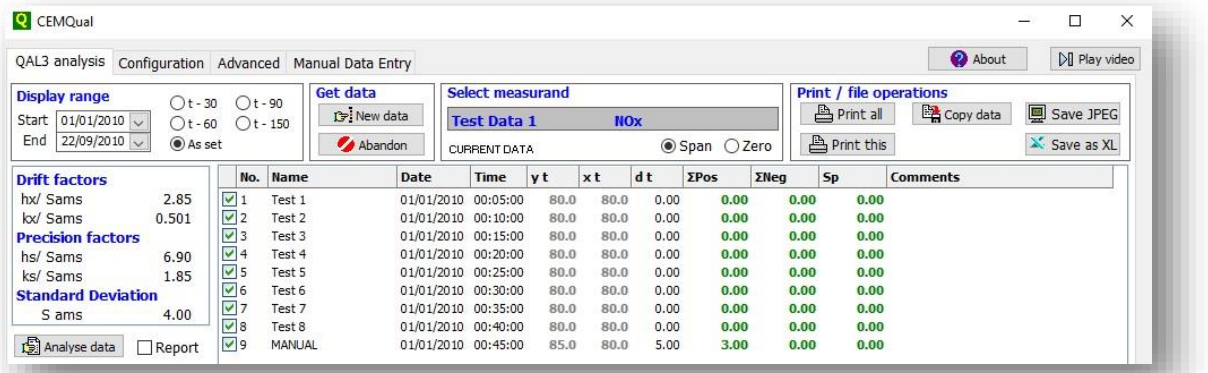



**Figure 53 Manual Data Entry CUSUM Analysis**

**Note:** Comments added to manual records within the Manual data Entry tab will not be shown within the QAL3 analysis tab. This is simply for manual record description purposes.

# 8 CONTROL CHART INFORMATION

## 8.1 CUSUM DRIFT CHART DETAILS

CEMQual calculates the CUSUM drift information for both positive and negative drifts according to the European standard, EN 14181 (part C4). It operates on a set of data consisting of a series of check readings and reference levels (typically the analyser reading, and the gas bottle concentration).

Two constants are calculated from the standard deviation (Sams) $h_x$ and $k_x$.

$$h\,x = 2.85\ Sams \qquad \text{(C.2)}$$
$$k\,x = 0.501\ Sams \qquad \text{(C.3)}$$

These values are used to test the QAL3 data. The difference between the recorded measurement and the reference is then calculated as:

$$dt = yt - xt$$

*Where: yt = recorded measurement, xt = reference value*

The CUSUM check for positive drift is then calculated as:

$$\Sigma(\text{pos})\text{p} = \Sigma(\text{pos})t\text{–}1 + dt - kx \qquad \text{(C.7)}$$

And the CUSUM check for negative drift calculated as:

$$\Sigma(\text{neg})\text{p} = \Sigma(\text{neg})t\text{–}1 - dt - kx \qquad \text{(C.8)}$$

Effectively, should the readings remain in a band of +/- 0.501 Sams around the zero error line, the two CUSUM values will remain at zero. Should the readings exceed these values, however, the CUSUM will increase rapidly. It is compared against the value of $h_x$ for both positive and negative drifts.

– if $\Sigma(\text{pos})t > hx$ , then a positive drift is detected;
– if $\Sigma(\text{neg})t > hx$ , then a negative drift is detected.

These constants are shown on CEMQual on the QAL3 page. These have been taken directly from the standard.

## 8.2 CUSUM DRIFT PASS / FAIL CRITERIA

On the face of it, the CUSUM drift calculations may appear complex, and often produce a chart which remains on the zero line. However, the criteria for pass or fail is very easy to assess; the data must remain within +/- 2.85 x Sams.

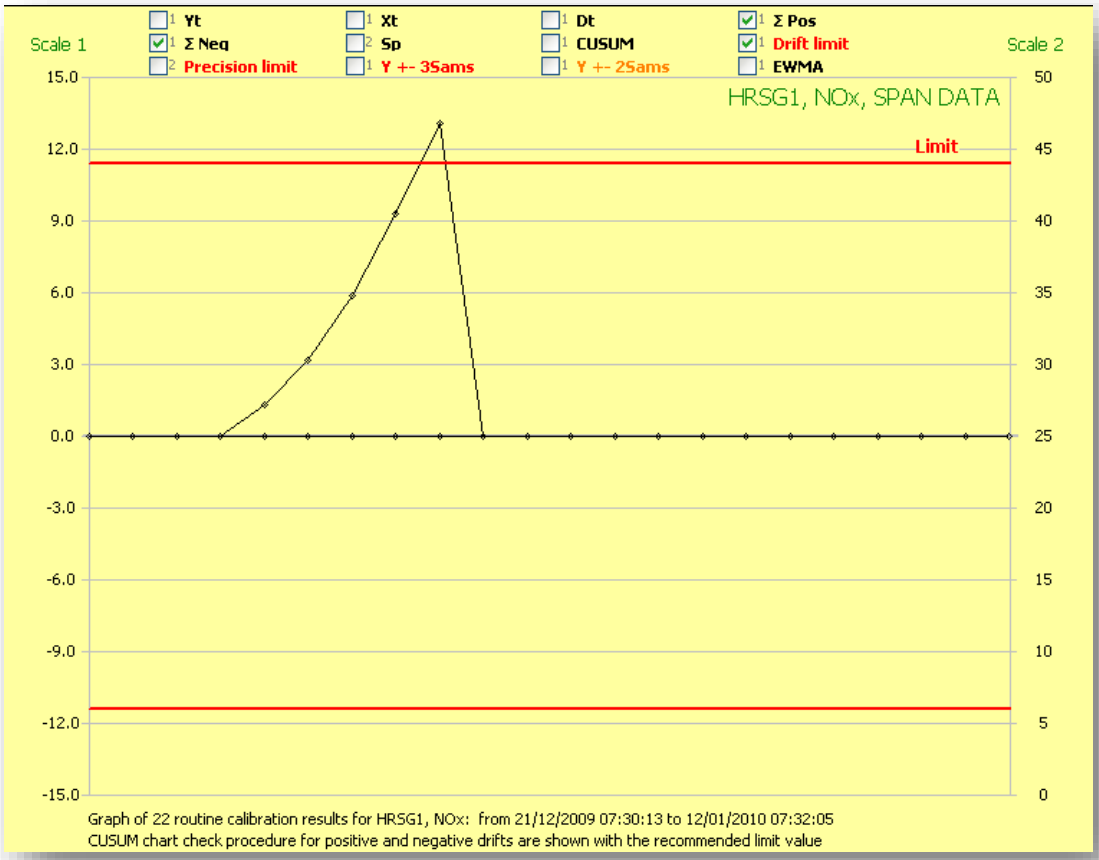



**Figure 54 CUSUM Drift Pass / Fail**

CEMQual plots the positive and negative drift values alongside their limit lines in RED (colour is selectable), and it is very easy to interpret whether the measurement system is in control or not. The above example indicates that the system went out of control for a period. Three items are checked – positive and negative drifts and the limit value.

Should the data have been examined as a spreadsheet, the positive drift column over this period would have been highlighted in RED – normally GREEN.

## 8.3 CUSUM PRECISION CHART DETAILS

CEMQual calculates the CUSUM precision information according to the European standard, EN 14181 (part C4). It operates on a set of data consisting of a series of check readings and reference levels (typically the analyser reading, and the gas bottle concentration).

Two constants are calculated from the standard deviation (Sams) $hs$ and $ks$.

$$h\,s = 6.90\ Sams \qquad \text{(C.2)}$$
$$k\,s = 1.85\ Sams \qquad \text{(C.3)}$$

The differences between each subsequent check readings are made (d(t) and d(t-1)) for each of the readings in the data set. According to the standard, the following formula is used:

$$Sp = s(t-1) + \frac{(d(t) - d(t-1))2}{2} - Ks$$

And then compared against the $hs$ value:
if $sp > hs$ then a decrease in precision of the AMS has been established.

**Note:** Effectively a band of +/- 1.85 x Sams exists around the data, and should the difference between the two consecutive readings remain in this band (according to the formula above) the Sp calculation will remain at zero constantly.

The precision check is an indication of how much the calibration check data is varying by between each calibration, not an indication of absolute value.

## 8.4 CUSUM PRECISION PASS / FAIL CRITERIA

To view a precision control chart, move to the Graph select box and click on the "CUSUM Precision" radio button; scale 2 is used for these charts. As long as the calculation of Sp remains under the precision limit, the measurement system meets the EN14181 criteria for precision.

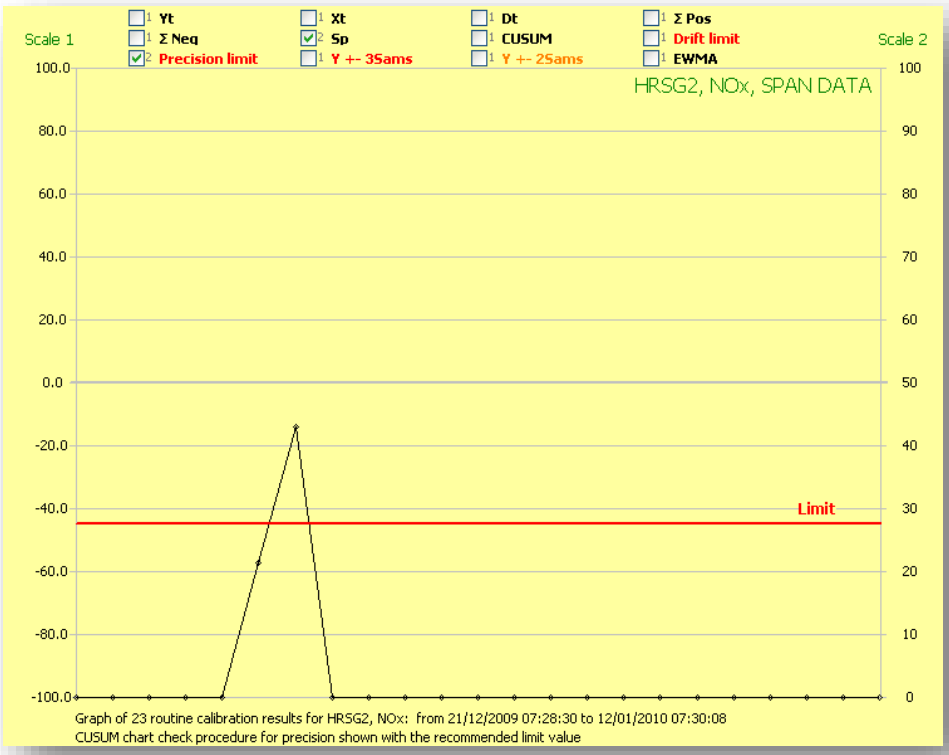



**Figure 55 CUSUM Precision Pass / Fail**

In this example, the system has failed. Should a spreadsheet have been selected for viewing, the Sp column for the data will be highlighted in RED as below.

| | No. | Name | Date | Time | y t | x t | d t | ΣPos | ΣNeg | Sp |
|---|---|---|---|---|---|---|---|---|---|---|
| ☑ | 1 | cell (17) | 20/12/2009 | 07:28:18 | 330.2 | 327.6 | 2.60 | 1.60 | 0.00 | 0.00 |
| ☑ | 2 | cell (16) | 21/12/2009 | 07:28:30 | 335.5 | 327.6 | 7.90 | 8.50 | 0.00 | 6.65 |
| ☑ | 3 | cell (18) | 22/12/2009 | 07:28:32 | 329.5 | 327.6 | 1.90 | 9.39 | 0.00 | 17.25 |
| ☑ | 4 | cell (17) | 23/12/2009 | 07:28:33 | 333.3 | 327.6 | 5.70 | 14.09 | 0.00 | 0.00 |
| ☑ | 6 | cell (17) | 24/12/2009 | 07:28:45 | 330.8 | 327.6 | 3.20 | 16.29 | 0.00 | 0.00 |
| ☑ | 7 | cell (18) | 25/12/2009 | 07:28:42 | 337.1 | 327.6 | 9.50 | 24.79 | 0.00 | 12.45 |
| ☑ | 8 | cell (17) | 26/12/2009 | 07:28:49 | 327.6 | 327.6 | 0.00 | 0.00 | 0.00 | 50.17 |
| ☑ | 9 | cell (17) | 27/12/2009 | 07:28:52 | 327.4 | 327.6 | -0.20 | 0.00 | 0.00 | 0.00 |

**Figure 56 Cusum Precision Spreadsheet**

## 8.5 SHEWHART CHART DETAILS

To view a Shewhart control chart, move to the Graph select box and click on the "Shewhart" radio button. Although these charts 'make sense' to the operator by plotting each of the calibration checks directly against warning and alarm lines, their interpretation can differ.

