



# Conference

**Next presentation at 14.00**

**The functional-tests required by EN 14181 -  
specifications and experience**

**Rick Gould, EA.**

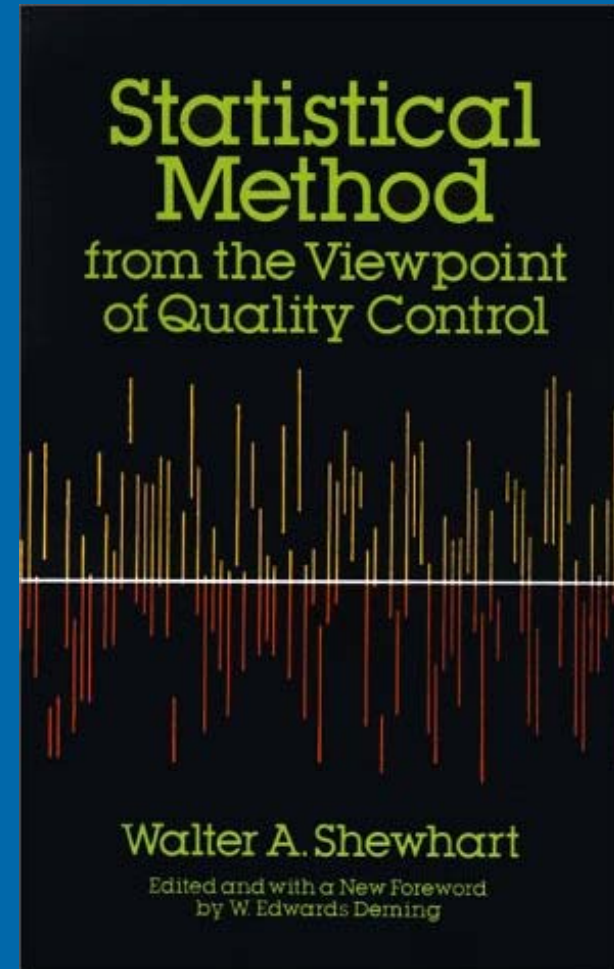
# EN 14181

# The Functional Tests

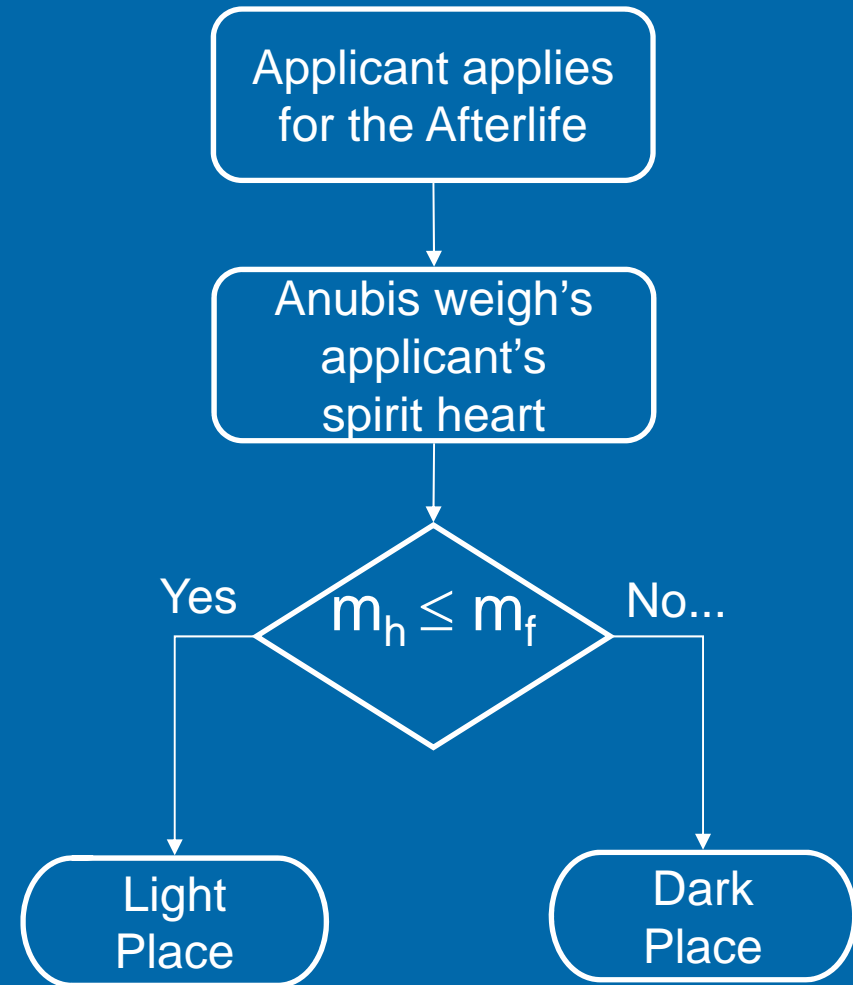
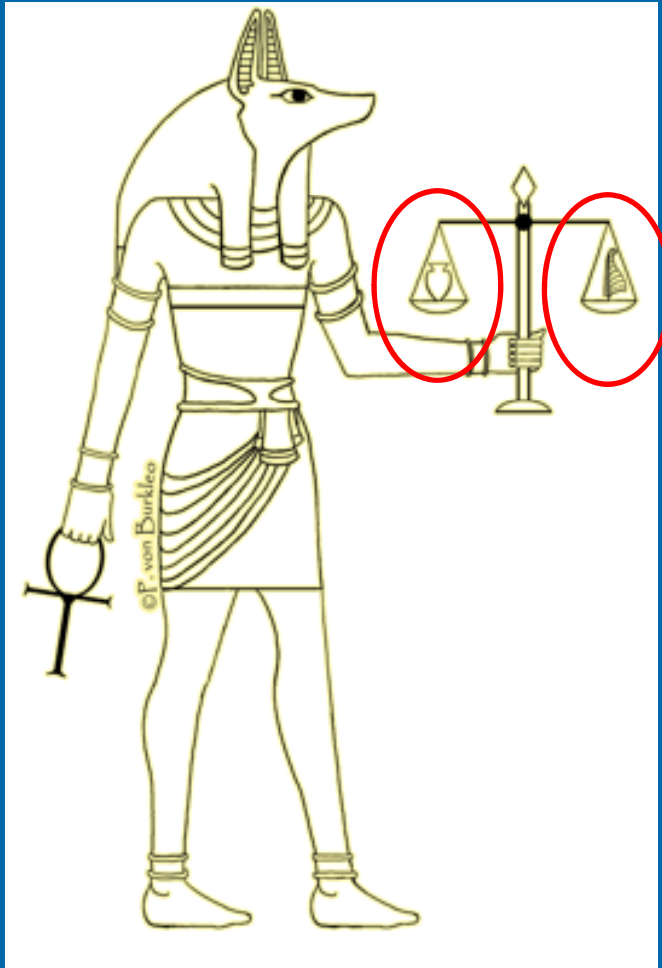
## MCERTS 2011

