Instrumentation

ABB Aztec 600 colorimetric analyzer
Pure continuity, clear compliance

Why does water quality need to be measured?

The high standard to which potable water is treated has in turn led to high expectations of its quality and appearance amongst consumers. Potable water, particularly for drinking, is expected to look, smell and taste a particular way, any departure from these expected standards can lead to dissatisfaction and complaints by consumers. Evidence of this can be seen in the annual drinking water quality reports produced by the UK's water companies, for example, where complaints relating to such issues are noted as part of their overall performance assessments.

Coupled with this is the more immediate need to eliminate the risk of waterborne diseases such as cryptosporidiosis, E.coli and other microbiological contaminants that cause illness, and, in extreme cases, death if not adequately treated.

ABB's Aztec 600 water analyzer series measures parameters concerned with safeguarding against the issues of appearance, odour and taste of potable water.

Fig.1 - ABB's new Aztec 600 colorimetric analyzer for iron, manganese, aluminium and phosphate monitoring.

1.0 Introducing the ABB Aztec 600 colorimetric analyzer range

Built on ABB's new analytical instrument platform, the ABB Aztec 600 series offers enhanced accuracy with simple operation and maintenance typically for potable water treatment applications.

The Aztec 600 series online monitors provide continuous automatic measurement, with up to six readings per hour. This provides several key advantages over manual testing methods, namely:

- Samples are automatically extracted and analyzed at regular intervals at the point of extraction. With manual methods, time lost between extraction of the sample and subsequent testing often affects the value of the end result obtained.
- Provides real-time indication of current process conditions. In contrast, manual testing methods only provide results for the moment in time when the test is actually made – there is no way of knowing what is currently happening in the process.
- Access to real-time information allows immediate action to be taken in the event of an issue.

Options are currently available within the ABB Aztec 600 series for the measurement of aluminium, iron, manganese and phosphate. More about the Aztec 600 series can be found in section 5.0 of this document.

1.1 Aztec 600 measurement parameters – what are they and why must they be monitored?

Today the task of managing the quantity of water resources and the quality of drinking water is unimaginable without on-line instrumentation aiding water utilities manage, treat, and deliver drinking water to consumers. The Aztec 600 series has been designed to measure four key parameters that affect water quality – aluminium, iron, manganese and phosphate.

- **Aluminium**

  Aluminium levels in water can be attributed either to its natural presence in soil or as a result of its usage as a flocculant to remove impurities during water treatment processes.

  Where used in water treatment processes, aluminium serves to reduce the turbidity and bacterial content of water prior to the final stages of treatment and disinfection.

  There is dispute to its potential effects on health with excessive levels of aluminium thought to be linked to Alzheimers disease, although aluminium in drinking water represents only a very small percentage of the average person's total daily intake. If left unchecked, excessive aluminium levels can lead to kidney dialysis problems.

  In the UK, the standard for aluminium in drinking water stipulates a maximum concentration of 0.2 milligrams per litre (0.2mg/l).

- **Iron**

  Iron in potable water does not present a health hazard. However, if not closely controlled, the presence of iron in water can cause problems. For example, iron can react with tannins in tea, coffee and some alcoholic drinks, resulting in the formation of a black sludge. It can cause staining of laundry and items such as crockery and cutlery; discoloration of water fittings such as taps and can also clog pipelines, pressure tanks, water heaters and water softeners.

Sources of iron vary, in most cases, it will be naturally present due to local geological conditions. It may well have been introduced as a result of water treatment or the corrosion of iron water mains. This last source is one of the key factors responsible for the elevated iron levels in the majority of cases where water fails to meet the permitted maximum level. Water that runs through distribution networks comprised of extensive runs of cast iron pipes is particularly prone to high levels of iron. Operational problems such as burst mains can disturb iron deposits in the pipes, discoloring the water and causing an unpleasant taste.

The maximum permitted level for iron in potable water is 0.2 mg/l.

- **Manganese**
  Manganese occurs naturally in many sources of water. Like iron, it has not been proven to pose a risk to human health but can have a negative impact on the appearance of drinking water if not properly treated. Failure to properly control manganese levels will result in black deposits collecting in pipe networks which may turn potable water black if disturbed. Most complaints about manganese in potable water relate to staining of laundry or vegetables becoming discolored during washing or cooking.