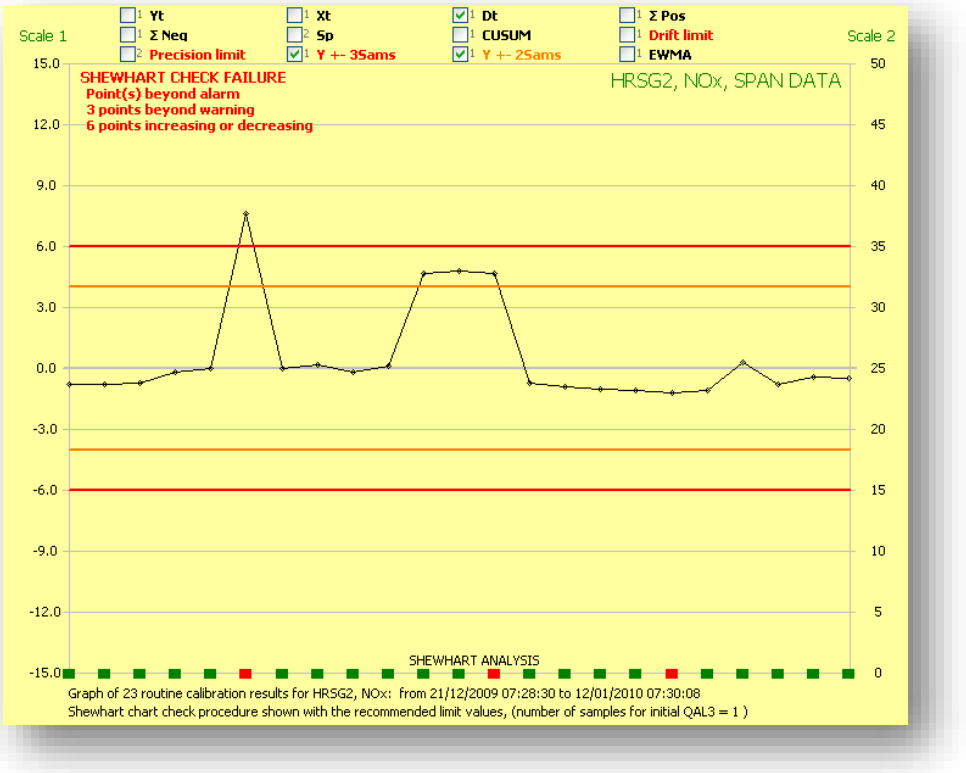



**Figure 57 Shewhart Details**

CEMQual uses the 5 parameters as detailed in the Environment Agencies Technical Guidance Note TGN-M20, and are, when:

1. One or more data points are beyond one of the upper alarm limits;
2. Three consecutive data points are beyond one of the warning limits;
3. Four points among 5 consecutive ones are beyond +/- Sams;
4. Eight consecutive points are on the same side of the mean;
5. Six consecutive points are either increasing or decreasing.

**Note:** For condition 4 and 5, CEMQual will not indicate a failure if the data is within 0.501 x Sams. This avoids potentially 'silly' failures that are possible when the recorded measurement is very close but consistently a little higher or lower than the reference. This agrees with the CUSUM check procedure (see page 47) which uses 0.501 x Sams as its 'acceptable window'.

## 8.6 SHEWHART CHART PASS / FAIL CRITERIA

The warning limits are set at +/- 2 x Sams, and the alarm limits at +/- 3 x Sams. These are drawn on the chart as illustrated above and are usually coloured in orange and red as seen here. These colours may be changed by the operator if required.

The interpretation of the data for the above 5 conditions is displayed on the chart area as a series of coloured blocks – one for each measurement. Normally these blocks are GREEN when none of the criteria has been breached, but this will turn to RED should one or more conditions be breached.

The example above shows three failure conditions, from left to right: one or more point beyond the alarm, three or more consecutive points beyond the warning, and 6 consecutive points either increasing or decreasing.

Although CEMQual will check for a pass/ fail automatically, it can be seen that the interpretation of this is not as straightforward as the CUSUM drift procedure detailed earlier.

There appears to be a tendency for the UK to use Shewhart charts rather than CUSUM charts for drift. According to the European standard, however, the opposite is true. Ultimately it is up to the operator and their EA representative to decide which chart to use.

**Note:** The Shewhart chart does not check on the precision of the measurement system.

## 8.7 EWMA CHART DETAILS

The exponentially weighted moving average (EWMA) charts were offered as an acceptable alternative to CUSUM or Shewhart charts for drift assessment in the European document: CEN/TR 15983.

Effectively, this calculation biases the result data according to historic data more than the effect of each individual check. One factor controls this bias, $l$, and subsequent readings are analysed by:

$$\text{New EWMA} = (1 - l) \times \text{Old EWMA} + l \text{ New Reading}$$

**NOTE:** For the first average, EWMA = New Reading.

This formula is as stated in the document referenced above, however, it only works for a constant reference value; a change in reference will see a step change that may well result in an error. To accommodate this likelihood, CEMQual uses the errors between the reading and reference, rather than the absolute value. This has been tested with the suggested information in the standard and the same results produced.

This bias value is selectable, but the following is suggested:

$$l = 0.35$$

Or, about two to one in favour of the old data compared to the new.

If $l$ nears 0, this will take the past more into account and detect small drifts, but sudden major drifts are less easily detected. If $l$ nears 1, this will take the past less into account and responsiveness to sudden major drifts are greater, but small drifts will be less easily detected.

The calculated EWMA is then compared against thresholds set at a suggested level of:

$$+/- \ 2.9445 \times \text{Sams} \ \sqrt{(l/(2 - l))}$$

When using 0.35, we get:

+/- 1.38 x Sams for drift limits.

## 8.8 EWMA PASS / FAIL CRITERIA

In a similar fashion to the CUSUM drift check procedure, the EWMA is easily assessed; it must remain within the two limit values.

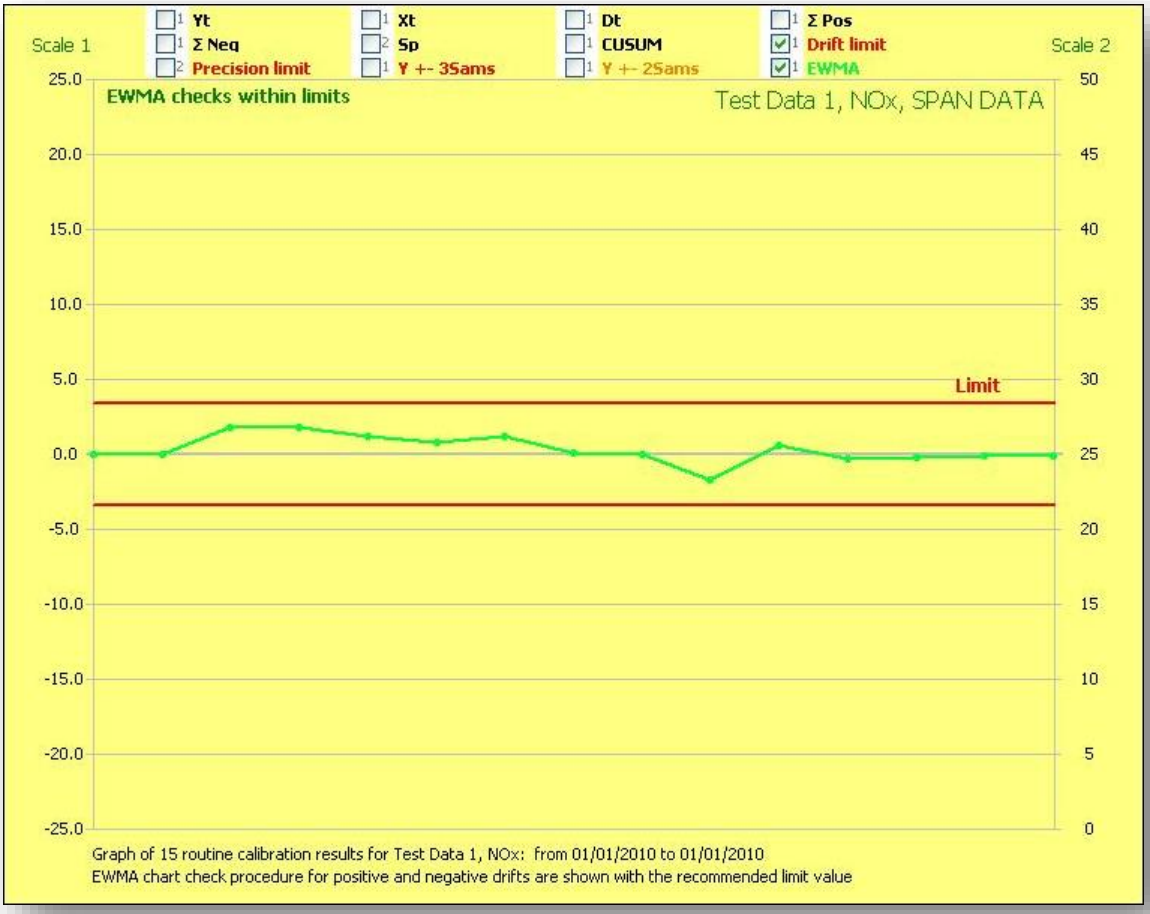



**Figure 58 EWMA Pass / Fail**

The example here indicates that the measurement system is within control for drift when assessed using the EWMA method.