Rick Gould  
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# Walter Shewhart



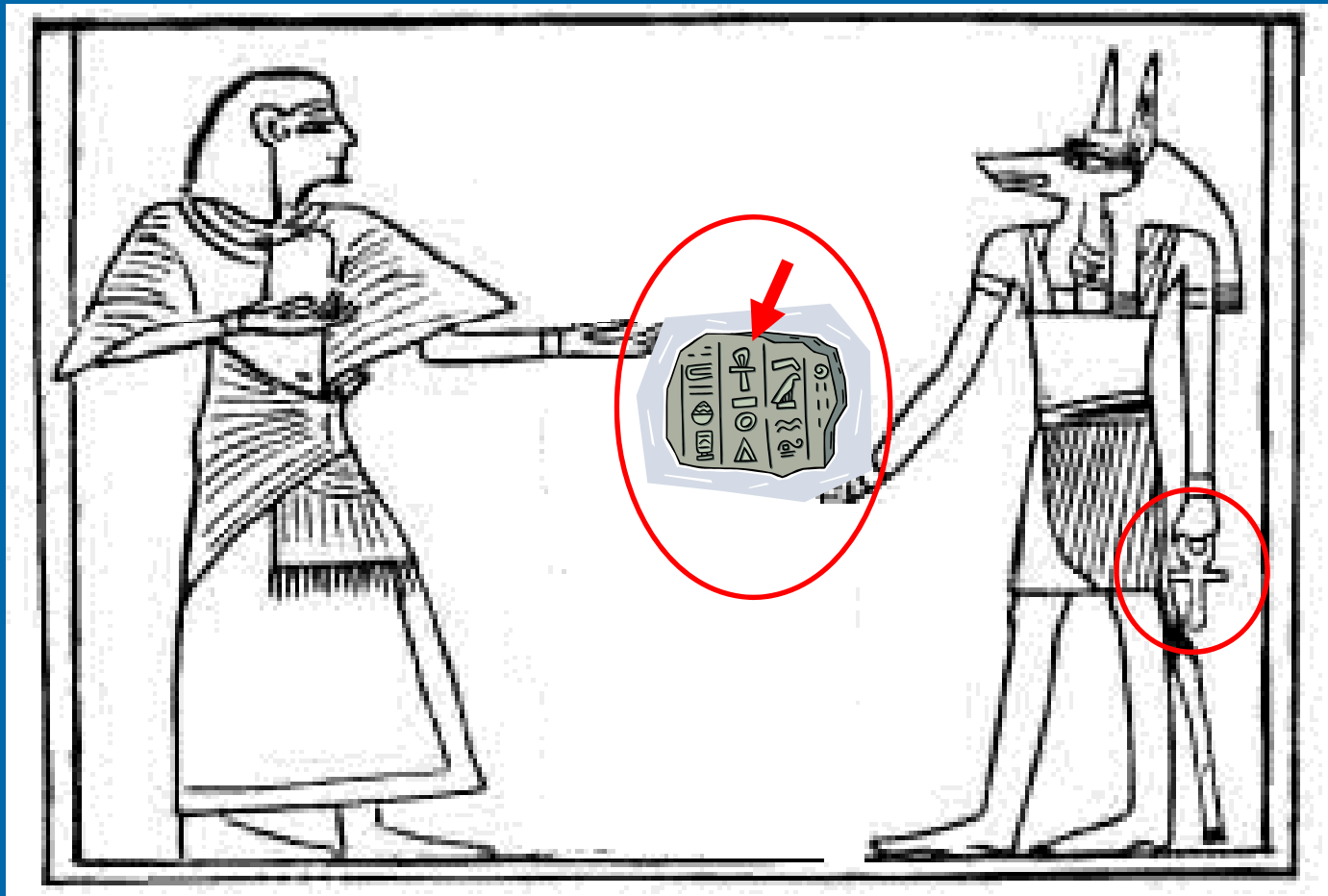
# The Anubis



# The Anubis – the first stack tester?



# Early Site-Specific Protocol?



# Outline

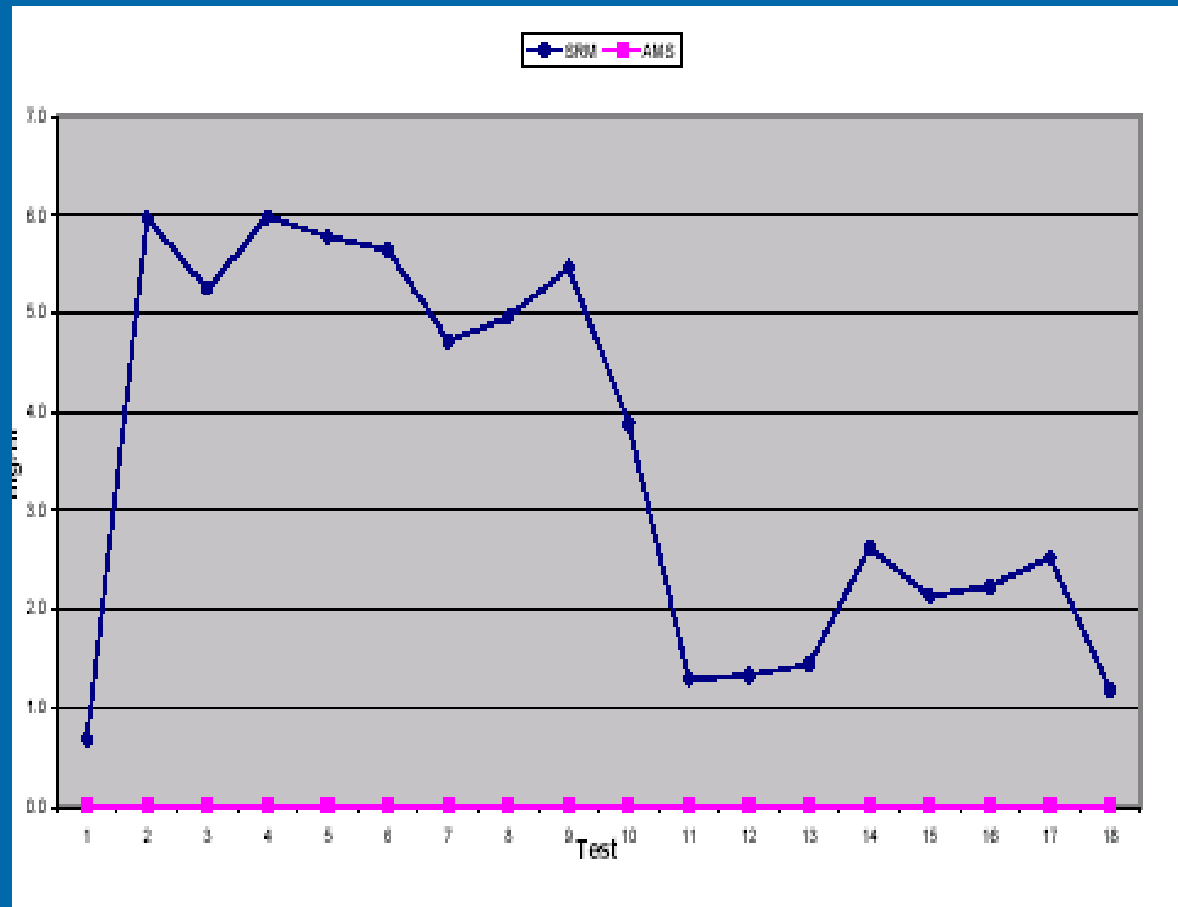
- ➡ What EN 14181 states
- ➡ The details of the functional tests
- ➡ How the Environment Agency applies them
- ➡ Who may perform the functional tests
- ➡ What we want to see
