Field Monitors

Fit for Purpose

Water Science Forum Nov 08

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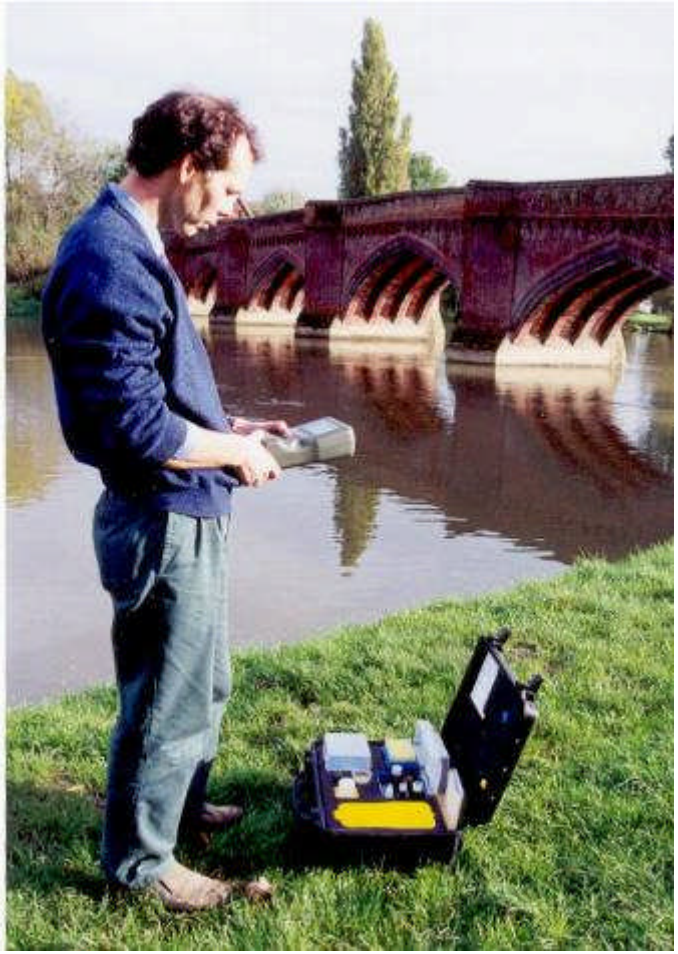
My Back Ground

- MSc in instrumentation and analytical chemistry
- 4 years ay WRC in the Instrumentation & Monitoring Section
- 4 Years at Oxford Instruments as an application chemist.
- 15 years at Severn Trent Services as a Project Manager for Online instruments & Water Test kits. *Municipal Bias*
- 3 Years at Kennet Water Components as a Product Manager *Private Water Bias*



Outline of Presentation

Define “Field Monitor”

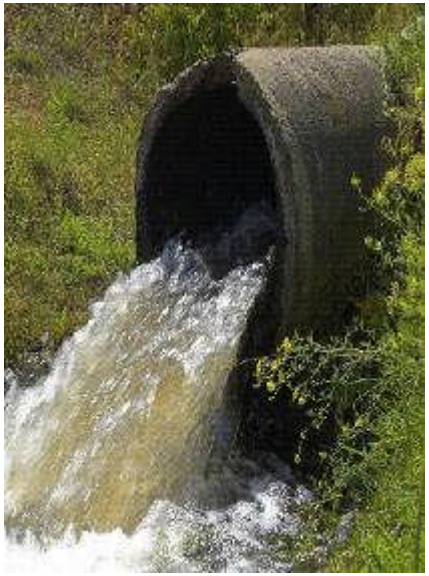
Advantages and disadvantages of Field Monitors

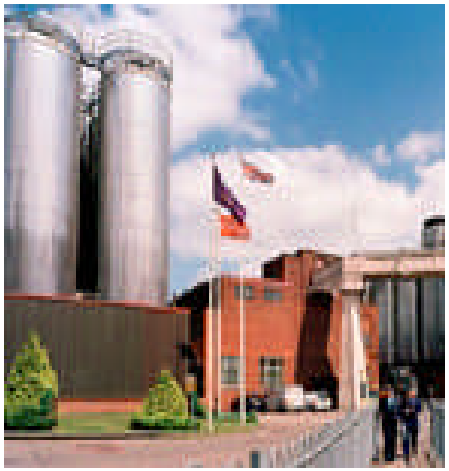
Define “fit for purpose”

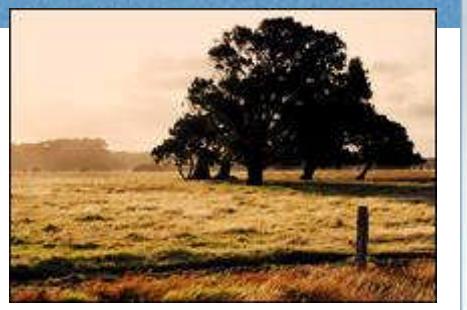
Applications and practical examples

Summary

What do we mean by Field Monitor







What are Field Monitors ?