## 8.9 SPREADSHEET GRID NOTES

After the QAL3 data has been read from the database, the parameters required under EN 14181 are calculated, and the remaining columns of the grid are populated. A typical grid is shown below and the columns identified.

| No. | Name | Date | Time | y t | x t | d t | ΣPos | ΣNeg | Sp | CUSU | +D Adj | -D Adj. | EWMA |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | cell (12) | 23/12/2009 | 07:30:16 | 330.8 | 332.0 | -1.20 | 0.00 | 0.00 | 0.00 | -1.20 | - | - | 330.80 |
| 3 | cell (13) | 24/12/2009 | 07:30:28 | 331.4 | 332.0 | -0.60 | 0.00 | 0.00 | 0.00 | -1.80 | - | - | 331.79 |
| 4 | cell (13) | 25/12/2009 | 07:30:39 | 331.2 | 332.0 | -0.80 | 0.00 | 0.00 | 0.00 | -2.60 | - | - | 331.58 |
| 5 | cell (12) | 26/12/2009 | 07:30:38 | 331.1 | 332.0 | -0.90 | 0.00 | 0.00 | 0.00 | -3.50 | - | - | 331.41 |
| 6 | cell (14) | 27/12/2009 | 07:30:42 | 331.2 | 332.0 | -0.80 | 0.00 | 0.00 | 0.00 | -4.30 | - | - | 331.34 |
| 7 | cell (12) | 28/12/2009 | 07:30:52 | 331.6 | 332.0 | -0.40 | 0.00 | 0.00 | 0.00 | -4.70 | - | - | 331.43 |
| 8 | cell (14) | 29/12/2009 | 07:30:52 | 331.6 | 332.0 | -0.40 | 0.00 | 0.00 | 0.00 | -5.10 | - | - | 331.49 |
| 10 | cell (14) | 31/12/2009 | 07:31:10 | 332.4 | 332.0 | 0.40 | 0.00 | 0.00 | 0.00 | -4.70 | - | - | 331.81 |
| 11 | cell (14) | 01/01/2010 | 07:31:10 | 332.4 | 332.0 | 0.40 | 0.00 | 0.00 | 0.00 | -4.30 | - | - | 332.02 |
| 12 | cell (13) | 02/01/2010 | 07:31:14 | 332.3 | 332.0 | 0.30 | 0.00 | 0.00 | 0.00 | -4.00 | - | - | 332.12 |
| 13 | cell (13) | 03/01/2010 | 07:31:24 | 331.9 | 332.0 | -0.10 | 0.00 | 0.00 | 0.00 | -4.10 | - | - | 332.04 |
| 14 | cell (13) | 04/01/2010 | 07:31:24 | 331.7 | 332.0 | -0.30 | 0.00 | 0.00 | 0.00 | -4.40 | - | - | 331.92 |
| 15 | cell (13) | 05/01/2010 | 07:31:36 | 331.7 | 332.0 | -0.30 | 0.00 | 0.00 | 0.00 | -4.70 | - | - | 331.84 |
| 16 | cell (13) | 06/01/2010 | 07:31:43 | 331.3 | 332.0 | -0.70 | 0.00 | 0.00 | 0.00 | -5.40 | - | - | 331.65 |
| 17 | cell (12) | 07/01/2010 | 07:31:39 | 331.9 | 332.0 | -0.10 | 0.00 | 0.00 | 0.00 | -5.50 | - | - | 331.74 |

**Figure 59 Spreadsheet Grid Notes**

| Column header | Description |
|---|---|
| No | Test number of the calibration between the dates selected. Should calibration checks have been discarded, then gaps will be seen as above (2 & 9 are missing) |
| Name | Name of the reference – usually gas bottle ID |
| Date | Date of check |
| Time | Time of check |
| yt | Value measured by the system |
| xt | Reference value expected |
| dt | The difference between yt and xt |
| SPos | Positive CUSUM drift calculation |
| SNeg | Negative CUSUM drift calculation |
| Sp | CUSUM precision calculation |
| CUSUM | Accumulated sum of dt |
| +D Adj. | + Adjustment required if out of control |
| – D Adj. | – Adjustment required if out of control |
| EWMA | Exponentially weighted moving average |

**Table 3 Spreadsheet Grid Notes**

**Note:** The four columns on the right are replaced with comments for this measurement time if this has been selected. This is discussed in the next section.

# 9 WHICH CHART SHOULD I USE / PRINT?

EN 14181 QAL3 analysis considers two different checks on the measurement system: drift and precision.

The check for complying with drift may be conducted using either:

1. CUSUM for Drift method, as defined within EN 14181 – Stationary source emissions – Quality assurance of automated measuring systems.

2. Shewhart charts, as defined in UK EA M20 document – Quality assurance of continuous emission monitoring systems application of BS EN 14181 and BS EN 13284-2.

3. Exponentially weighted moving averages (EWMA) as defined in FprCEN/TR 15983 – Stationary source emissions – Guidance on the application of EN 14181:2004.

4. Any method appears to be acceptable and may depend on the local inspectorate as to which is preferred. CEMQual can conduct all of these analysis types if required.

5. Only one check is discussed for precision analysis and this is the CUSUM method in EN 14181. CEMQual conducts this if required and can plot the data with limits.

6. For record keeping, it is advised that at least the spreadsheet view is printed – this will display the raw data and also demonstrate compliance with all of the above checks.

# 10 QAL3 SAMS & REFERENCE VALUES FOR QAL3 CONTROL CHARTS.

To use QAL3 control charts effectively, a realistic standard deviation value (Sams) is required. This value plays a key role in determining whether an analyser measurement is in control. A fault may not be detected if it's too high, and a false error reported if too low. Where this data is available from the manufacturer, and has provided reasonable QAL3 results and the control charts look 'healthy', they should normally be used.

Typical figures for Sams are:

Sams Span = 2 - 5% of span gas value
Sams zero = 0.5 % of span gas value or 2, whichever is the greater

The values entered must balance the advantages of the early detection of a real analyser drift problem, with the disadvantages of false alarms from the natural variation of results.

The Environment Agency's Technical Guidance Note for Emissions, M20, gives operators some freedom to decide upon a sensible value for the Sams. It mentions the French (AFNOR) method for determining this, which is based on a fraction of the uncertainty specified in the applicable Directive. This is seen as a simpler approach, rather than combining all the uncertainties for each measurement. In the same section of M20, operators are informed that they can determine the limits for control charts based on experience.

A reliable method is to use a mathematical approach in determining the Sams; that is to calculate the standard deviation from a series of QAL3 tests, usually during analyser commissioning or after a gas bottle change. This should always result in realistic values being used, provided that the analyser was working correctly at the time. It will certainly indicate whether there has been a drift in the data after this.

The same method can also be used to determine the reference value to be used, rather than the actual bottle certificate. It must be borne in mind that QAL3 is a check on drift rather than absolute accuracy, and complications can occur when a QAL3 measurement consistently reads lower or higher than the selected reference gas or material. So, if the reference level used Is not adjusted to match that recorded, the QAL3 control chart will fail, unless either the Sams or reference values are adjusted. Widening the Sams will delay the detection of a drift problem, and it is better to adjust the reference value to match the result. Caution must be used here if the result is significantly different from the stated bottle concentration. We would suggest that a 5% error is probably not that significant, but a 10% error may be. Common sense must be used here in conjunction with other tests, for example: QAL2 and AST results.

## 10.1 SAMS & REFERENCE CALCULATIONS USING CEMQUAL (V4.56 ONWARDS)

CEMQual provides the ability to calculate directly the standard deviation values and the average measured concentrations from any set of QAL3 results. Further, they may be entered automatically into the databases and used for all future QAL3 test results until intervention.

In order to check the current standard deviation and average reference results, conduct the following:

1. Perform serval (6 or more) QAL3 tests. This is advised after analyser commissioning or a gas bottle change.
2. Gather the data within CEMQual and select the results required using the 'As set' date selection.Remember to remove any obvious outliers from the data before continuing, this may be conducted using the 'NO QAL3' comment.
3. Click the 'Analyse results' button at the bottom left of the front page and a statistical summary will be displayed.

Calculated and actual reference values

GT, CO, Span data, 08/08/2016 – 15/08/2016, 15 measurements.

| Results |
|---|
| 412.4 |
| 414 |
| 413 |
| 414 |
| 414 |
| 415 |
| 415 |
| 414.8 |
| 412 |
| 413 |
| 413.2 |
| 414 |
| 413 |
| 416 |
| 415 |

| Analysis summary | | Actual | Error % |
|---|---|---|---|
| Max. | 416 | | |
| Min. | 412 | | |
| Average | 413.89 | 416 | 0.51 |
| Sams | 1.085 | 4.00 | 7.08 |
| Sams * | 2.37 | | |

* Recalculated Sams using the original reference value

Calculated and actual Sams values

Calculated Sams using the original reference

**Notes on the summary table:**

1. In this example, a bottle concentration of 416 has been used, but the results show an average of 413.89 has been measured by the analyser; this would be seen as a small, acceptable error – shown as 0.51%.
2. The standard deviation used for QAL3 was 4.0, but the results show a calculated standard deviation of 1.085. This is significantly smaller than that used.
3. Should the original reference value (416) be used, then the results have a standard deviation of 2.37.

## 10.2 OPTIONS AFTER ANALYSIS

Two option buttons are available above the summary; Save the results to the database, or just save the data as an excel file for reference. The results may only be saved to the database if the security has been entered from the configuration page.

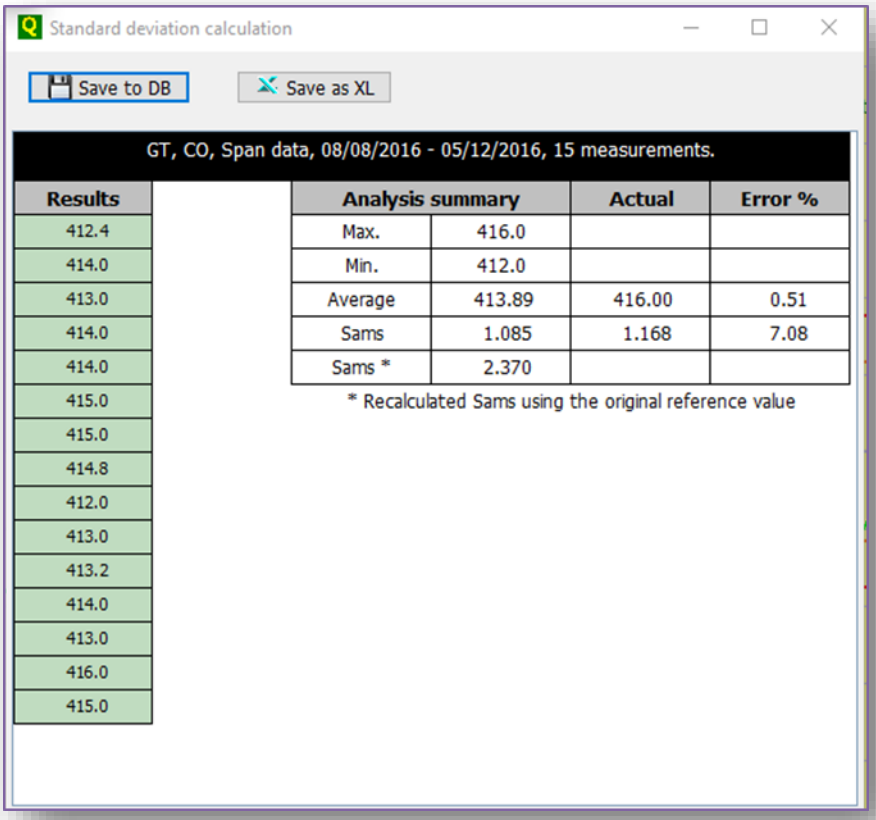



Figure 60 - Standard Deviation Calculation

See the following page for the details of the save options.

## 10.3 SAVE RESULT OPTIONS

The two selections within the Save results data box provide the following when checked.

1. 'New Sams and calculated gas bottle value' checkbox will save the calculated value as a new reference value, using a start date as set from the start of the analysis period. If required, this may be edited manually from the configuration page. Additionally, the calculated Sams from this data will be saved and used.
2. 'Sams calculated using the original reference value' will save the Sams as calculated using the original reference value; 2.37 in the example provided on the previous page but not enter the new calculated reference value.