- ➡ How the functional tests should be reported
- ➡ What, who, when, how

# Why?

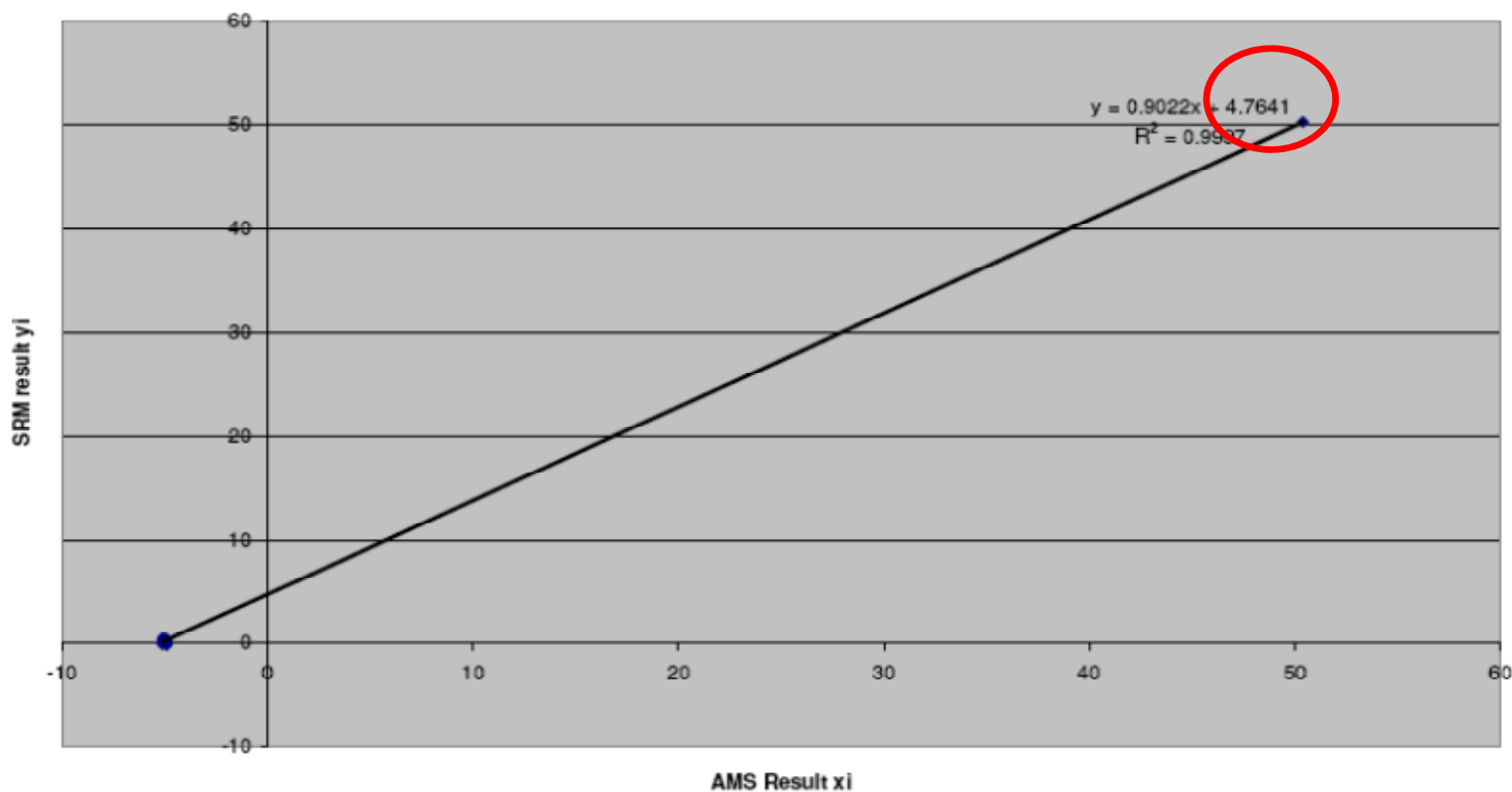
- ➡ The word functional derived from Latin verb *to perform, to work*
- ➡ *Ergo*, the tests show that the CEMs are working properly
- ➡ Parallel reference tests will need repeating on CEMs which do not work properly
- ➡ If there is a QAL2/AST failure, the tests can be used for mediation
  - ➡ e.g. following a poor application of the SRMs