  Although the maximum permitted level for manganese in potable water is 0.05 mg/l.

- **Phosphate**
  Many water companies introduce phosphates to their water supplies in order to prevent lead from old pipes dissolving into the water, the aim is to keep the lead content in the water below the maximum permitted level of 25 mg/l of lead as set by the European Drinking Water Directive.

  The main concern relating to phosphate concentrations is the issue of "eutrophication". Put simply, too much phosphate in water can lead to excessive growth of plants and algae.

  As well as being added during the treatment process, phosphate levels in water can also be attributed to agricultural activities, animal wastes, human sewage, food wastes, urban run-off, vegetable matter, industry and detergents.

  The amount of phosphate in water is not regulated. However, the WHO (World Health Organization), sets a recommended maximum 'safe' level of around 5mg/l and states that a person's Recommended Daily Allowance (RDA) should not exceed 800mg.

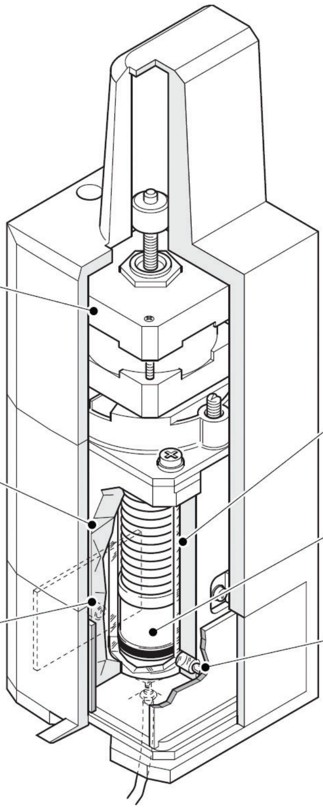
1.2 Aztec 600 measurement ranges:

Parameter	Range	Application
Aluminium	0.005 ... 1.5 mg/l Al	– Residual Coagulant Monitoring
Iron	0.005 ... 5 mg/l Fe	– Residual Coagulant Monitoring – Iron removal
Manganese	0.020 ... 10 mg/l Mn	– Manganese Removal
Phosphate	0.050 ... 50 mg/l PO4	– Plumbosolvency schemes – Monitoring municipal wastewater effluent

1.3 How do the Aztec analyzers work?

The Aztec 600 series uses the principle of colorimetry to measure concentrations of aluminium, iron, manganese and phosphates. The analyzers use an LED and detector to measure the passage of light through a sample. A single precisely controlled piston pump provides all the sample and reagent fluid handling, including the mixing and disposal required for the measurement to be made. This patented fluid handling system also cleans the measuring cell. Measurements are taken before and after reagents are added to compensate for background color and turbidity.

The analyzers can make up to six measurements per hour.



The following description is for the measurement of aluminium.

The process begins with the removal of any contaminants that could affect the accuracy of the measurement by simply rinsing the measurement cell with fresh sample. Air is then introduced to purge the tubing between the measurement head and the valve manifold block, further ensuring the removal of any contaminants. The waste valve is then opened and the solution is removed via the waste valve. The number of sample rinses is user configurable, the default is twice.

The next step sees the introduction of a small amount of an acid reagent into the cell, which is then mixed with the sample to be measured.

The acidified sample solution is then held in the measurement cell for three minutes. This acidification is normally sufficient to convert all soluble forms of aluminium to those that will react with the color forming reagent. Before any color forming chemicals are added, a measurement of the background is taken to account for any natural color of the sample.

Buffer reagent is introduced into the cell to raise the pH of the solution in order that it will react with the color forming reagent when this is added next.

Air is brought in to the cell to purge the tubing and ensure thorough mixing of the solution; this solution is then held for five minutes to allow the color complex to develop.

At the end of the five minute holding period, the final absorbance of the solution is measured. The amount of absorbance will be proportional to the concentration of aluminium in the sample. The concentration of aluminium is calculated by the software and the analyzer display updated. The unit is now made ready for the next analysis.