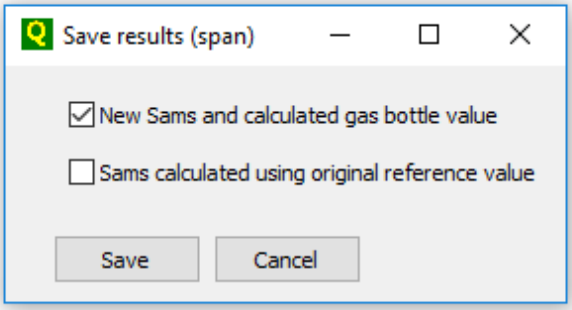



**Figure 61 - Save results**

After pressing the 'Save' button, apart from the above, the following operations are also conducted.

1. The display spans for the control charts will be adjusted to 10 x the Sams values.
2. The control charts will be recalculated using the new data. **Note:** should a new reference value be selected (option 1) this will need to be applied manually from the configuration page.

# 11 IGNORING ERRONEOUS READINGS

For many reasons, the results of QAL3 for a particular day may be in error – e.g. the gas bottle was empty or the analyser aborted the calibration half way through. CEMQual provides three ways of ignoring this data, please note, however, that data from the CEMSuite database is never deleted, it is only the QAL3 analysis that is affected. The three methods of ignoring the QAL3 data are:

1. For temporary exclusion – uncheck the box from the spreadsheet view of the data. The QAL3 analysis will re-appear every time the same selection is made again.

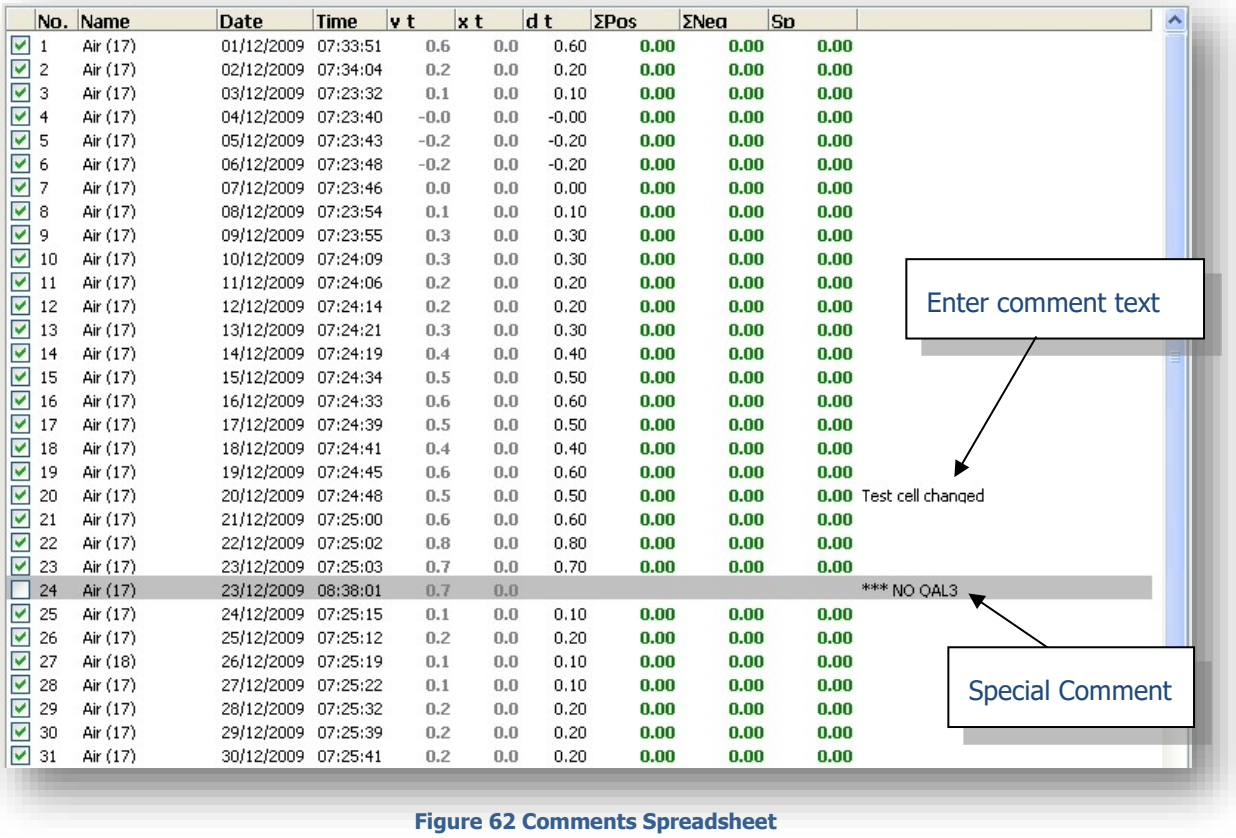
2. Semi-permanent exclusion – Enter the text "*** NO QAL3" within the comments. This will cause this record to be ignored every time the data is recalled or re-analysed. Effectively any calibration from the same date and time (nearest minute) will always be ignored by this measurement group.

   **Note:** Operators can set up a 'timed window' allowing for multiple data entries to be unchecked. See section 14.2 for more information.

3. Permanent exclusion – For permanent exclusion of data, the records for the day should be deleted from the 'Advanced page' - see page 71. Records here will only re-appear after this data has been re-analysed.

# 12 ADDING / DISPLAYING COMMENTS

Comments may be added to the charts. To add a comment, use the spreadsheet option. To display the data select the 'Display comments' option. The right-hand column is now filled with any comments that may have been made, to add a new comment just type in this field.




| No. | Name | Date | Time | y t | x t | d t | ΣPos | ΣNeg | Sp | |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Air (17) | 01/12/2009 | 07:33:51 | 0.6 | 0.0 | 0.60 | 0.00 | 0.00 | 0.00 | |
| 2 | Air (17) | 02/12/2009 | 07:34:04 | 0.2 | 0.0 | 0.20 | 0.00 | 0.00 | 0.00 | |
| 3 | Air (17) | 03/12/2009 | 07:23:32 | 0.1 | 0.0 | 0.10 | 0.00 | 0.00 | 0.00 | |
| 4 | Air (17) | 04/12/2009 | 07:23:40 | -0.0 | 0.0 | -0.00 | 0.00 | 0.00 | 0.00 | |
| 5 | Air (17) | 05/12/2009 | 07:23:43 | -0.2 | 0.0 | -0.20 | 0.00 | 0.00 | 0.00 | |
| 6 | Air (17) | 06/12/2009 | 07:23:48 | -0.2 | 0.0 | -0.20 | 0.00 | 0.00 | 0.00 | |
| 7 | Air (17) | 07/12/2009 | 07:23:46 | 0.0 | 0.0 | 0.00 | 0.00 | 0.00 | 0.00 | |
| 8 | Air (17) | 08/12/2009 | 07:23:54 | 0.1 | 0.0 | 0.10 | 0.00 | 0.00 | 0.00 | |
| 9 | Air (17) | 09/12/2009 | 07:23:55 | 0.3 | 0.0 | 0.30 | 0.00 | 0.00 | 0.00 | |
| 10 | Air (17) | 10/12/2009 | 07:24:09 | 0.3 | 0.0 | 0.30 | 0.00 | 0.00 | 0.00 | |
| 11 | Air (17) | 11/12/2009 | 07:24:06 | 0.2 | 0.0 | 0.20 | 0.00 | 0.00 | 0.00 | |
| 12 | Air (17) | 12/12/2009 | 07:24:14 | 0.2 | 0.0 | 0.20 | 0.00 | 0.00 | 0.00 | |
| 13 | Air (17) | 13/12/2009 | 07:24:21 | 0.3 | 0.0 | 0.30 | 0.00 | 0.00 | 0.00 | |
| 14 | Air (17) | 14/12/2009 | 07:24:19 | 0.4 | 0.0 | 0.40 | 0.00 | 0.00 | 0.00 | |
| 15 | Air (17) | 15/12/2009 | 07:24:34 | 0.5 | 0.0 | 0.50 | 0.00 | 0.00 | 0.00 | |
| 16 | Air (17) | 16/12/2009 | 07:24:33 | 0.6 | 0.0 | 0.60 | 0.00 | 0.00 | 0.00 | |
| 17 | Air (17) | 17/12/2009 | 07:24:39 | 0.5 | 0.0 | 0.50 | 0.00 | 0.00 | 0.00 | |
| 18 | Air (17) | 18/12/2009 | 07:24:41 | 0.4 | 0.0 | 0.40 | 0.00 | 0.00 | 0.00 | |
| 19 | Air (17) | 19/12/2009 | 07:24:45 | 0.6 | 0.0 | 0.60 | 0.00 | 0.00 | 0.00 | |
| 20 | Air (17) | 20/12/2009 | 07:24:48 | 0.5 | 0.0 | 0.50 | 0.00 | 0.00 | 0.00 | Test cell changed |
| 21 | Air (17) | 21/12/2009 | 07:25:00 | 0.6 | 0.0 | 0.60 | 0.00 | 0.00 | 0.00 | |
| 22 | Air (17) | 22/12/2009 | 07:25:02 | 0.8 | 0.0 | 0.80 | 0.00 | 0.00 | 0.00 | |
| 23 | Air (17) | 23/12/2009 | 07:25:03 | 0.7 | 0.0 | 0.70 | 0.00 | 0.00 | 0.00 | |
| 24 | Air (17) | 23/12/2009 | 08:38:01 | 0.7 | 0.0 | | | | | *** NO QAL3 |
| 25 | Air (17) | 24/12/2009 | 07:25:15 | 0.1 | 0.0 | 0.10 | 0.00 | 0.00 | 0.00 | |
| 26 | Air (17) | 25/12/2009 | 07:25:12 | 0.2 | 0.0 | 0.20 | 0.00 | 0.00 | 0.00 | |
| 27 | Air (18) | 26/12/2009 | 07:25:19 | 0.1 | 0.0 | 0.10 | 0.00 | 0.00 | 0.00 | |
| 28 | Air (17) | 27/12/2009 | 07:25:22 | 0.1 | 0.0 | 0.10 | 0.00 | 0.00 | 0.00 | |
| 29 | Air (17) | 28/12/2009 | 07:25:32 | 0.2 | 0.0 | 0.20 | 0.00 | 0.00 | 0.00 | |
| 30 | Air (17) | 29/12/2009 | 07:25:39 | 0.2 | 0.0 | 0.20 | 0.00 | 0.00 | 0.00 | |
| 31 | Air (17) | 30/12/2009 | 07:25:41 | 0.2 | 0.0 | 0.20 | 0.00 | 0.00 | 0.00 | |

**Figure 62 Comments Spreadsheet**

To ensure that the comment has been entered correctly, select a chart and check that the new text is displayed (See next page). The checkbox to the left of each row may be unchecked to temporarily remove this QAL3 record from the analysis.

Two 'special' comments are available, these are:

1. "***** NO QAL3**" – Ignores this data for all QAL3 analysis. Uncheck the checkbox automatically.

   **Note:** Operators can set up a 'timed window' allowing for multiple data entries to be unchecked. See section 14.2 for more information.

2. "***** RESET QAL3**" – Resets the CUSUM drift calculation from this calibration.

These may be accessed easily by clicking the right-hand mouse button over the comment field. The text will change from BLANK to *** No QAL3 to *** RESET QAL3 and then back again to BLANK.