# Was the CEM functioning?



# Was the FID functioning?



# Was the FID functioning?

Measurements for QAL 2 Test

Date	Time	Sample Number <i>i</i>	SRM Value <i>y<sub>i</sub></i> mg/m <sup>3</sup>	AMS signal <i>x<sub>i</sub></i> mg/m <sup>3</sup>
17/01/07	19:00	1	0.50	-5.10
17/01/07	20:00	2	0.45	-5.00
17/01/07	21:00	3	0.11	-5.10
17/01/07	22:00	4	0.25	-5.00
17/01/07	23:00	5	0.19	-5.00
18/01/07	00:00	6	0.29	-5.00
18/01/07	20:00	7	-0.15	-4.90
18/01/07	21:00	8	0.23	-5.00
18/01/07	22:00	9	-0.06	-5.10
18/01/07	23:00	10	-0.04	-5.00
19/01/07	00:00	11	0.15	-5.10
19/01/07	01:00	12	0.08	-5.10
19/01/07	17:00	13	0.45	-5.00
19/01/07	18:00	14	0.38	-5.00
19/01/07	19:00	15	0.38	-5.00
19/01/07	20:00	16	0.40	-4.90
19/01/07	21:00	17	0.34	-5.00
19/01/07	22:00	18	0.36	-5.00
29/03/07	ABB Cal.	19	50.22	50.38
Σ			54.50	-39.92

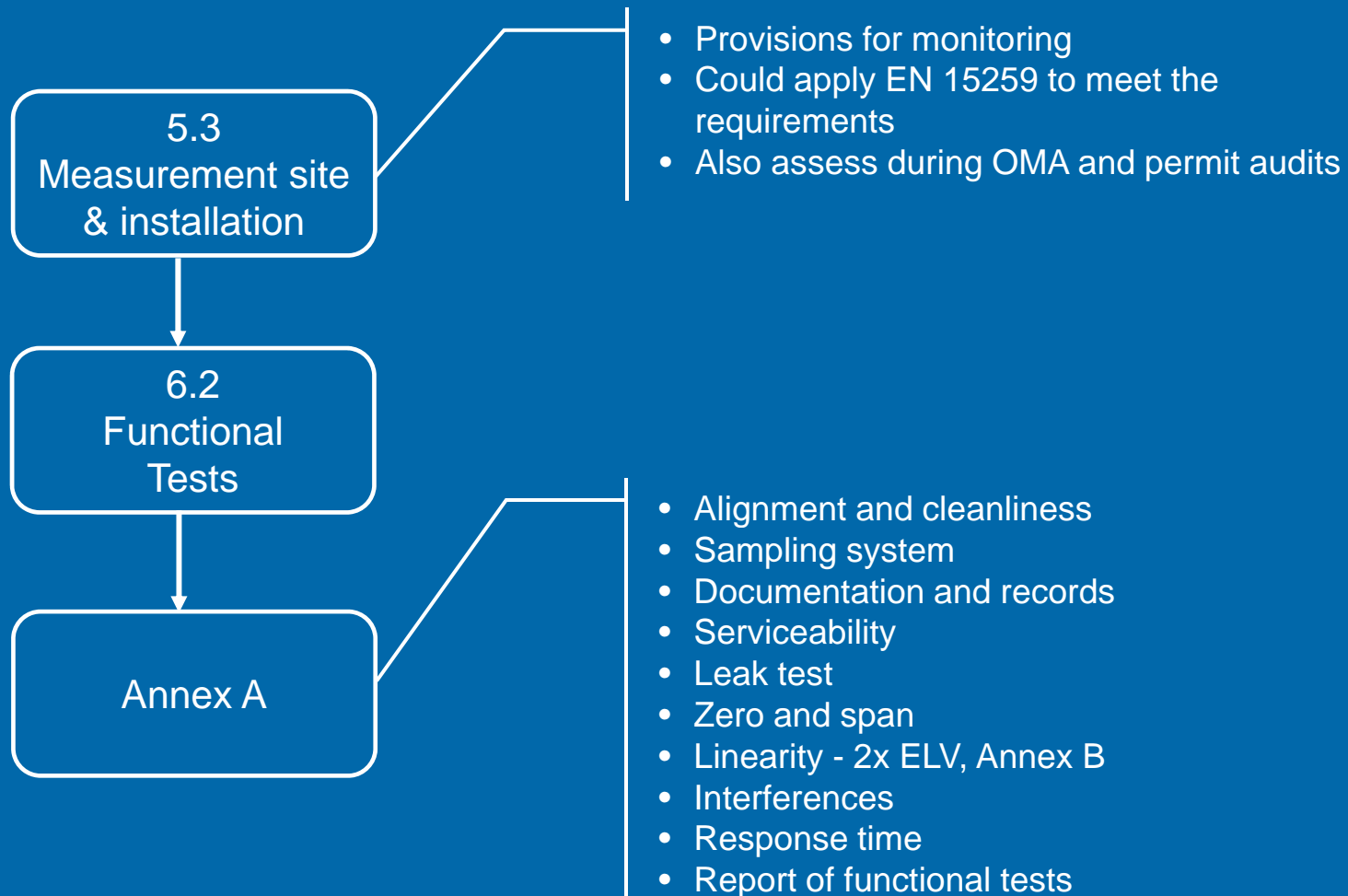
## Calibration Function

Method: 0.24 (ppm) = 1 (mg/m<sup>3</sup>) - 0.5% FID

# In both these examples

- ➡ There was no data or insufficient data for the functional tests
- ➡ The FID read  $-5 \text{ mg.m}^{-3}$  when it should be reading zero
  - ➡ EN 14181 states this clearly, more than once
- ➡ The functional tests had to be performed
- ➡ **The parallel reference tests had to be repeated**
- ➡ Cost to the operators – many thousands of £