Portable sensors and instrumentation which give an immediate answer.

Single parameter test kit

Multi parameter test kit

Continuous Monitoring Instruments

Suite of monitoring instruments

Single Parameter Test Kit

Test Strips and drop test

Colour comparison test

Single parameter photometer

Probe Tests (pH, conductivity)

Generally quick, simple and in expensive.

Give low to moderate accuracy

Multi Parameter Test Kit

Photometers

Sondes

Moderately expensive (hundreds pounds)

Give moderate accuracy

Advantages of Test Kits

Portability – go anywhere

Robust

Immediate Results – which allow immediate action

Inexpensive - typically are less than a pound a test

Simple to use

Can measure transient samples eg DO, Cl2

Disadvantages of Test Kits

The location – wind/rain/noise/ temperature

The difficulty of running calibrations/blanks etc

Availability of equipment/tables/benches

Inherent design of the test kits themselves

The lack of accuracy/reproducibility data supplied with the test kit.

Lack of tests eg for the WFD 33 priority substances

Test Kit Chemistry

Test kit sensors – been around for years

Lovibond "encyclopedia" from the 50's

1980s Dept of Environment produced reports defining a series of parameters

Standard Methods for the Examination of Water and Wastewater

Since 1905, *Standard Methods for the Examination of Water and Wastewater* has represented "the best current practice of American water analysts." This comprehensive reference covers all aspects of water and wastewater analysis techniques. *Standard Methods* is a joint publication of the American Public Health Association (APHA), the American Water Works Association (AWWA), and the Water Environment Federation (WEF).

Test Kit Chemistry

Colorimetric Test

Been around for 100 years

This chemistry is used in the tablets of the test kits and the wet chemistry behind many online monitors.

Soluble Aluminium in Raw and Potable Waters by Spectrophotometry (1987 version)

Note: Throughout this method aluminium is expressed as the element (Al).

A1 Performance Characteristics of the Method

(For further information on the determination and definition of performance characteristics see reference 5).

A1.1	**Substance determined**	Those forms of aluminium reacting with pyrocatechol violet, α, α-bis (3,4-dihydroxphenyl) toluene-2, α-sultone. (See sections A2 and A8).
A1.2	**Type of Sample**	Raw and potable waters.
A1.3	**Basis of method**	The reaction of aluminium with pyrocatechol violet to form a blue-coloured complex the concentration of which is measured by spectrophotometry at 585 nm.
A1.4	**Range of application**	Up to 0.3 mg/l.
A1.5	**Calibration curve (a)**	Linear to at least 0.3 mg/l.
A1.6	**Total Standard Deviation (a)**	

Aluminium Concentration (mg/l)	Standard Deviation (mg/l)	Degrees of Freedom
0.060(b)	0.005	18
0.180(b)	0.004	18
0.300(b)	0.005	17
0.017(c)	0.005	14
0.318(d)	0.008	12

A1.7	**Limit of detection (a)**	0.013 mg/l with 10 degrees of freedom.
A1.8	**Sensitivity (a)**	0.1 mg/l gives an absorbance of approximately 0.16.
A1.9	**Bias (a)**	No bias detected except when interferences occur (see Section A1.10).
A1.10	**Interferences (a)**	Certain substances are known to cause interference in this determination (see Section A3).
A1.11 (a)	**Time required for analysis**	The total analytical and operator times are the same. Typical times for 1 and 10 samples are approximately 60 and 90 minutes excluding any pretreatment time.

Test Kit Chemistry

Field tests are now often very different form the laboratory tests

Eg Iron. Test Kit use TPTZ, ferrozine or phenanthroline colorimetric reagents while the lab uses ICP

Cause problems:

Colorimetric test often run at neutral pH and measure only the dissolved inorganic portion of in this case iron.