**Note:** This automatic text entry will not occur should any other text exist in the field.

*Adding / Displaying Comments continued…*

Comments displayed on the chart area (This is as entered from the previous page):

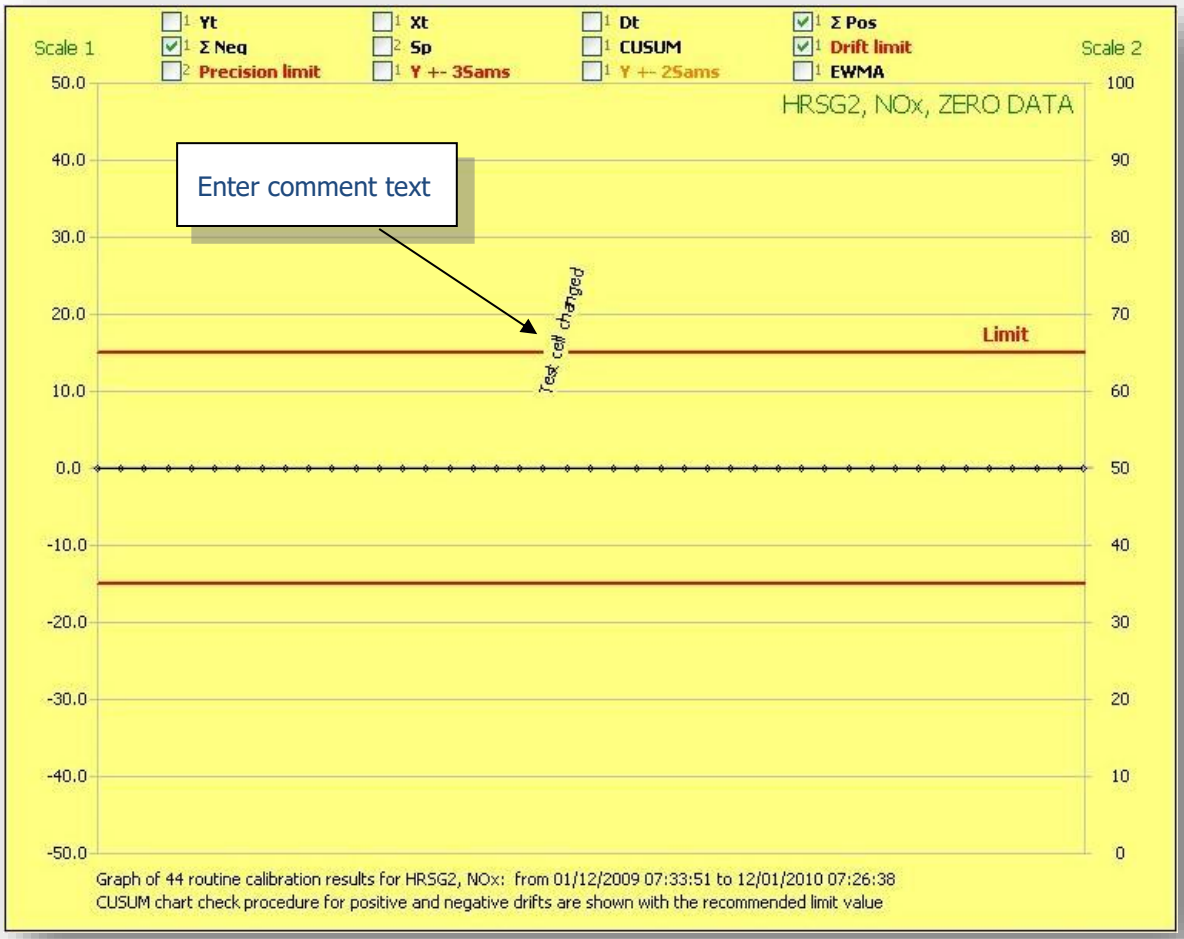



**Figure 63 Comments Graph**

Here the comment entered on the previous page may be seen. The angle of the text and the position (Y axis) may be changed from the advanced page – See QAL3 Plot Settings (page 14.167)

Comments are associated with the selected group of measurands and are tied to the nearest minute of calibration date and time. So, a calibration ending at 12:30:35 will have a comment stored at 12:31. All measurands that have a calibration check (either span or zero) will have this message displayed. In reality, there should be at least one-minute calibrations of measurands within the same group.

# 13 VALID CALIBRATED RANGE (VCR) INFORMATION

EN14181 also requires that the measurements have been within their calibrated ranges for most of the time, extract from standard:

"The validity of the valid calibration range shall be evaluated by the plant owner on a weekly basis (Monday to Sunday). A full new calibration (QAL 2) shall be performed, reported and implemented within 6 months if any of the following conditions occur:

> 5% of the number of AMS measured values calculated over this weekly period (based on calibrated values and expressed in the same units as the calibration) are outside the valid calibration range for more than 5 weeks in the period between two ASTs.

> 40% of the number of AMS measured values calculated over this weekly period (based on calibrated values and in the same units as the calibration) are outside the valid calibration range for one or more weeks."

The CEMQual program can access the time that the data for each measurement is above its calibrated range. It will check that the data for each measurement and assess how often as a percentage it has been above its calibrated range, on a weekly basis. This number accumulates during each week from Monday to Sunday, resetting on a Monday morning.

In reality, this check is only for measurements that are transient in nature, and where the fuel burnt is not known, i.e., the CO measurement on an incinerator. Here the levels are typically very low, but during periods of poor combustion when some wet or low-calorie waste is being burnt; very high levels of CO are possible (thousands of ppm/ mg).

On older analogue systems, high levels would have been clipped by the A/D circuitry and never recorded. Indeed, with a reduced range of the analogue outputs, it was possible to prevent any excursions above the ELV or the VCR. With modern digital systems, however, the data is transferred as real numbers, so little or no clipping takes place; sometimes, artificial clipping of the reported data is available so as to not prejudice these systems. In such circumstances, it is desirable that the VCR is assessed to ensure that CEMS have been ranged correctly.

## 13.1 USING THE VALIDATED CALIBRATED RANGE (VCR)

For a measurement that is rarely or never above its VCR, selecting this option will produce a chart similar to that below:

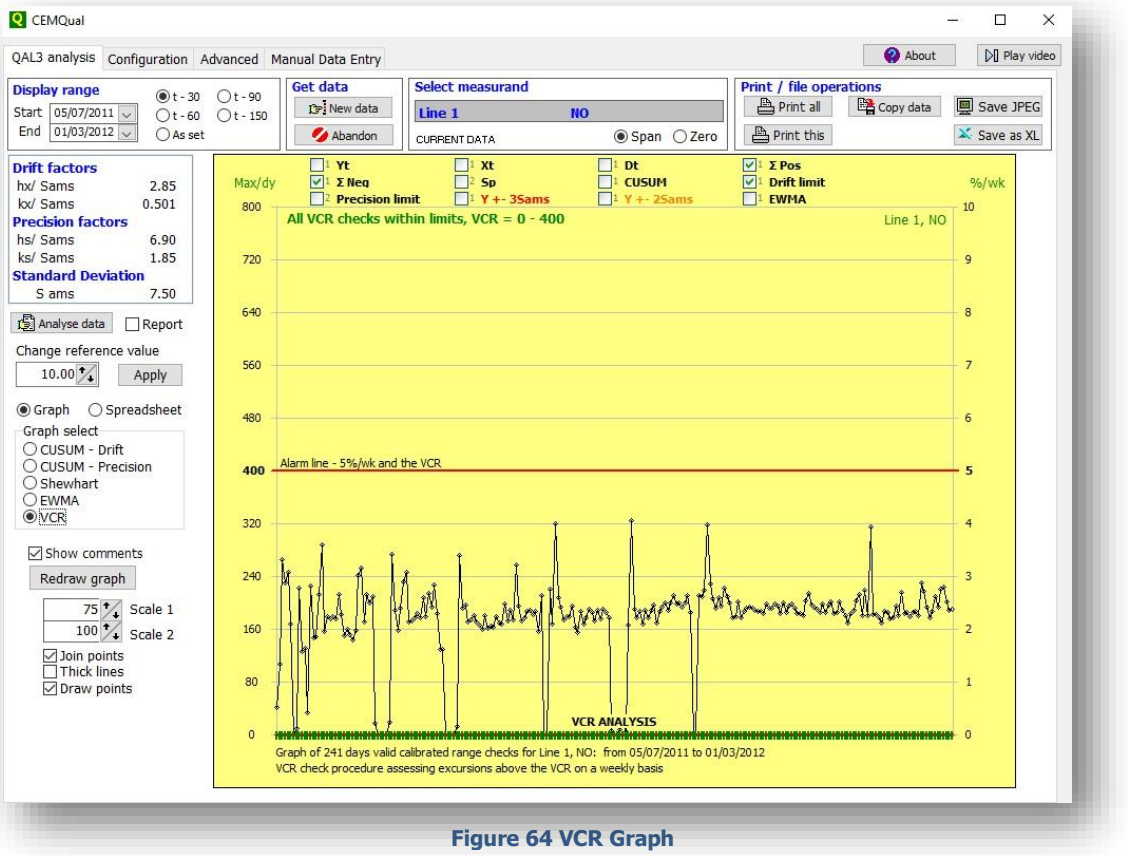



**Figure 64 VCR Graph**

Here the maximum level recorded in each day is shown as the **black** line, and the **red** line indicates the VCR. Here it is clear that the levels are always within the range and so the VCR analysis is **green** for each day at the bottom of the graph.

The spreadsheet view of some of this data is as below:

| No. | Date | DoW | Max | Time over | Agg. Time | % Time / wk |
|---|---|---|---|---|---|---|
| 1 | 05/07/2011 | Tue | 41.3 | 00:00:00 | 0d:, 00:00:0 | 0.00 % |
| 2 | 06/07/2011 | Wed | 107.9 | 00:00:00 | 0d:, 00:00:0 | 0.00 % |
| 3 | 07/07/2011 | Thu | 265.3 | 00:00:00 | 0d:, 00:00:0 | 0.00 % |
| 4 | 08/07/2011 | Fri | 230.6 | 00:00:00 | 0d:, 00:00:0 | 0.00 % |
| 5 | 09/07/2011 | Sat | 246.6 | 00:00:00 | 0d:, 00:00:0 | 0.00 % |
| 6 | 10/07/2011 | Sun | 168.1 | 00:00:00 | 0d:, 00:00:0 | 0.00 % |
| 7 | 11/07/2011 | Mon | 0.0 | 00:00:00 | 0d:, 00:00:0 | 0.00 % |
| 8 | 12/07/2011 | Tue | 8.9 | 00:00:00 | 0d:, 00:00:0 | 0.00 % |
| 9 | 13/07/2011 | Wed | 222.9 | 00:00:00 | 0d:, 00:00:0 | 0.00 % |
| 10 | 14/07/2011 | Thu | 126.0 | 00:00:00 | 0d:, 00:00:0 | 0.00 % |
| 11 | 15/07/2011 | Fri | 131.9 | 00:00:00 | 0d:, 00:00:0 | 0.00 % |
| 12 | 16/07/2011 | Sat | 33.2 | 00:00:00 | 0d:, 00:00:0 | 0.00 % |
| 13 | 17/07/2011 | Sun | 226.0 | 00:00:00 | 0d:, 00:00:0 | 0.00 % |
| 14 | 18/07/2011 | Mon | 146.5 | 00:00:00 | 0d:, 00:00:0 | 0.00 % |
| 15 | 19/07/2011 | Tue | 148.2 | 00:00:00 | 0d:, 00:00:0 | 0.00 % |
| 16 | 20/07/2011 | Wed | 212.3 | 00:00:00 | 0d:, 00:00:0 | 0.00 % |
| 17 | 21/07/2011 | Thu | 287.6 | 00:00:00 | 0d:, 00:00:0 | 0.00 % |
| 18 | 22/07/2011 | Fri | 156.2 | 00:00:00 | 0d:, 00:00:0 | 0.00 % |

**Figure 65 VCR Spreadsheet**

For a transient measurement such as CO, however, selecting VCR will produce a chart similar to the one below.