# What



# Provisions for CEMs and monitoring



# Provisions for CEMs and monitoring



# Provisions for CEMs





# Annex A – The functional tests

- ➡ Alignment and cleanliness
- ➡ Integrity of the sampling system
- ➡ Documentation and records
- ➡ Serviceability
- ➡ Leak test
- ➡ Zero and span
- ➡ Linearity
- ➡ Interferences
- ➡ Response time
- ➡ Report of functional tests

# Annex A – The functional tests

- ➡ Alignment and cleanliness
- ➡ Integrity of the sampling system
- ➡ Documentation and records
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Inspection  
activities  
(ISO 17020)

# Annex A – The functional tests

- ➡ Alignment and cleanliness
  - ➡ Integrity of the sampling system
  - ➡ Documentation and records
  - ➡ Serviceability
- 

- ➡ Leak test
  - ➡ Zero and span
  - ➡ Linearity
  - ➡ Interferences
  - ➡ Response time
  - ➡ Report of functional tests
- Test and inspection activities  
(ISO 17025/17020)

# Gaseous CEMs – all determinands



# Provisions for zero and span



# Functional tests – Particulate CEM





# Linearity test for a particulate monitor



# Peripheral determinands





# Who

- ➡ Does not matter who does the tests, but...
  - ➡ The tests must be performed according to the requirements of Annex A of EN 14181
- ➡ Evidence of competence, training
- ➡ Organisation performing the tests
  - ➡ Documented procedures applying the requirements of Annex A of EN 14181 (Annex B for linearity)
- ➡ Operator makes the results of tests available to the QAL2/AST test laboratory before the parallel reference tests
- ➡ Test laboratories report the results of the tests