The color comes from the absorption of certain wavelengths from the visible light spectrum within the range 400 to 700 nanometers (nm). A diagram illustrating this is shown below:

2.0 What is colorimetric analysis?

Colorimetric measurement is used extensively throughout water, power and process industries. Put simply, the technique can be described as the color-based measurement of a chemical in a solution. It is used to determine either the absorption or concentration of that chemical, based on the degree of color and the ability of light to pass through it.

Where water is concerned, many of the substances that need to be measured are colorless as they do not absorb light in the visible spectrum. To overcome this, and enable the substances to be measured, chemical reagents are used to create a reaction and form a colored complex. The reagents vary according to the parameter being measured (see table, on the following page).

Adding the reagent creates a solution of molecules that absorb light. As stated previously, the Aztec 600 analyzers use an LED and detector to measure the passage of light through the sample. By measuring the absorption/ passage of light through the colored sample, the concentration of the parameter being measured can be ascertained.

Parameter	Chemical Method	Max. Sample Frequency	Instrument Measurement Range (including dilution)
Aluminium	Pyrocatechol Violet	6/hr	0.005 - 0.3mg/l Al
			0.3 – 1.5mg/l Al
Iron	TPTZ	6/hr	0.005 - 1mg/l Fe
			1 - 5mg/l Fe
Manganese	Formaldoxime	6/hr	0.020 - 2mg/l Mn
			2 - 10mg/l Mn
Phosphate	Molybdate	4/hr	0.050 – 8.5mg/l PO_4
			8.5 – 50mg/l PO_4

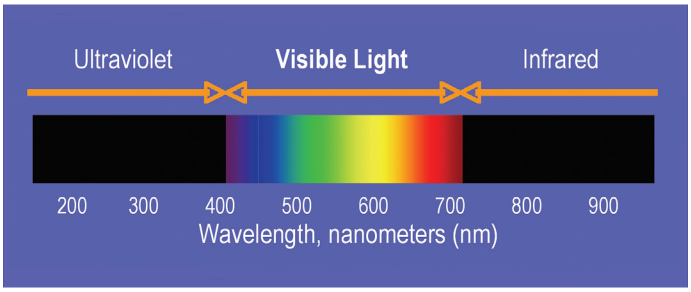
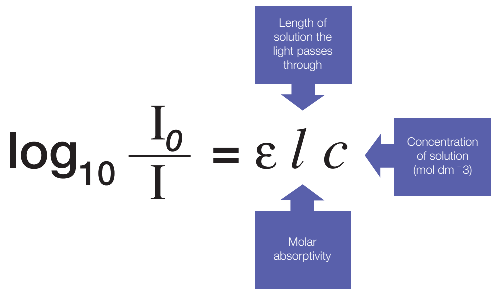


Fig.2 - The electromagnetic spectrum

2.1 The Beer Lambert law

The relationship between absorption and concentration is set down by the Beer Lambert law, which basically states that the absorbance of UV/visible radiation is proportional to the concentration of the absorbing compound and the distance the light travels through the solution. This relationship is expressed by the Beer Lambert equation as follows:

$$\log_{10} \frac{I_0}{I} = \varepsilon\, l\, c$$



3.0 Applications for the Aztec 600 series analyzers

3.1. Iron and manganese removal processes

Water scarcity has led to a rise in the levels of manganese and iron present in raw water sources. As naturally occurring minerals, these two substances can easily find their way into raw water supplies, with levels tending to fluctuate according to conditions such as climate, ground erosion, thermal changes and disturbances of water sources.

Removal plants are installed to reduce the levels of these substances and to help control the taste, odour and fouling caused by their presence. Close control of treatment processes is required to help reduce energy consumption, optimize chemical usage and minimize wastage in terms of incorrectly treated water.

The way in which iron and manganese levels are controlled varies according to whether they are in insoluble/particulate or soluble form.

Insoluble / particulate iron or manganese are characteristic to well oxygenated water sources and can be easily removed by filtration.