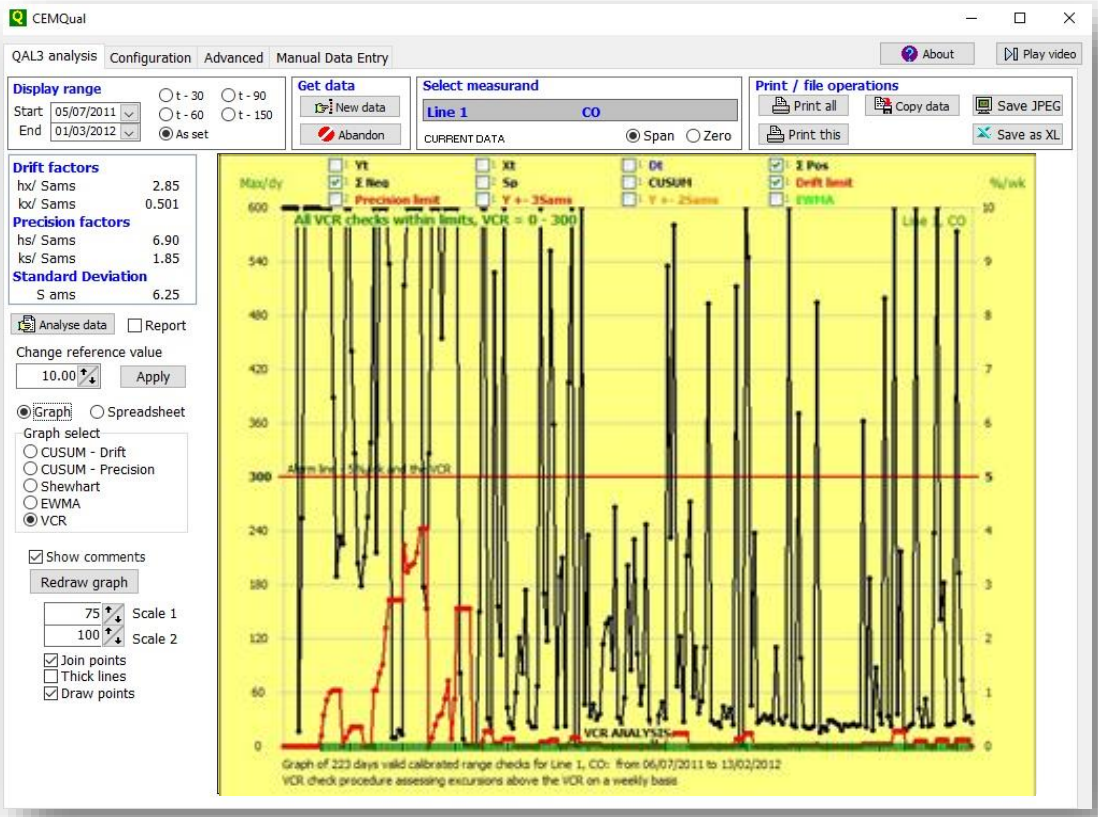



**Figure 66 VCR Graph Checks**

Again, the maximum level recorded in each day is shown as the **black** line, and the **red** line indicates the VCR. Here the VCR is exceeded and this time accumulates on a weekly basis as shown by the thick **red** line at the bottom. Even though the VCR is exceeded, it has never reached 5% in the week; this is also shown here using the same red line using the scale on the right - %/ wk. This is shown by the VCR analysis at the bottom and is still **green** for each day.

The spreadsheet view of some of this data is as below:

| No. | Date | DoW | Max | Time over | Agg. Time | % Time / wk |
|---|---|---|---|---|---|---|
| 23 | 27/07/2011 | Wed | 4810 | 00:13:49 | 0d:, 00:29:42 | 0.29 % |
| 24 | 28/07/2011 | Thu | 440 | 00:05:40 | 0d:, 00:35:22 | 0.35 % |
| 25 | 29/07/2011 | Fri | 326 | 00:01:15 | 0d:, 00:36:37 | 0.36 % |
| 26 | 30/07/2011 | Sat | 204 | 00:00:00 | 0d:, 00:36:37 | 0.36 % |
| 27 | 31/07/2011 | Sun | 179 | 00:00:00 | 0d:, 00:36:37 | 0.36 % |
| 28 | 01/08/2011 | Mon | 211 | 00:00:00 | 0d:, 00:00:0 | 0.00 % |
| 29 | 02/08/2011 | Tue | 256 | 00:00:00 | 0d:, 00:00:0 | 0.00 % |
| 30 | 03/08/2011 | Wed | 339 | 00:01:15 | 0d:, 00:01:15 | 0.01 % |
| 31 | 04/08/2011 | Thu | 9613 | 01:42:27 | 0d:, 01:43:42 | 1.03 % |
| 32 | 05/08/2011 | Fri | 216 | 00:00:00 | 0d:, 01:43:42 | 1.03 % |
| 33 | 06/08/2011 | Sat | 8843 | 00:33:30 | 0d:, 02:17:12 | 1.36 % |
| 34 | 07/08/2011 | Sun | 16173 | 00:17:14 | 0d:, 02:34:26 | 1.53 % |
| 35 | 08/08/2011 | Mon | 5373 | 03:41:36 | 0d:, 03:41:36 | 2.20 % |
| 36 | 09/08/2011 | Tue | 538 | 00:51:46 | 0d:, 04:33:22 | 2.71 % |
| 37 | 10/08/2011 | Wed | 10 | 00:00:00 | 0d:, 04:33:22 | 2.71 % |
| 38 | 11/08/2011 | Thu | 10 | 00:00:00 | 0d:, 04:33:22 | 2.71 % |
| 39 | 12/08/2011 | Fri | 18 | 00:00:00 | 0d:, 04:33:22 | 2.71 % |
| 40 | 13/08/2011 | Sat | 13 | 00:00:00 | 0d:, 04:33:22 | 2.71 % |
| 41 | 14/08/2011 | Sun | 513 | 01:44:01 | 0d:, 06:17:23 | 3.74 % |
| 42 | 15/08/2011 | Mon | 3031 | 05:27:16 | 0d:, 05:27:16 | 3.25 % |
| 43 | 16/08/2011 | Tue | 736 | 00:12:09 | 0d:, 05:39:25 | 3.37 % |
| 44 | 17/08/2011 | Wed | 740 | 00:04:25 | 0d:, 05:43:50 | 3.41 % |
| 45 | 18/08/2011 | Thu | 4713 | 00:18:14 | 0d:, 06:02:4 | 3.59 % |
| 46 | 19/08/2011 | Fri | 4763 | 00:46:34 | 0d:, 06:48:38 | 4.05 % |
| 47 | 20/08/2011 | Sat | 178 | 00:00:00 | 0d:, 06:48:38 | 4.05 % |
| 48 | 21/08/2011 | Sun | 153 | 00:00:00 | 0d:, 06:48:38 | 4.05 % |
| 49 | 22/08/2011 | Mon | 326 | 00:01:23 | 0d:, 00:01:23 | 0.01 % |
| 50 | 23/08/2011 | Tue | 1552 | 00:13:33 | 0d:, 00:14:56 | 0.15 % |

**Figure 67 VCR Spreadsheet Check**

Each day is analysed separately and the maximum level, the time over the VCR and aggregate time over each week shown. The latter is reset each Monday.

In this example, the VCR was exceeded for a maximum of 4.05% of the week.

# 14 ADVANCED CONFIGURATION

The Advanced tab can be used to customise CEMQual, Archive data and set up Printers.

## 14.1 QAL3 PLOT SETTINGS

A number of things may be selected to change the graphs layout and format within the 'QAL3 plot settings' as seen in the image below. Change the graph background colour by double clicking within the box indicated by the red arrow shown in the image below. This opens up the colour pallet window, where you can choose the appropriate colour followed by the 'OK' button.

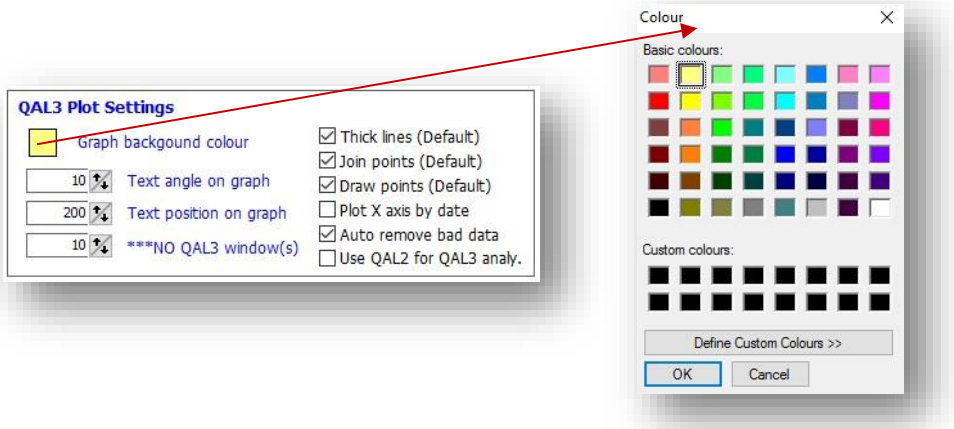



**Figure 68 Graph Background Colour**

If any comments are present, they are also visible in graph view in line with their relevant plot number, as indicated by the red arrow above. To change the angle of this comment, simply adjust the 'text angle on graph' number as necessary, as indicated by the arrow below.

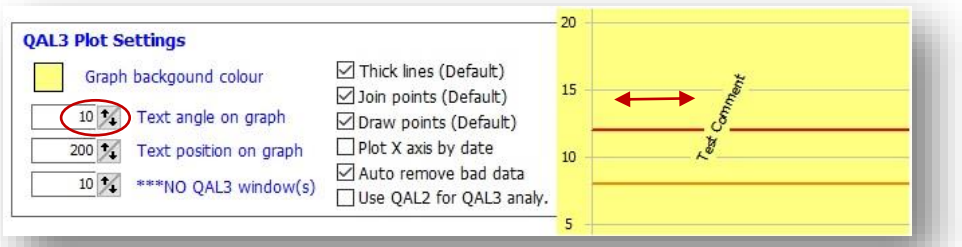



**Figure 69 Graph Text Angle**

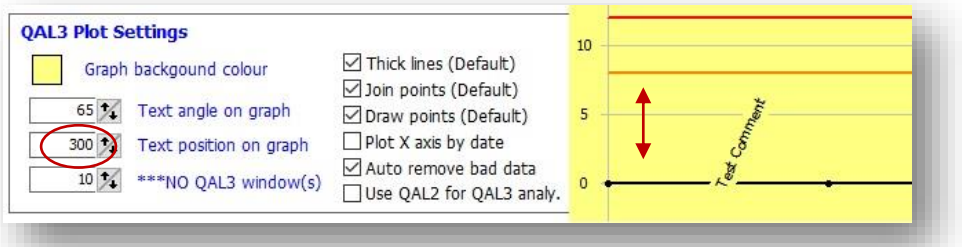



**Figure 70 Graph Text Position**

The position of the text may be modified by changing the 'text position on graph' number as indicated by the arrow above. This will move the text vertically according to the number entered.