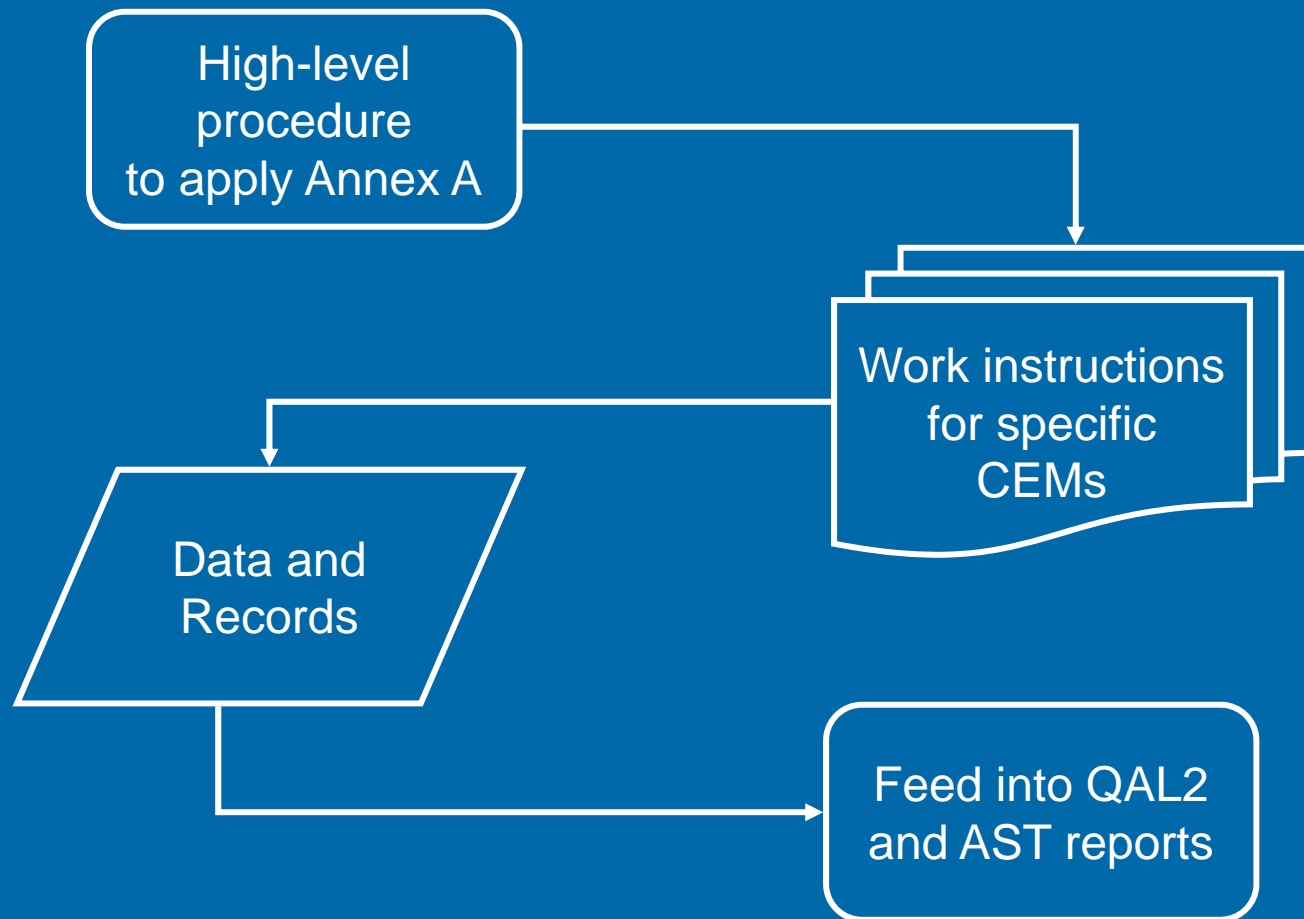
# Test labs - frequent functional tests



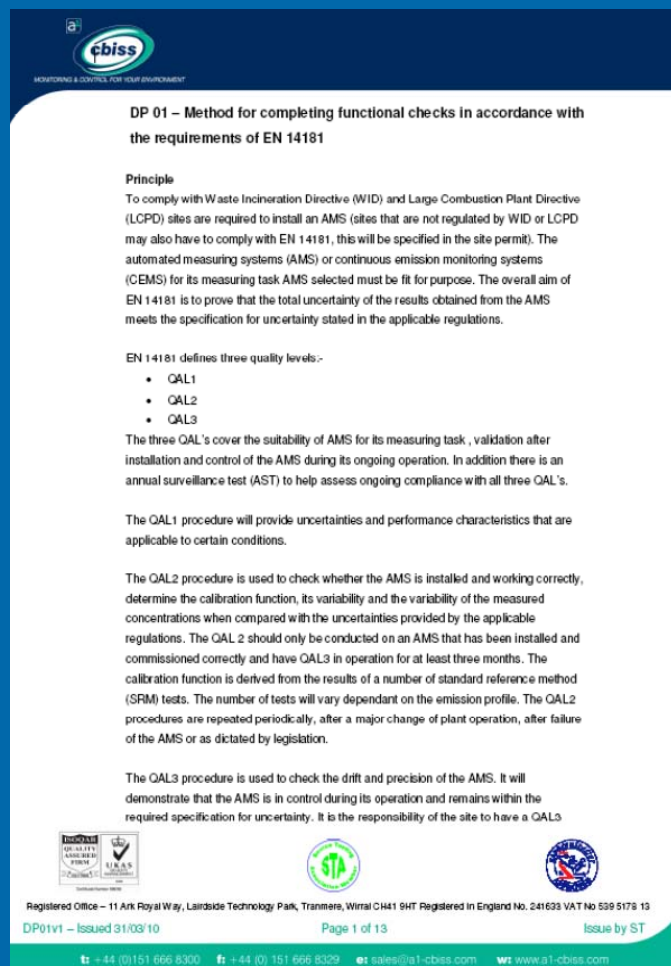
# Conditioning systems



# Example – a CEMs supplier



# A procedure to apply the tests



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## DP 01 – Method for completing functional checks in accordance with the requirements of EN 14181

**Principle**  
To comply with Waste Incineration Directive (WID) and Large Combustion Plant Directive (LCPD) sites are required to install an AMS (sites that are not regulated by WID or LCPD may also have to comply with EN 14181, this will be specified in the site permit). The automated measuring systems (AMS) or continuous emission monitoring systems (CEMS) for its measuring task AMS selected must be fit for purpose. The overall aim of EN 14181 is to prove that the total uncertainty of the results obtained from the AMS meets the specification for uncertainty stated in the applicable regulations.

EN 14181 defines three quality levels:-

- QAL1
- QAL2
- QAL3

The three QAL's cover the suitability of AMS for its measuring task, validation after installation and control of the AMS during its ongoing operation. In addition there is an annual surveillance test (AST) to help assess ongoing compliance with all three QAL's.

The QAL1 procedure will provide uncertainties and performance characteristics that are applicable to certain conditions.

The QAL2 procedure is used to check whether the AMS is installed and working correctly, determine the calibration function, its variability and the variability of the measured concentrations when compared with the uncertainties provided by the applicable regulations. The QAL2 should only be conducted on an AMS that has been installed and commissioned correctly and have QAL3 in operation for at least three months. The calibration function is derived from the results of a number of standard reference method (SRM) tests. The number of tests will vary dependant on the emission profile. The QAL2 procedures are repeated periodically, after a major change of plant operation, after failure of the AMS or as dictated by legislation.

The QAL3 procedure is used to check the drift and precision of the AMS. It will demonstrate that the AMS is in control during its operation and remains within the required specification for uncertainty. It is the responsibility of the site to have a QAL3.

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# When

- ➡ Ideally one month before the parallel reference tests for the QAL2/AST
- ➡ Timing flexible
- ➡ At least annually
- ➡ There must be no changes to the CEMs before the parallel reference tests
  - ➡ i.e. perform the same
  - ➡ Records
  - ➡ QAL3

# Servicing and functional tests



# How – Inspection activities

Requirement	✓	Notes
<b>1. Alignment and Cleanliness</b>		
A visual inspection, with reference to the CEMs manuals, shall be carried out on the following when applicable:		
• Internal check of the CEM		
• Cleanliness of the optical components		
• Flushing air supply		
• Obstructions in the optical path		
• After re-assembly at the measurement location at least the following shall be checked		
• Alignment of the measuring system		
• Contamination control (internal check of optical surfaces)		



# How – Inspection activities

2. Sampling Systems		
A visual inspection of the sampling system shall be performed, noting the condition of the following components, when fitted:		
• Sampling probe		
• Gas conditioning systems		
• Pumps		
• All connections		
• Sample lines		
• Power supplies		
• Filters		
• NOx converters – if the sampling system contains a NOx converter, then the test laboratory shall record when the last efficiency-test was performed, and the result of this test.		
• The sampling system shall be in good condition and free of any visible faults, which may decrease the quality of data		