The soluble forms tend to be encountered at the deeper sedimentary levels in rivers and other water sources, most often at times of hotter weather when water is less abundant. Removing soluble iron and manganese is more difficult and requires a number of different processes, the first to convert them to particulates and then the second to remove them through filtration. The main methods used to achieve this are:

- Oxidation
- Through chemical reactions with oxidizing agents such as chlorine or permanganate
- The use of ‘green sand’, a permanganate impregnated sand which acts as an ion exchange medium
- Biological action, involving bacterial conversion to other forms

3.2 Using the Aztec 600 analyzer to control iron and manganese levels

In these processes, the manganese and iron versions of the Aztec 600 will be used to monitor water quality at several key stages, namely:

– **Pre-treatment**
  This stage sees the quality of the incoming water being measured to assess initial levels of iron or manganese present before the application of treatment processes including aeration and chemical dosing.

– **Treatment stages**
  After any pre-treatment process, the water will again be monitored to check iron or manganese concentrations. Where a clarification process is used, water may also be monitored to assess whether coagulants used in the treatment process are being under or overdosed, use of other ABB analyzers can aid here e.g. color, UV254 or turbidity.

– **Post filtration**
  A final measurement will be carried out after the filtration process to ensure that any remaining iron or manganese present meet the required treatment standards. Where iron-based / ferric chloride coagulants are used, this measurement will also be used to assess the efficiency of the coagulation process, by identifying any potential overdosing. Overdosing of water with ferric chloride can lead to sludge formation and discoloration which can cause problems for customers, as outlined earlier in this document.

– **Waste discharge**
  In addition to the above, the Aztec 600 analyzer can also be used to monitor the effluent discharge from the sludge holding tanks, again to assess the efficiency of the treatment process. In particular, this helps to identify whether the correct levels of treatment chemicals are being used, which can help operators to find potential areas for cost savings through greater efficiency.

3.3 Residual coagulant monitoring

Coagulation is a safe and effective method of treating surface water. It is used to improve water quality by reducing levels of organic compounds such as manganese, dissolved phosphorous, color, iron and suspended particles.

The coagulation technique has been developed to bind together very small particles in water that will not settle or float and which cannot be removed by filtering. To achieve this, coagulation processes involve the addition of a chemical salt to electrically charge small water borne particles (known as 'colloidal matter') so that they attract and bind to each other to make larger particles, termed as 'floc', which can then float or settle. These salts are either ferric (iron) or aluminium based.

The coagulation and flocculation processes are illustrated by the diagrams below:

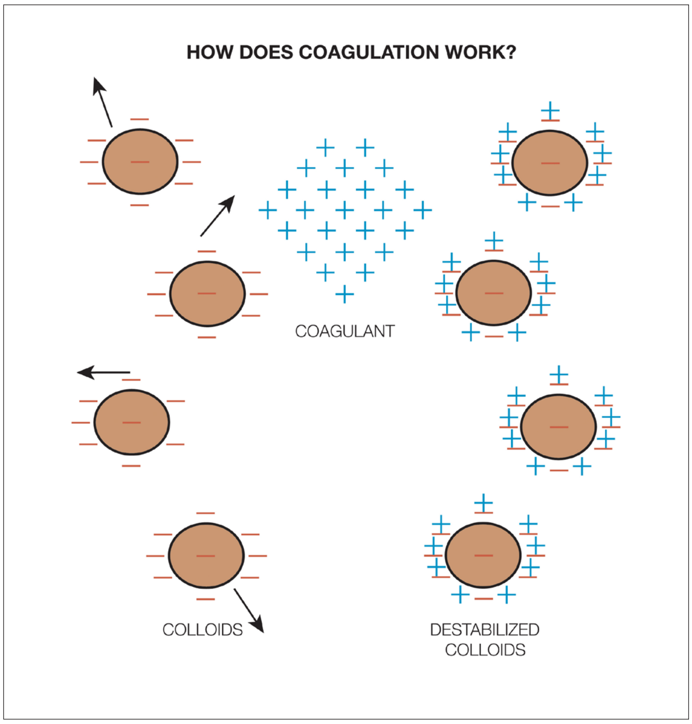
The coagulation process

The coagulation stage is designed to remove any remaining particles that cannot be removed by sedimentation or filtration. These particles are referred to as 'colloids' (see figure 3) and are the main reason for the color and turbidity of water. Colloids include clays, proteins, metal oxides and dissolved organic substances.