ICP which cost 100's K will pre acid digest the sample then heat it to hundreds of degrees to break it down to constituent parts to give a definitive concentration of iron.

Need to be aware of differences.

Continuous Monitoring: RSC Report

RSC Sustainable Water Summary 2007 puts it's emphasis on continuous monitoring equipment:

"Monitoring of water bodies will increase over the coming years, within Europe in response to the needs of the Water Framework Directive, and globally due to the pressure from climate change, which will lead resource scarcity in some areas as well as water quality changes, and increasing demand from population and manufacturing growth. Monitoring at river basin level from the WFDs is a significant financial burden using conventional sampling and laboratory based techniques, but sensors offer the potential to reduce the costs considerably, as well as providing useful continuous monitoring capabilities."

Continuous Monitoring Instruments

Colorimeteric

Probe type

HPLC/MS etc

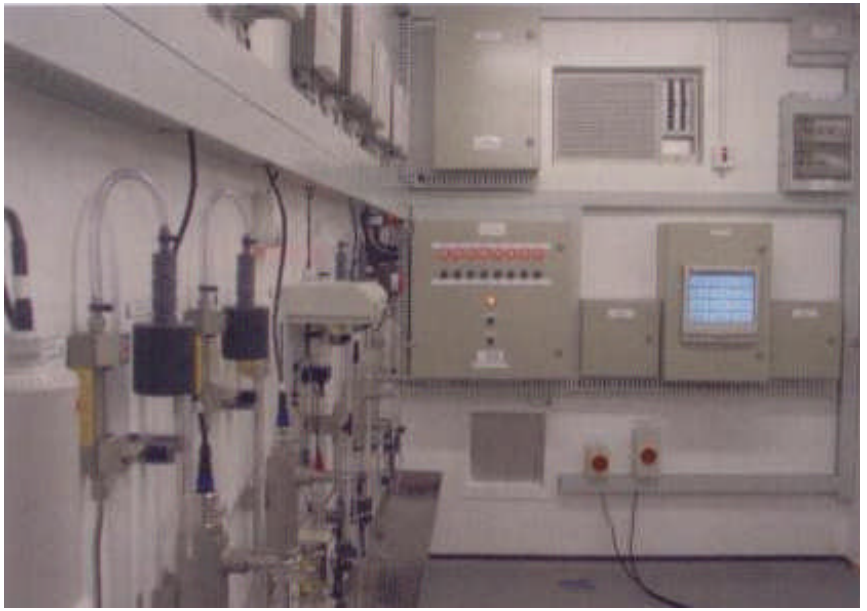
Expensive (£1000's)

Generally good accuracy

Suite of instruments

Multiparameters normally connected to PLC/SCADA

Very expensive, and complicated



Advantages of Online instruments

On-line instruments

Improvements in process control

Improvements in process reliability

Process optimisation for water quality

Potential capital and operating cost reductions

Allows continual monitoring of Remote or un-staffed sites

Improved reporting

Disadvantages of Field Monitors

Online Instruments In particular:

Fouling

Cost

Complexity

Servicing

On-line Instruments

Same chemistry issues for traditional colorimetric or electrode based analysers as test kits.

Additional problem of biofouling. Measuring nutrient rich waste water is very difficult eg ammonia or dissolved oxygen in waste water sites.

Laboratory equipment is now appearing in the field but tends to suffer from unreliability – like buying a Peugeot 206 convertible versus true designed convertible such as the MR5 – full of small compromises.

Fit For Purpose

Completely depends on the application

Depends on the budget!

Only as good as the chemistry or physics behind the test or sensor.