# Complete CEMs



# Extractive sampling system



# Cross duct systems



# Heated lines



# Provisions for zero and span checks

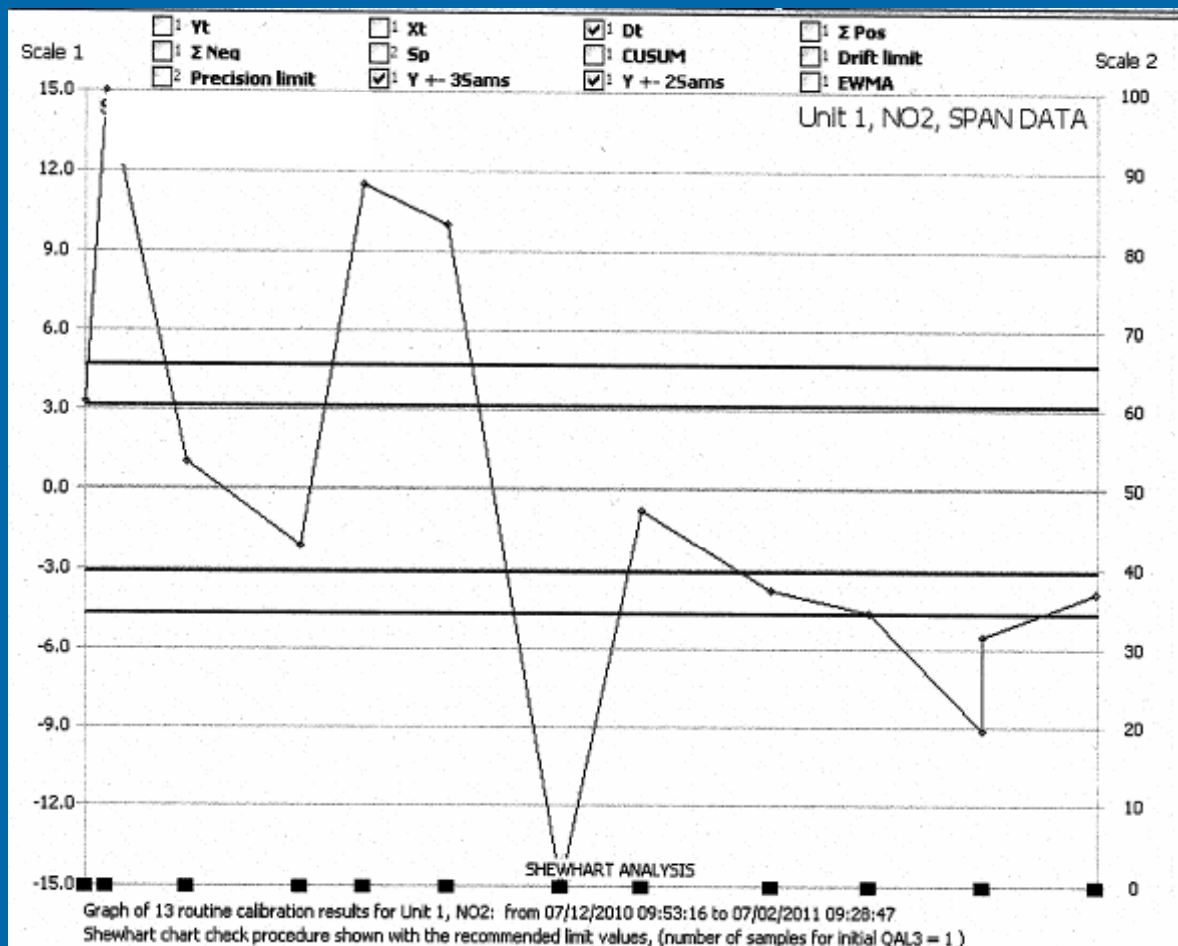




# Gas regulators



# Inspect QAL3 records





# How – functional tests

## ➡ Interferences

- ➡ Very rarely required
- ➡ Known two examples in six years

## ➡ Leak test

## ➡ Zero and span

## ➡ Linearity

## ➡ Response time

## ➡ The above three tests can be combined

- ➡ e.g. EN ISO 9169 describes such a procedure

# Guidance

## ➡ TGN M20

- ➡ Annex on the functional tests

- ➡ Explains how we want people to perform the tests

## ➡ MID EN 14181

- ➡ Shows exactly what the Environment Agency wants test labs to report

# Test gases

## ➡ Category 1

- ➡ Accredited sources
- ➡ SRM instruments
- ➡ Initial CEMs calibration
- ➡ Method 'C' – calibration by linearity

## ➡ Category 2

- ➡ Don't have to be accredited
- ➡ QAL3 checks
- ➡ Other functional tests
- ➡ Not calibration

# Functional tests and QAL3

- ⇒ Zero and span readings
- ⇒ Span checks for all determinands
- ⇒ Ensure bottles are within lifetime
- ⇒ Stability more important than accuracy
- ⇒ No adjustments, unless, at the time of the service:
  - ⇒ There are changes outside the QAL3 limits, or
  - ⇒ There is a clear trend of drift before limits are reached
  - ⇒ The warning/action limits have a degree of subjectivity

# Linearity

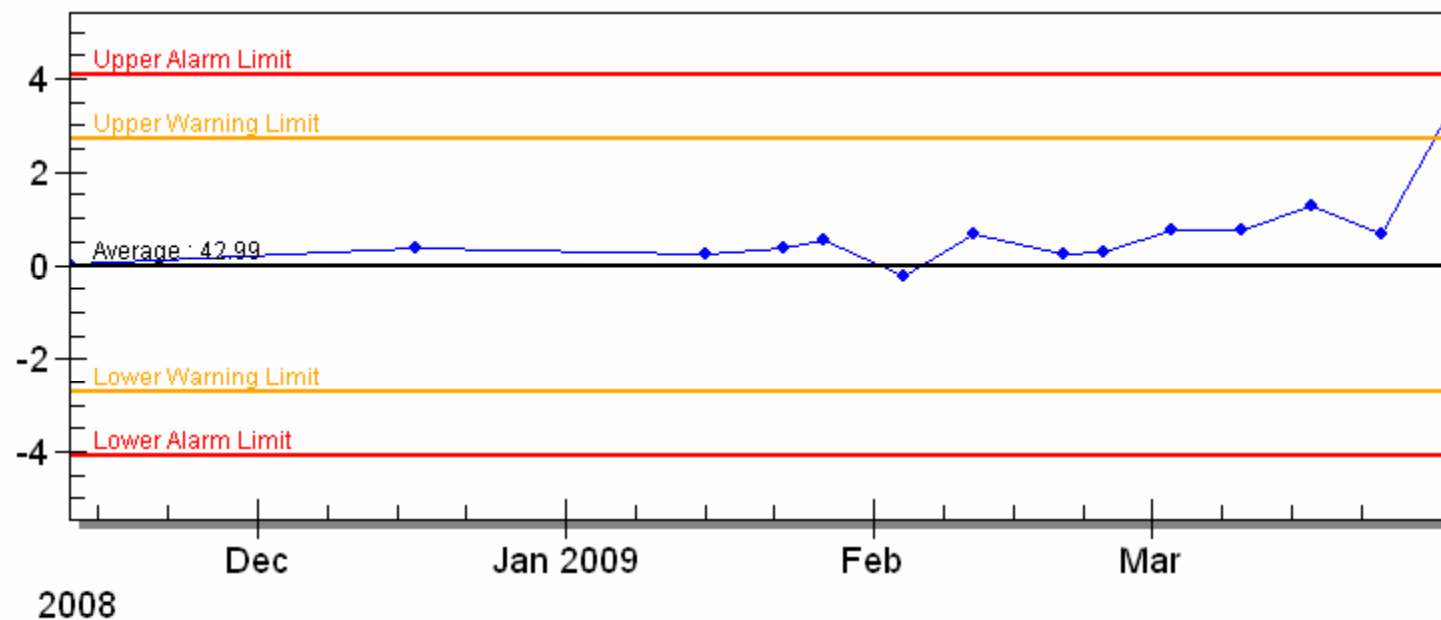
- ➡ Nominal range – 2x daily ELV, Annex B
- ➡ Flexibility allowed – contact us first
- ➡ Performance specifications from EN 15267-3
- ➡ Concentrations – not in sequence of increases/decreases
- ➡ Quality of gas depends on intention
  - ➡ Just linearity or Method C calibration?
- ➡ Axes can be reversed for calibration
- ➡ Do not combine with SRM data
- ➡ Provides response-time data at the same time