Generally less than one micron in size, colloids are impossible to remove through filtration only. Their removal is further complicated by the fact that they carry a negative charge, which causes them to repel rather than gather together or settle.

The solution is to introduce a positively charged chemical coagulant, most commonly either aluminium or ferric salts. These coagulants cancel out the colloids' negative charge, causing them to destabilize and attract into larger sized clusters that can then settle and be readily removed.

Fig. 3 – diagram showing the coagulation process



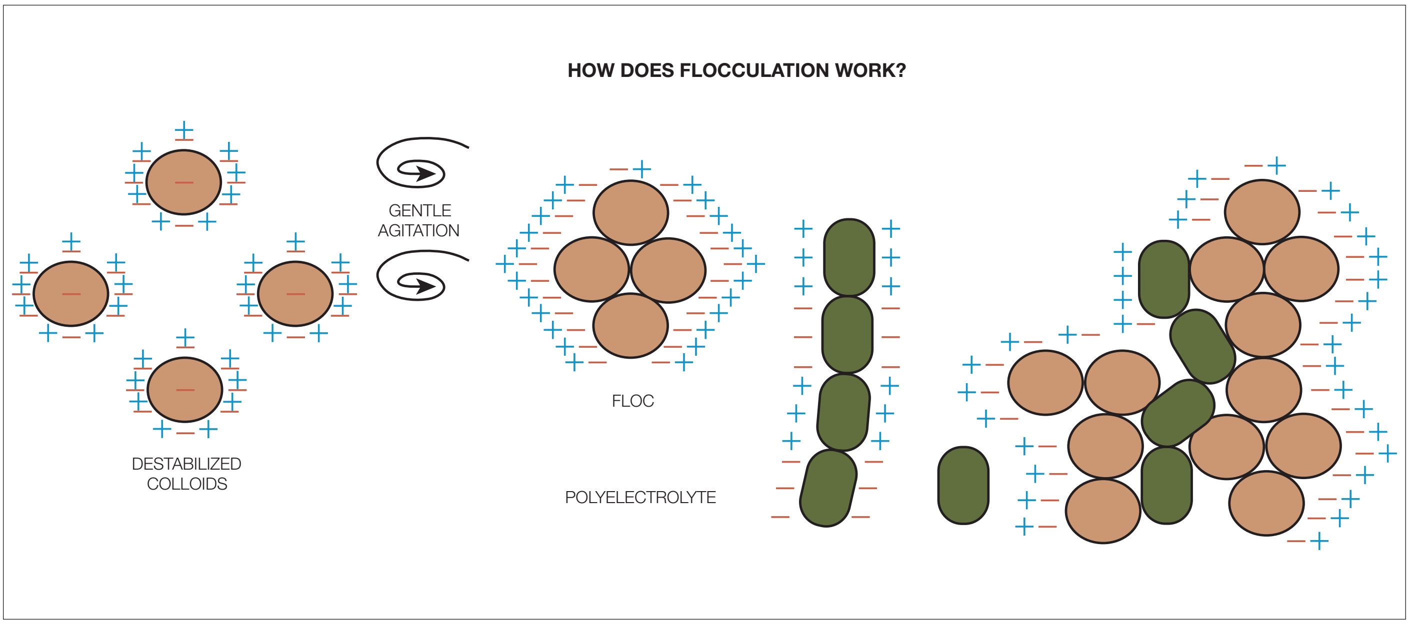


Fig. 4 – diagram showing the flocculation process

To aid the mixing process, the water is mixed very quickly in a flash mixer chamber as the coagulants are added. On smaller plants, the coagulants might sometimes be introduced before a weir, with the subsequent turbulence of the water as it passes through the weir serving to perform the mixing process.

The flocculation process

The aim of the flocculation process, as outlined in figure 4, is to combine the colloidal matter into sufficiently large clumps that can be more easily removed through settlement during sedimentation. The 'floc' forms as a result of the coagulants added during the previous stage and serves to combine the colloids into larger masses.

To aid the process, the water is gently stirred, or agitated, using paddles or baffles to create a rolling motion and draw together the colloidal particles.