Most people assume absolute accuracy even of £1 test kits

The Application

Routine Monitoring

Environmental Monitoring

Servicing

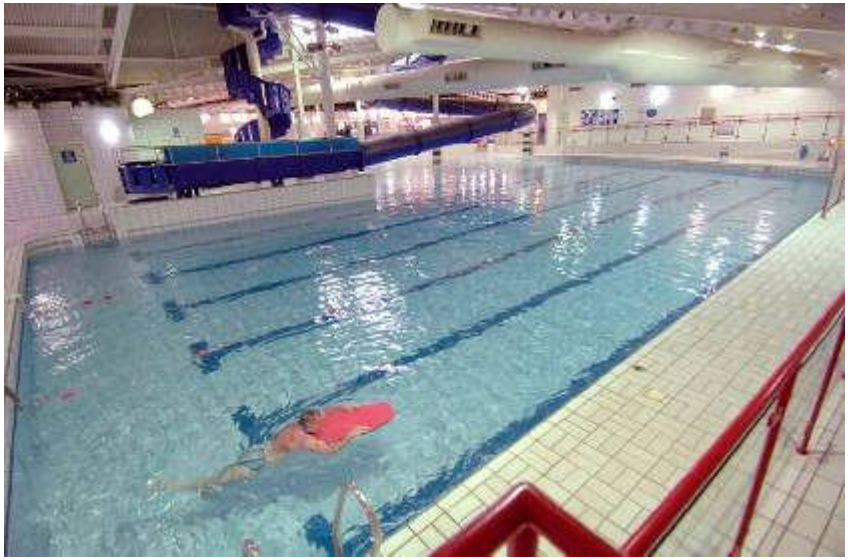
Process Control

Regulatory

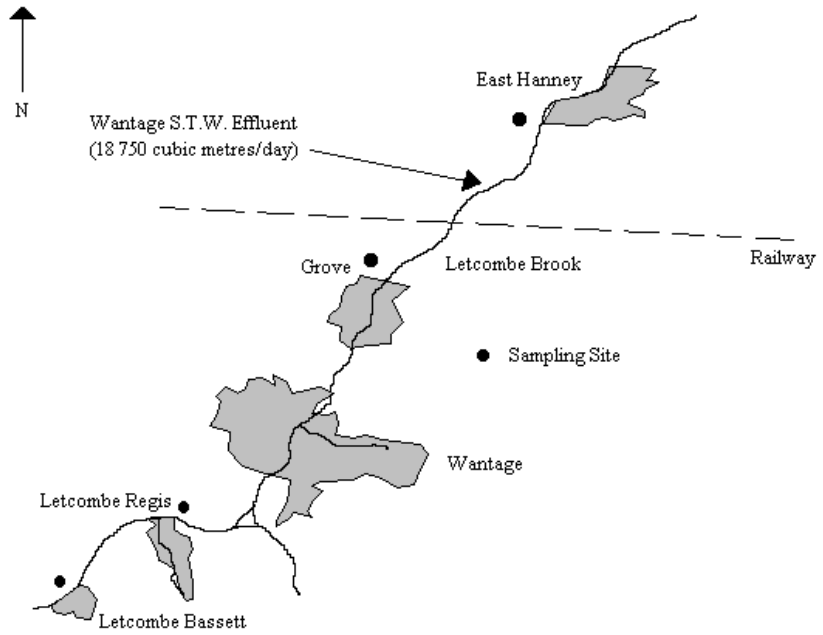
The Application: Routine Monitoring

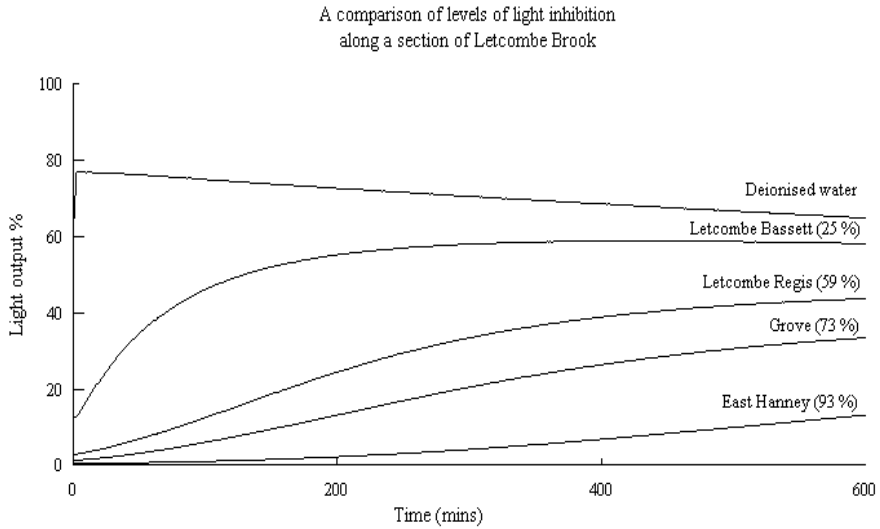
Routine Monitoring

Chlorine by far the most common used by Water Authority Operators & swimming pool staff.