*QAL3 Plot Settings continued...*

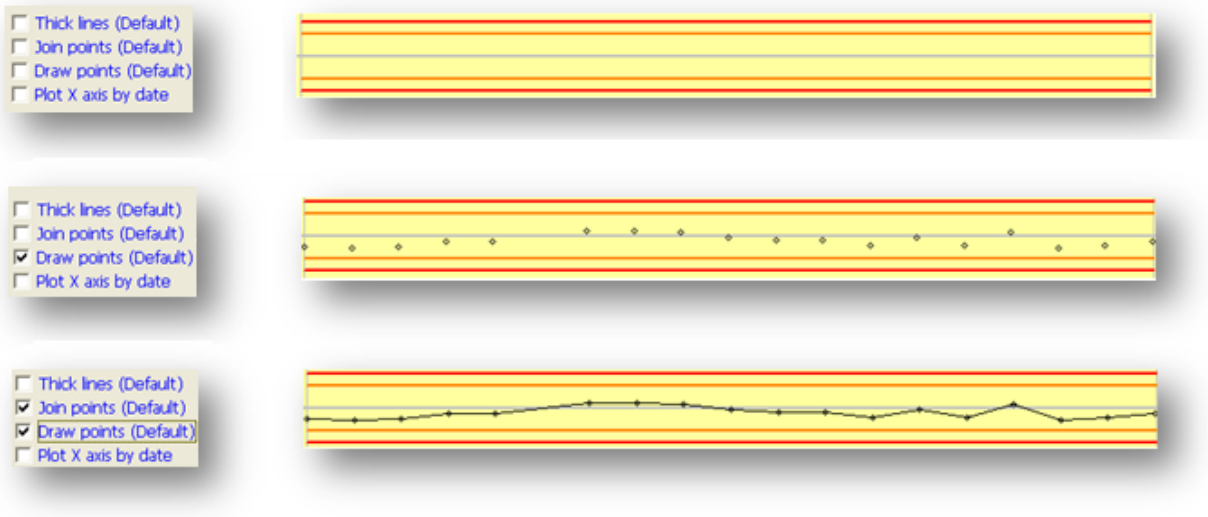



**Figure 71 Graph Plot Display Settings**

A number of items within the QAL3 Plot Settings effect the default start up, therefore when you next initiate CEMQual, these attributes will appear as previously set. This includes; 'thick lines' if this option is selected, the line which indicates the points will increase in thickness. Selecting the 'Draw points' option plots the points on the graph. If both; 'join points' and 'Draw Points' options are selected, then the points are plotted and joined together by a line, as shown above. If the 'Plot X axis by date' is selected, then the points are spaced out according to the date they were taken. If only one reading was taken per day, there wouldn't be a significant difference as all the points would be spaced out evenly.

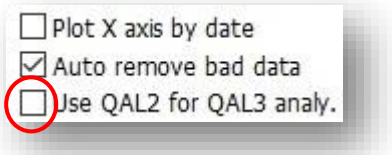



**Figure 72 Plot Settings: QAL2**

Here, you can change whether you want to use raw data or data calibrated with the QAL2 factors for analysing in QAL3. Check the red circled box shown in the image above if you wish to analyse calibrated data, otherwise leave unchecked to analyse raw data. Most plants should leave this unselected.

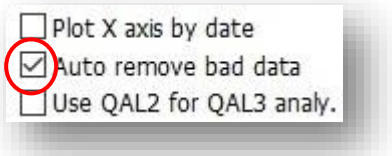



**Figure 73 Plot Settings: Bad Data**

Selecting the 'Auto remove bad data' check box will reject data that fails the error removal criteria automatically during the QAL3 analysis.

## 14.2 NO QAL3 WINDOW

Operators can set up a 'No QAL3' window allowing multiple QAL3 data entries within that window to be ignored every time the data is recalled or re-analysed. Effectively, once the "***No QAL3" comment has been entered any calibration within the window will always be ignored from the measurement group.

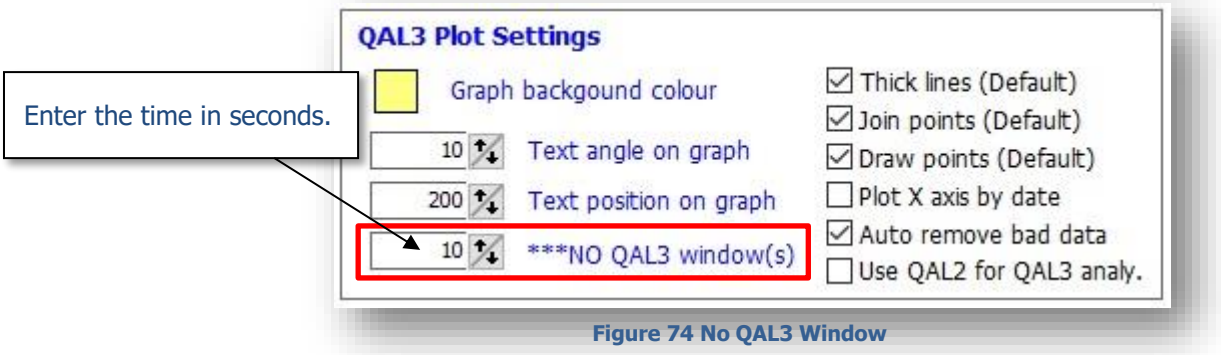



**Figure 74 No QAL3 Window**

Enter the timing span of the window by selecting the text entry box and inputting the required value (in seconds).

Once entered, any "***NO QAL3" comments, see section 12, will also uncheck and replicate the comment on any data entries both before and after, if they fall within the timed window (as shown below).

| No. | Name | Date | Time | y t | x t | d t | ΣPos | ΣNeg | Sp | Comments |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Test 1 | 01/01/2010 | 00:05:00 | 80.0 | 80.0 | 0.00 | 0.00 | 0.00 | 0.00 | |
| 2 | Test 2 | 01/01/2010 | 00:10:00 | 80.0 | 80.0 | 0.00 | 0.00 | 0.00 | 0.00 | |
| 3 | Test 3 | 01/01/2010 | 00:15:00 | 80.0 | 80.0 | 0.00 | 0.00 | 0.00 | 0.00 | |
| 4 | Test 4 | 01/01/2010 | 00:20:00 | 80.0 | 80.0 | 0.00 | 0.00 | 0.00 | 0.00 | |
| 5 | Test 5 | 01/01/2010 | 00:25:00 | 80.0 | 80.0 | 0.00 | 0.00 | 0.00 | 0.00 | |
| 6 | Test 6 | 01/01/2010 | 00:30:00 | 80.0 | 80.0 | 0.00 | 0.00 | 0.00 | 0.00 | |
| 7 | Test 7 | 01/01/2010 | 00:35:00 | 80.0 | 80.0 | 0.00 | 0.00 | 0.00 | 0.00 | |
| 8 | Test 8 | 01/01/2010 | 00:40:00 | 100.0 | 80.0 | 20.00 | 0.00 | 0.00 | 0.00 | *** NO QAL3 |
| 9 | Test 9 | 01/01/2010 | 00:40:10 | 100.0 | 80.0 | 20.00 | 18.00 | 0.00 | 185.20 | *** NO QAL3 |
| 10 | Test 10 | 01/01/2010 | 00:40:20 | 100.0 | 80.0 | 20.00 | 35.99 | 0.00 | 0.00 | *** NO QAL3 |

**Figure 75 NO QAL3 Window Example**

Entering "***NO QAL3" at Data Point 9 with a 15-second window will also uncheck points 8 and 10.

## 14.3 QAL3 RECORD ARCHIVING

To re-analyse QAL3 data between specific dates, choose a start and end date and click 'get data', this will re-analyse and overwrite the current data set with the data from in between the date band specified. CEMQual always deletes the stored QAL3 data for a date before it is analysed again.

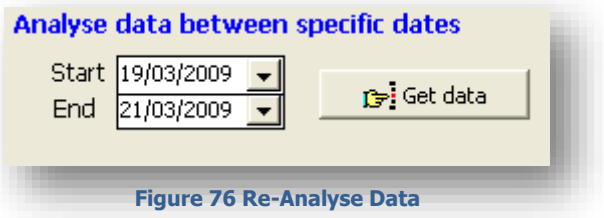



Figure 76 Re-Analyse Data

Changing the 'default look back days' within the 'advanced tab' will also change the 'default look back days' within the 'QAL3 Analysis' tab accordingly, as shown. To change the values enter specific look back days into the four boxes. These will be stored and recalled on the start-up of the program.

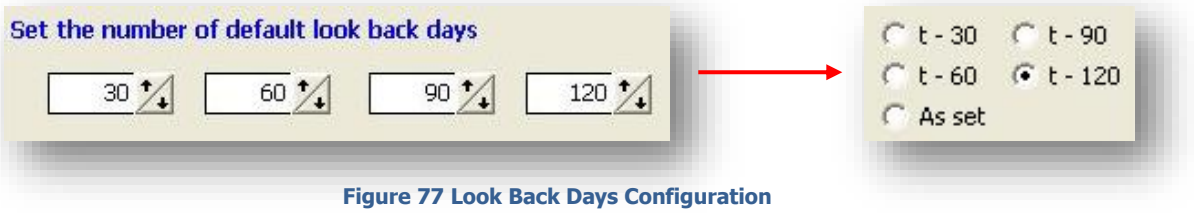



Figure 77 Look Back Days Configuration

To Backup the current data set, click the 'Backup current data set' button, or
check the 'Automatically backup QAL3 data before adding new results'. It is now safe to overwrite this current data set because it is safely backed up. If this data set is required again, as long as it was the previous data set viewed, it can be restored by clicking the 'restore current data set' button.

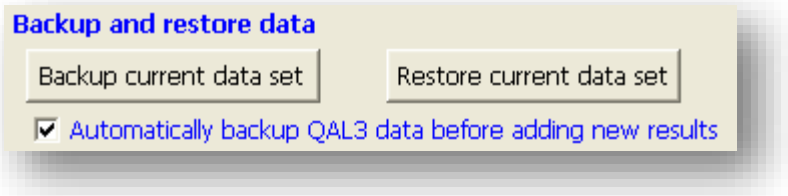



Figure 78 Backup / Restore Data

*QAL3 Record Archiving continued…*

Old records can be deleted by selecting a starting date and an end date then by clicking 'delete old records now' this will delete all record sets within the specified date band. Live progress is also visible in the bottom left corner. Note that this only deletes the analysis of records and will remove them from the both the Graphical and spreadsheet displays – the CEMSuite database is not affected.