In certain types of waters, it may be necessary to introduce coagulant aids to help boost the process. In most cases, these additional substances will be 'polyelectrolytes'. Most simply, these are high molecular weight substances which create charged ions upon dissolving in water, helping to aid the aggregation of the negatively charged colloids.

3.4 Using the Aztec 600 analyzer for residual coagulant monitoring

The iron and aluminium versions of the Aztec 600 analyzer can be used to implement the correct dosing of these salts thus ensuring the treated water meets the required standards.

Monitoring the efficiency of the coagulation process also provides an added safeguard against the risk of waterborne diseases, in particular cryptosporidiosis. Failure to correctly coagulate and filter water can increase the risk of a cryptosporidium outbreak, which can have serious repercussions on water companies if they are found not to have exercised every care in treating their water supplies.

3.5 Benefits of on-line monitoring of final coagulant levels

Continuous monitoring of final water provides valuable information about overall plant and process efficiency. As such, it offers a number of key benefits, including:

- Early indication of any process problems, e.g. incorrect dosing and/or issues with the filtration process
- Real time information allows immediate decisions and actions to be made in response to issues or abnormal/ unexpected conditions
- Early warning of any potential regulatory compliance failures
- The ability to gather accurate data to optimize plant to handle varying conditions caused by seasonal changes

4.0 Aztec 600 – cost saving benefits

As a means of continually monitoring water quality throughout the water treatment process, the Aztec 600 analyzer series offers a number of cost saving benefits compared to manual sample collection and analysis.

Foremost amongst these is the ability to optimize plant operation and output consistency through:

- Reduced failures and maintenance issues caused by underdosing, such as plant shutdowns or increased cleaning of sand filters
- Reduced delays and failures caused by overdosing, such as discoloration, plus the associated costs of chemical dosing for pH correction
- Reduced operator intervention through the ability to carry out automatic monitoring
- Decreased levels of sludge, leading to a reduction in the cost and resources connected with sludge disposal
- Reduced likelihood of problems caused by regulatory breaches or non-compliance

Improvements in any of these areas can offer savings of thousands of pounds.

5.0 Aztec 600 – key features

The Aztec 600 colorimetric series of analyzers from ABB are a range of compact and reliable on-line colorimetric analyzers for the key parameters in water treatment. Combining the novel ABB Aztec fluid handling and measurement design with ABB's versatile electronic platform, the Aztec 600 series offers powerful, compact, and highly reliable measurement of aluminium, iron, manganese, ammonia and phosphate.

Key features of the Aztec 600 series include automatic two point calibration, enabling operators to verify analyzer performance against standards of known concentration.

Accuracy is further enhanced by various self-cleaning abilities to ensure the optical cell and analyzer tubing used for sample measurements remain free of residual particles between each analysis. A patented mechanical cleaning function uses the piston movement to wipe the optical cell with every measurement, particularly important when measuring raw waters where optical contamination can be a real issue. The analyzers also include various user programmable automatic options for cell rinsing and acid or alkali washing.

To maximize the measuring range, the Aztec 600 features automatic sample dilution. This function allows the instrument to be set to automatically adjust to monitor higher levels of samples by using deionized water to dilute the sample.

The analyzers are available in single or multi-stream configurations, enabling operators to use just one device to monitor up to three streams sequentially all with current loop, Ethernet or Profibus outputs.

The Aztec 600 analyzers are also simple to maintain. The piston and optical sensor use air to mix the sample and reagents, eliminating the cost and maintenance associated with mechanical or electrical stirring systems. The inherent product design and auto-calibrating features means that maintenance is only required annually, compared to every three months with some competitor's units.

A key benefit of the Aztec 600 is its ease of operation. Front-mounted pushbuttons allow easy device interaction in a familiar Windows™ environment. Operation and commissioning is straightforward, with menus presenting options for setting and fine-tuning parameters. Added support is provided by an extensive context-sensitive on-line help feature.

Based on ABB Instrumentation's highly successful common operator interface, the Aztec 600 colorimetric analyzers feature a full color graphical display, allowing process trends to be easily viewed and analyzed locally. Historical logs provide operators with access to alarm and audit trail data. Process data and historical logs are securely archived to a removable SD card with capacity of up to 2 GB.