The Application: Environmental Monitoring





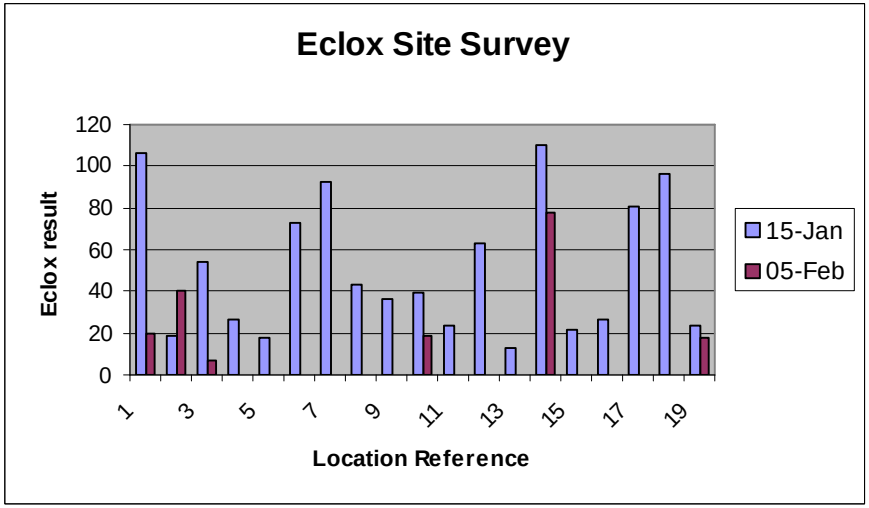
The Application: Site Monitoring

Tracing sources of pollution

Identification

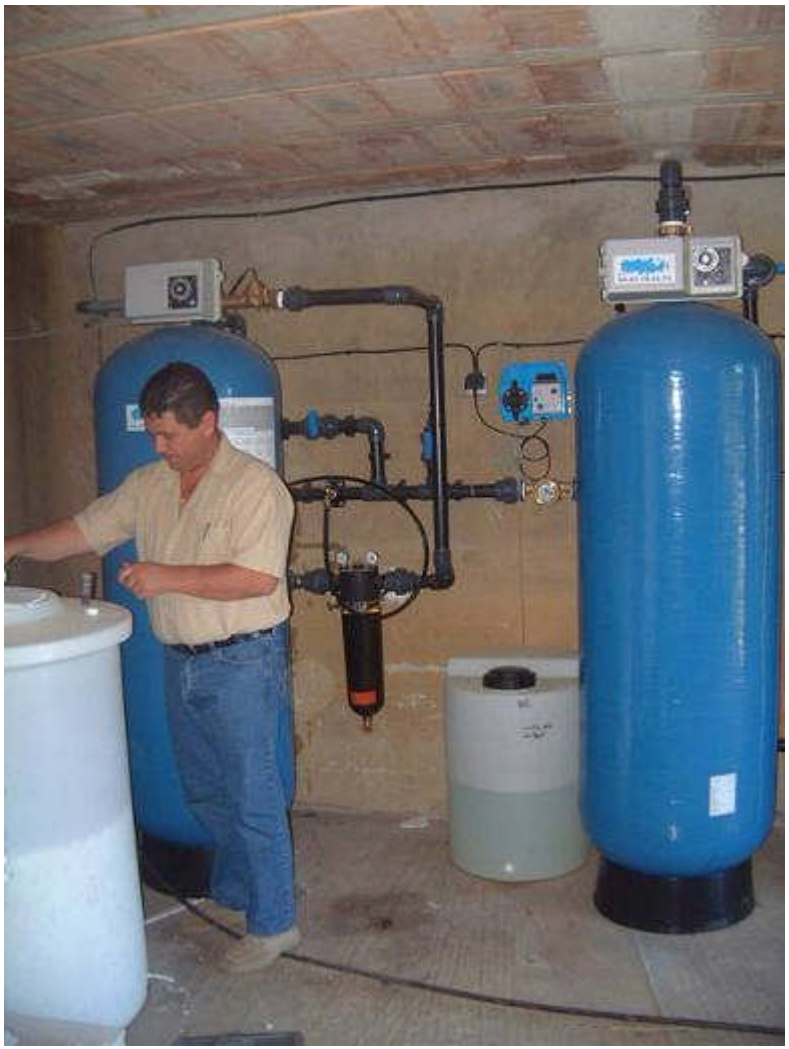
Targeting remediation effort

Evaluating effectiveness of cleaning



The Application: Servicing

Simple yes/no tests to check water softener is working



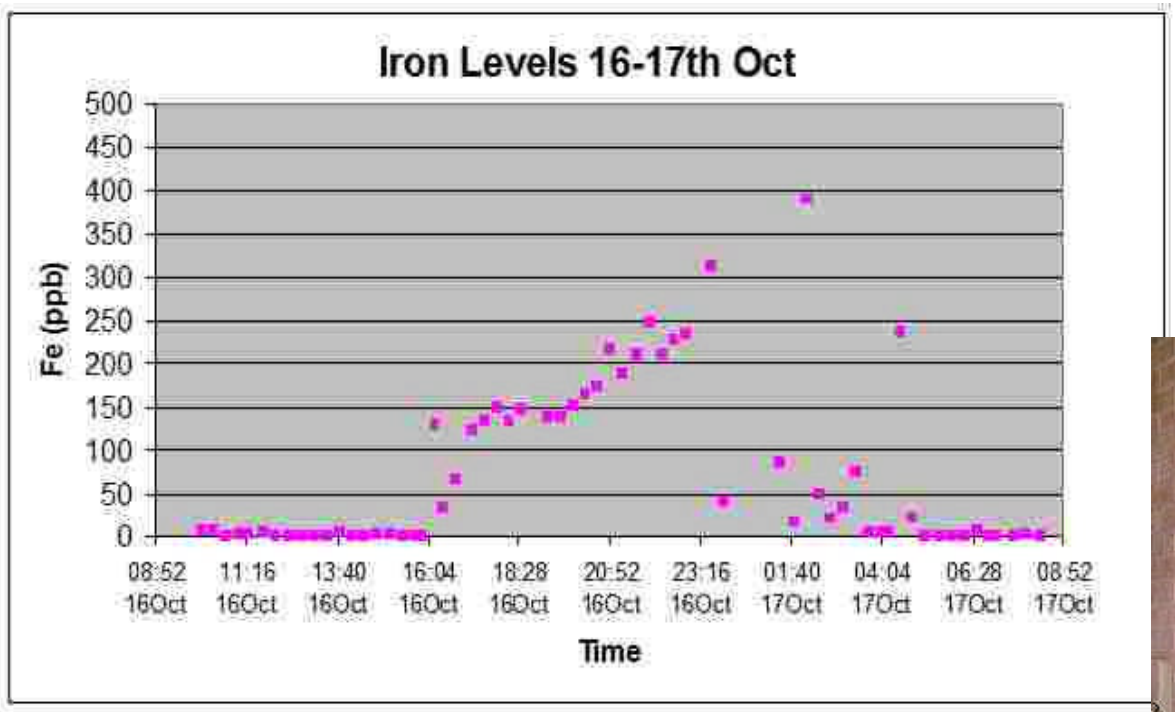
The Application: Process Control

Running many tests

Looking for trends rather than absolute accuracy