# Anticipating drift and QAL3

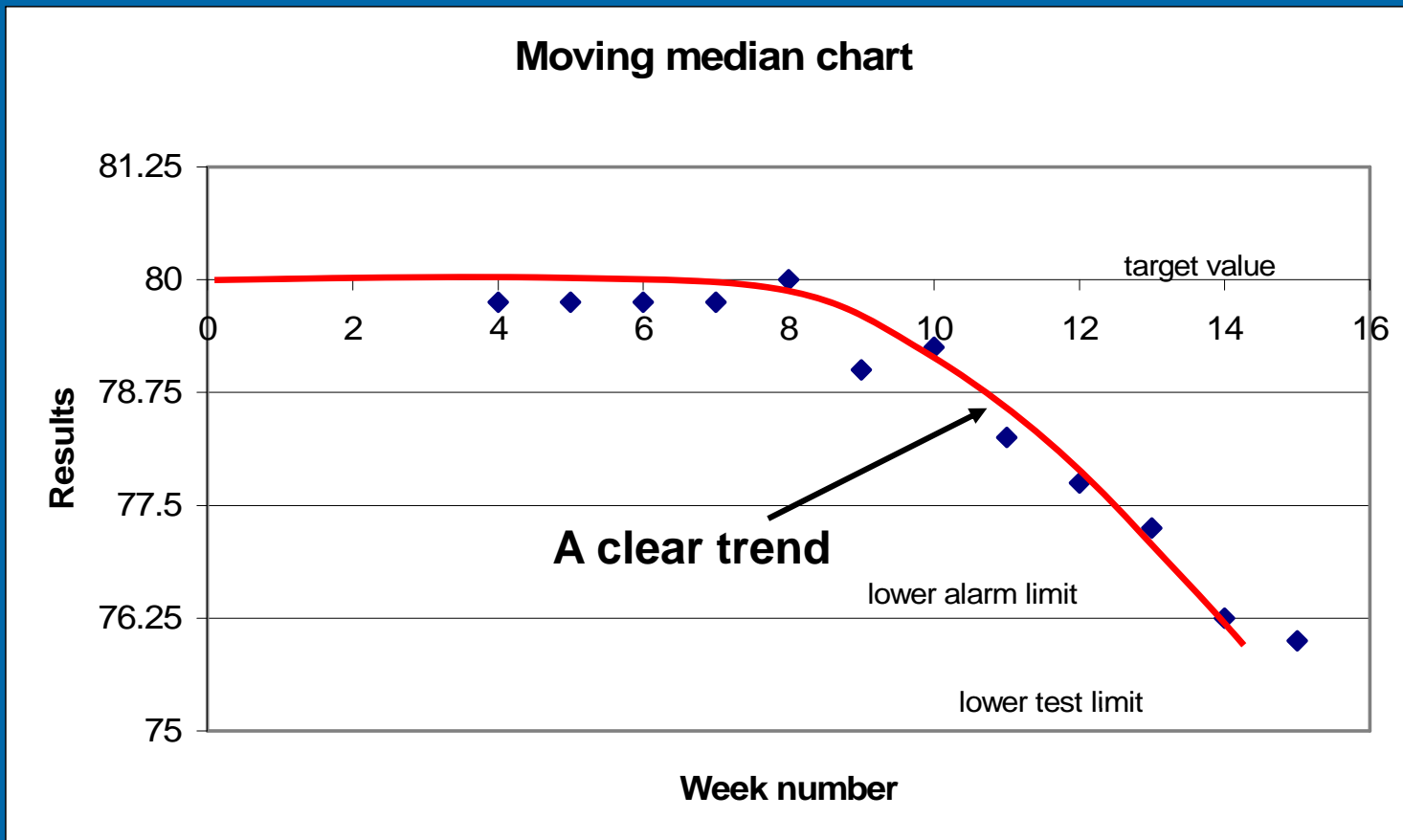
- ➡ Sometimes drift is apparent before the limits are reached
- ➡ If so, then it is not necessary to wait until the drift reaches the limits
- ➡ But look for the causes of any changes, rather than making simple adjustments

# Anticipating drift

EN14181 QAL 3 Span Shewhart Chart for Stream One Duty MIRFT : SO<sub>2</sub>



# Anticipating drift





# Moisture

- ➡ If CEMs measure moisture, then functional tests are required
- ➡ There are moisture generators available
- ➡ We have seen test laboratories and CEMs suppliers using them on site

# Moisture



# Moisture



# Accreditation

- ➡ Functional tests not within the scope of the scheme for EN 14181
- ➡ Reporting the tests
  - ➡ Inspection activities, ISO 17020
- ➡ Organisations could be accredited for the functional tests
  - ➡ ISO 17025

# Reporting

- ➡ Follow Annex A on EN 14181

- ➡ Annex B for linearity

- ➡ TGN M20 – Annex on functional tests

  - ➡ Produced by the Environment Agency and varied STA members

- ➡ MID EN 14181

  - ➡ Reporting template

  - ➡ Therefore the template shows what we need to see

# Summary

- ➡ Anyone competent can perform the functional tests
- ➡ Competency is going to be specific to certain CEMs
- ➡ Ideally around a month before the parallel reference tests for EN 14181
- ➡ Tests in-between – preventative maintenance
- ➡ Annex A of EN 14181 specifies the tests
- ➡ Extra guidance in TGN M20

# Acknowledgment

- ➡ Veolia
- ➡ Lafarge
- ➡ UPM
- ➡ CES
- ➡ Sick-Maihak
- ➡ Catalyst
- ➡ CBISS
- ➡ ABB