A built-in Ethernet communications link with onboard web and ftp servers enables remote monitoring, configuration selection, data and log file access to the analyzer from a web browser.

Aztec 600 - key features at a glance:

– Ease of operation
- Familiar Windows menu system
- Built-in context sensitive help
- Data trending and analysis

– Flexible communications
- Web and FTP-enabled for easy data file access, remote viewing and configuration
- Email capability
- Optional Profibus DP v1.0

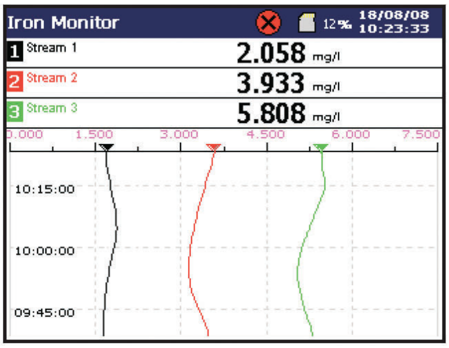
– Modular design
- Single and multi-stream options allowing analysis of up to three sample streams
- Common consumables across the range

– Ease of maintenance
- Self-cleaning measurement cell
- Simple to perform annual service
- Intuitive maintenance diagnostics

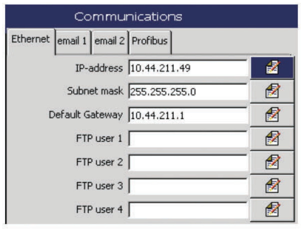
– Reliable measurement
- Automatic two-point calibration
- Automatic sample dilution to maximize measurement range
- Automatic background color compensation

Easy-to-use Windows-based Menu System

Graphical Trending of Results

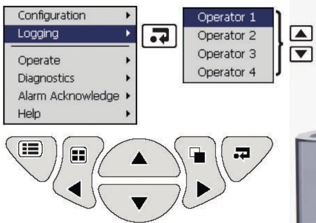


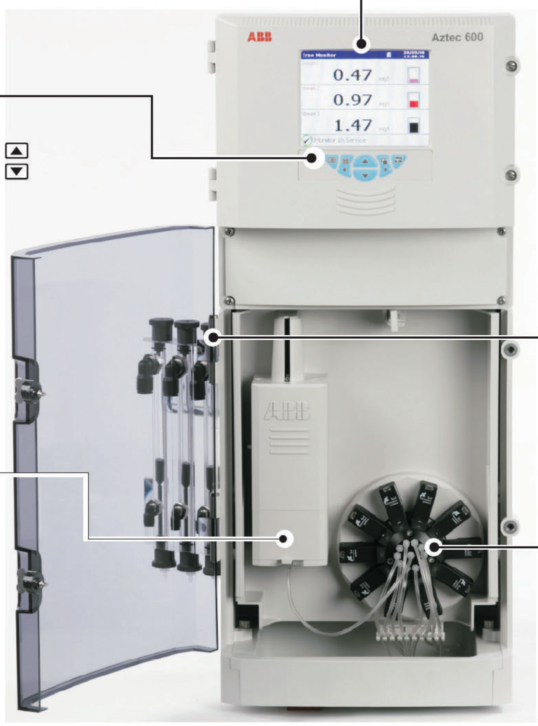
Flexible Communications



- Ethernet Connectivity
- 6 mA Outputs
- 10 Alarm Relays (configurable)
- Profibus DP v1.0
- SD Memory Card
- Process Data Trends

Simple Navigation





Single- or Multi-stream Options

- Integrated side-sample pot for ease of plumbing
- Magnetic sample flowswitch alarms when sample is not present

Advanced Optics

- Automatic LED intensity adjustment at every calibration – eliminates drift and compensates for any cell fouling
- Temperature-controlled for optical stability
- Automatic 2-point calibration
- Automatic sample dilution to maximize measurement range
- Background sample color compensated for

Simplified Fluid Handling

- Single piston pump draws in precise volumes of reagents and samples through a valve manifold into
  the optical measuring cell
- Air is used in the chemical sequence for mixing and purging the reagents and sample
- Piston movement provides mechanical cleaning the measurement cell

Notes

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