Testing plant bit by bit

The Application: Process Control



The Application: Regulatory

Chlorine in water treatment plant

Compare with lab results

DO in waste water

The Application: Military

To deploy a full and comprehensive testing regime within a theatre of operations which is both auditable, and can be defended in law

Generic qualitative testing
- Water test kit

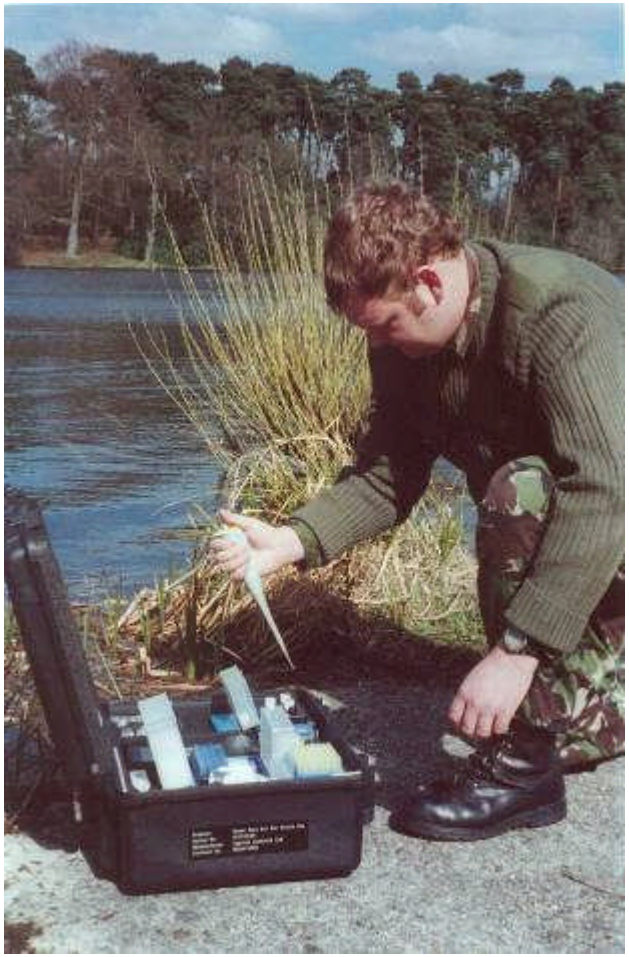
Diagnostic quantitative testing
- Field testing
- Definitive testing