**Figure 80 Delete Old Records**

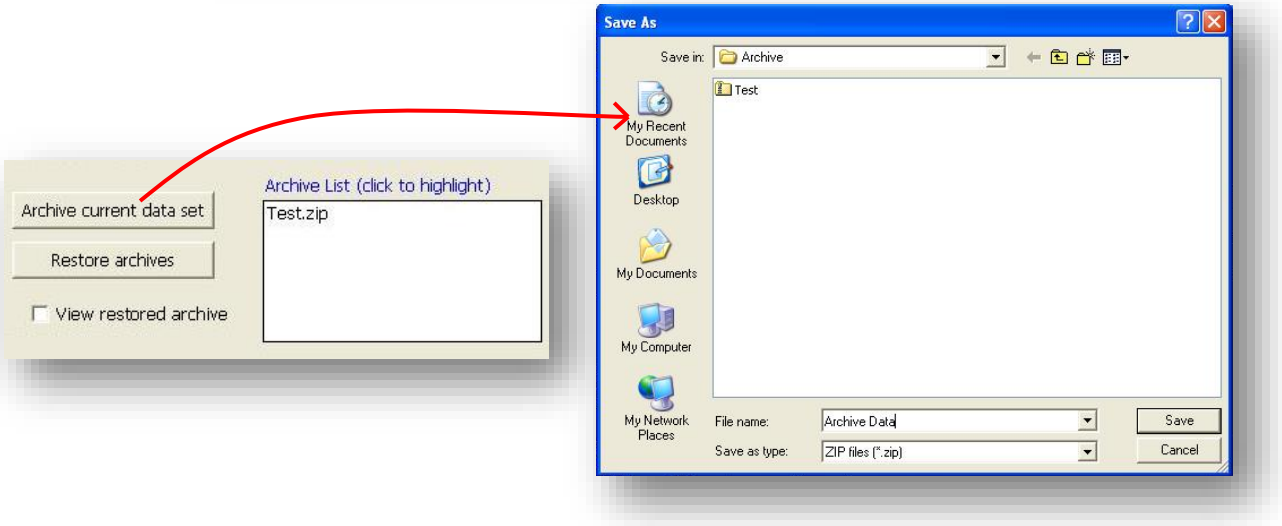



**Figure 79 Archive Current Data Set**

The current data set can be archived for future reference by clicking the 'archive current data set' button, then saving the zip file in the Archive folder, as indicated in the image above.

Archived files can be viewed by clicking the relevant zip file within the archive list, then clicking the 'restore archives' button, which restore the data set within that specific zip file. The 'View restored archive' check box will be automatically checked here, and the displays on the QAL3 analysis will display. Once finished with the archived files, untick this checkbox to display the current data set once more.

## 14.4 REPORT AND PRINTER SETTINGS

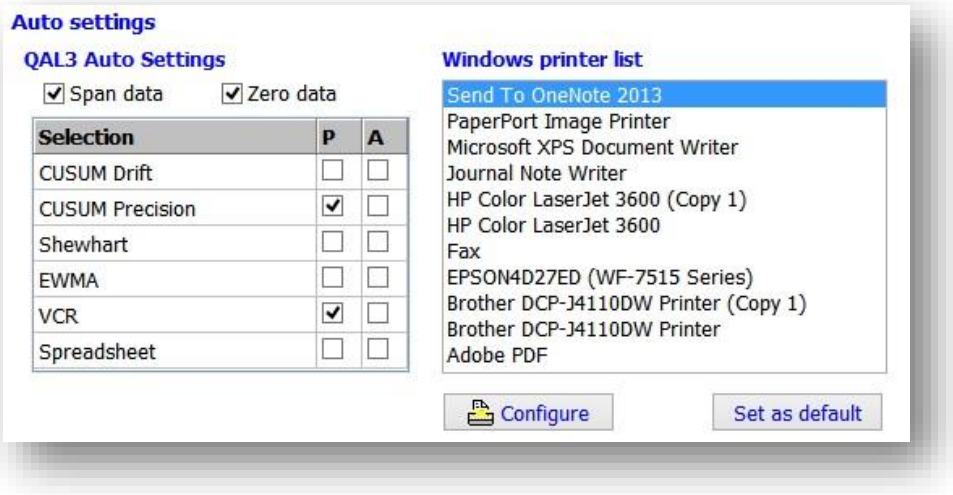



**Figure 81 Printer Settings**

Two columns make the following selections: A – which control charts are printed when using the 'Print all' function, and R – which control charts are reported from the 'Analyse' function. Required measurands (as selected from the QAL3 parameters table) for zero and or span are used. Relevant graphs and spreadsheets for either the span data or zero data can always be printed for the QAL3 page.

To change the printer CEMQual uses, highlight it in the list and press the 'Set as default' button. This printer will now be used by CEMQual until this setting is changed. Note, should printers be added or removed after this operation, CEMQual might revert to another printer by default. It is advisable to redefine the default printer if any changes have been made.

**Note:** The printer orientations are fixed; portrait for spreadsheets and landscape for Graphs.

The Search backwards checkbox allows the data to be analysed backwards in time when searching for the QAL3 data. This may be useful should analysers wait for stabilising before ending the calibration. In such cases, the time that the calibration bit switches off is used, and the delay becomes the time before this event. Note that the delay can also be negative to allow for a look back in time.

# 15 APPENDIX A – GLOSSARY OF TERMS

**AMS**: Automated Measuring System (see CEM)
**AST**: Annual Surveillance Test refer CEN standard EN14181
**CEM/S**: Continuous emission monitoring system – the equipment for the sampling, analysis and data reduction of gaseous emissions measurements on a continuous basis.
**Drift**: Monotonic change of the calibration function over a period of unattended operation, which results in a change of the measured value.
**EA**: Environmental Agency responsible for England and Wales.
**ELV**: Emission Limit Value.
**HWI**: Hazardous Waste Incinerator, refer WID.
**ISO**: International Standards Organisation – Multinational organisation that develops and publishes measurement criteria and performance standard.
**LAU**: Environmental Agency Local Authority Unit.
**Measurand**: Particular quantity subject to measurement.
**MID**: Method Implementation Document – developed by EA and STA on how to apply standards in the UK.
**Precision**: Closeness of agreement between results obtained from the AMS.
**QA**: Quality Assurance.
**QAL**: Quality Assurance Level.
**QAL1**: Quality assurance level 1 – AMS as tested to the requirements CEN standard EN15267 or MCERTS CEM system.
**QAL2**: Quality assurance level 2 – Calibration of an AMS in accordance with CEN standard EN14181.
**QAL3**: Quality assurance level 3 – Ongoing performance of an AMS in accordance with CEN standard EN14181.
**Reference Material**: Material simulating a measurand of known concentration of the input parameter and traceable to national standards.
**SRM**: Standard Reference Method.
**SSP**: Site Specific Protocol
**SD**: Standard Deviation.
**Sams**: Standard deviation for the for the automated measurement system.
**Variability**: Standard deviation of the differences of parallel measurements between the SRM and AMS.
**TC**: Technical committee as referred to in standards organisations e.g. CEN.
**TE**: Technical Endorsement as referred to in MCERTS performance standard for personnel.
**WID**: Waste Incineration Directive.

# 16 APPENDIX B – EXTRACT FROM EN 14181 CALCULATIONS

## 16.1 C.4 CALCULATION PROCEDURE

A spreadsheet is suitable for the calculation procedure given below. However, in order to avoid the use of a computer at the measuring site, manual calculations may be performed on site. A sheet, as given in annexe H, can be very helpful for those calculations. At the same time, the sheet can be used for documentation of the documentation of the AMS (see clause 9).

This procedure has to be performed at each reading of the zero and span values from the AMS. Calculate the provisional sum for standard deviation, and the provisional sums for positive and negative difference.

$$Sp = s(t-1) + \frac{(d(t)-d(t-1))2}{2} - Ks \quad \text{(C.6)}$$

$$S(pos)p = S(pos)t\text{-}1 + dt - kx \quad \text{(C.7)}$$

$$S(neg)p = S(neg)t\text{-}1 - dt - kx \quad \text{(C.8)}$$

Where

$$dt = yt - xt$$

and is the difference between the actual instrument reading and the reference value; notice the sign

p indicates the provisional value of the normalised sums
$t$ indicates the actual instrument reading
$t$ - 1 indicates the previous instrument reading

Calculate the test values, and add up the number of instrument readings since the standard deviation and the (positive or negative) difference occurred as follows:

Precision check:
If sp > 0 : st = sp And N(s)t = N(s)t-1 + 1
If sp <= 0 : st = 0 And N(s)t = 0

Positive and Negative drift checks:
If S(pos)p > 0 : S(pos) = S(pos)p t And N(pos)t = N(pos)t-1 + 1
If S(pos)p <= 0 : S(pos) = 0 t And (pos) = 0 N t

If S(neg)p > 0 : S(neg) = S(neg)p t and N(neg)t = N(neg)t-1 + 1
If S(neg)p <= 0 : S(neg) = 0 t and (neg) = 0 N t

## 16.2 C.5 TEST FOR A DECREASE OF PRECISION

Test the precision of the AMS:

– if $st > hs$ then a decrease in precision of the AMS has been established.

If this inequality is false for both zero and span precision then these components of the AMS are in control, and the test for zero and span drift shall be performed. However, if the above inequality is true for either zero or span precision, the manufacturer shall be contacted. In this latter case, it is unnecessary to perform the drift tests at this time.

## 16.3 C.6 TEST FOR DRIFT AND THE NEED FOR ADJUSTMENT

Test for positive or negative drift of the AMS:

– if S(pos)$t > hx$ , then a positive drift is detected;
– if S(neg)$t > hx$ , then a negative drift is detected.

If both of the two inequalities above are false for both zero and span, then the AMS is in control and no action is required. However, if one value is true for either zero or span, then an adjustment of the AMS is required, and thereafter the calculations continue from C.2.

# 17 APPENDIX C – CONVERSION FACTORS FROM PPM TO MG/M3 DATA

Conversion from ppm to mg/m3 at 0°C and 101.3kPa

| Gas | Conversion from |
|---|---|
| $SO_2$ | 2.86 |
| NO | 1.34 |
| $NO_2$ | 2.05 |
| HCL | 1.64 |
| C0 | 1.25 |
| $CO_2$ | 1.96 |
| $NH_3$ | 0.76 |
| $CH_4$ | 0.716 |
| $O_2$ | 1.429 |

**Table 4 Conversion Factors**

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## 18.4 MANUAL REVISION HISTORY

| Revision Number | Date | Summary of Changes | Author |
|---|---|---|---|
| v1.05 | 14/12/07 | Appendix 3 added | S.A.Wright |
| v1.06 | 30/09/09 | CEMQual V3 | Richard Grant |
| v1.07 | 03/12/09 | CEMQual V3.05 | Rob Swift |
| v1.08 | 15/04/10 | CEMQual 3.07 | Dima Volgin |
| v1.09 | 30/04/10 | Extra QAL3 parameter info | Rob Swift |
| v1.10 | 30/05/10 | Manual data entry page described | Richard Grant |
| v1.11 | 30/09/10 | Apply gas reference changes described | Paul Swindell |
| v1.12 | 01/01/11 | Analyse Data section added. Format update. | Paul Swindell |
| v1.13 | 14/12/11 | MCERTS Version | P. Swindell |
| v1.14 | 30/05/13 | General Update | P. Swindell |
| v1.15 | 24/06/14 | New MCERTS certificate / Minor changes | P. Swindell |
| v1.16 | 07/10/14 | QAL2 Section Added | P. Swindell |
| v1.17 | 05/02/15 | Minor Changes | - |
| v1.18 | 05/01/16 | Format Change | P. Swindell |
| v1.19 | 03/02/16 | Addition of QAL2 History and No QAL3 Window | P. Swindell |
| v1.20 | 17/03/17 | Addition of Sams & ref. values for control. | P. Swindell |
| V1.21 | 18/10/17 | Minor Updates | P. Swindell |

## 18.5 APPROVALS

This document requires the following approvals:

| Name | Title |
|---|---|
| R. Grant | Managing Director |
| R. Swift | Technical Manager |
| | |
| | |