Laboratory testing
- In theatre
- UK home base

Generic Qualitative Testing

To test source waters in the field to give a rapid indication of water quality

To test product water to ensure the effective operation of purification systems



Generic Qualitative Military Test Kit

AGREED CHARACTERISTICS SPECIFICATION FOR A WATER TEST KIT (BIOLOGICAL AND CHEMICAL) TO THE REQUIREMENTS OF MMER(SLA/3/93)

FOREWORD

This Agreed Characteristics Specification (ACS) describes a new requirement for a Water Test Kit (Biological and Chemical) [WTK(B&C)] for the field determination of the quality (potability) of both source and treated water.

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Specifications new test needed to meet

•Capable of assuring the military potability of water
•WTK can be used to identify the best source for purification
•WTK can confirm the effectiveness of the WPU in operation
•Can identify minimum quality of water for short term consumption
•Specific detection of nerve and mustard agents

•Display readability at 0.5m in IPE, day or night
•Chemical hardness: WTK Outer Case
• Decontaminability: High-
•Storage and use of WTK in a range of climatic conditions
•Mission reliability to be at least 95% probability of completing a mission

Performance Characteristics: Military Test Kit

	SOURCE WATER	SHORT TERM CONSUMPTION	LONG TERM CONSUMPTION
PHYSICAL CONSTITUENT			
PH	5.0 to 9.2	5.0 to 9.2	5.0 to 9.2
Temperature (^{0C})	4 to 35	4 to 35	15 to 22
Conductivity	1,500	1,500	1,500
Colour (colour units)	75	NA	15
CHEMICAL (mg/l)			
Arsenic	20	1.4	0.04
Cyanides	200	14	0.4
Mustard	2	0.1	0.04
Nerve agents	20	0.01	0.004
Chloride	600	NA	425
Magnesium	150	NA	105
Sulphates	400	NA	280
Cadmium	50	3.5	0.09
Antimony	50	3.5	0.09
Copper	50	3.5	0.09
Lead	20	7	0.04
Mercury	100	1.4	0.02
Thallium	20	2	0.07
Mycotoxins [1]	0.1	0.02	0.006
Glycollates [1]	1	0.05	0.005
Pesticides (e.g. Lindane)	20	0.4	0.1
BIOLOGICAL (see Section 2.2.4)			
Coliform [1]	10^{4} CFU/ml	1 CFU/100ml	1CFU/100ml
Virus [1]	10^{2} PFU/ml	1 PFU/100ml	1PFU/100ml
Spores /Cysts [1]	10^{4} CFU/ml	1 CFU/100ml	1CFU/100ml
Free Chlorine (mg/ml)	0.1 - 8.0 (see Section 2.2.4)		

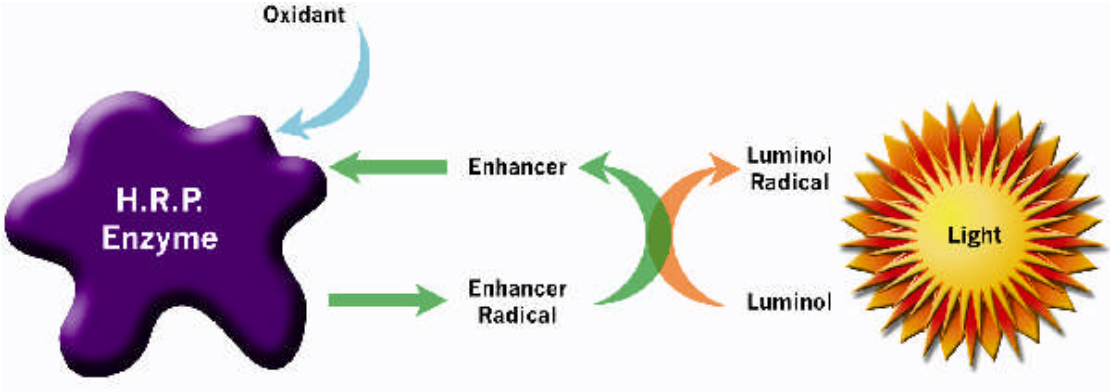
Water Test System
A Generic Qualitative Test

8 Determinands

1. Chemiluminescence
2. Arsenic
3. Pesticide/Nerve Agent
4. Chlorine
5. Color
6. TDS
7. pH
8. Mustard Gas (optional)

Chemiluminescence Test

- Uses Chemiluminescence
- The generation of light by a chemical reaction
- Used to check for pollutants in the water



- **When these are added to pure water they provide a steady light output**
- **Any pollutants in the sample will reduce the light output**
- **The light is measured on a luminometer**

Military Test Kit Components

- Arsenic

- Pesticide/ nerve agent

- Chlorine

Specifications new test needed to meet

WTK(B&C) Reliability Testing Programme (ACS)

Instrument	Component	Test Criteria	BFMs	Test Sequence
Luminometer	Electronics	1023 hours of operation	68	5 units operated for 205 hours each
	Buttons	277259 operations	134	3 sets of 2 buttons operated for 46210 cycles each
	Battery	69 operations	136	3 Battery compartments will have 24 complete battery changes each
TDS Meter	Electronics	636 hours of operation	82	3 units operated for 220 hours each
	Push Buttons	32162 operations	138	3 meters will have On/Off button operated for 10720 cycles each
	Trimmer	1109 operations	138	3 units will have 400 calibration trim operations each
pH Meter	Electronics	166 hours of operation	83	3 units operated for 60 hours each
	Probe	16081 operations	138	3 units will have 5400 probe operations each
	Push Buttons	33271 operations	141	3 meters will have On/Off button and Calibration button operated for 11090 cycles
Pipette	Small	12060 operations	34	3 units will have 4200 pipette use sequence operations each
	Large	4020 operations	34	3 units will have 1400 pipette use sequence operations each

The Application: Military

Generic qualitative testing

Water test kit

This was a difficult brief

Water Test Kit was produced on time and to budget

Conclusions: Are Field Monitors Fit For Purpose ?

Depends on the Application and what is needed.

Quality - Rely on the manufacturing companies internal QA ISO 9000

Accuracy/reliability data is very rarely stated on any instructions

Field conditions affect the result

Difficult for the user to compare tests and decide if it is fit for purpose

On-line instruments similar but starting to come in eg

ISO for Turbidity ISO 15389

MCERTs for a limited number of on line instruments. By The EA in Bsi

Determinands included in the on-line analyser standard are: Turbidity; pH; ammonia; COD; TOC; dissolved oxygen; total phosphorus; nitrates; total oxidised nitrogen.

Conclusions

EA Chief Executive Dr Paul Leinster says, “The Environment Agency is committed to protecting and improving the environment in England and Wales and our Monitoring Certification Scheme, MCERTS,

PPM’s Steve Tuck says, “Entering various product(s) for independent testing is a costly and time consuming exercise, however, MCERTS underpins the sale of our TOC instrument since it has been deemed fit for purpose by independent third party evaluation.”

The Environment Agency is working with BSi to link the MCERTS standard to the re-write of BS1472: Guide to field and on site test methods for the analysis of waters. Additional determinands will also be included in future versions of the standard if there is a demand.

Conclusions

From a Manufacturers point accreditation/ certification must be economic -preferably European wide

WRAS – UK water standard for pipe fittings. Different in France, Germany etc. WRAS costs £100's per substance to be tested and will not accept other European or USA tests results to be taken into account.

Companies will ignore it unless it is Economically viable – increased sales or because of legislation.

The Future

Development of more test Kits and continuous monitors

RSC Report stated

It will require the development of new test and sensors if we are meet the needs of the framework directive.

Many of these are new and as yet impossible to detect reliably in the field (at the concentrations necessary).

Improved transparency