Water and wastewater

An Introduction

June 2020

1. Introduction

Water is vital to our daily lives, both for personal and domestic use and industrial/commercial applications. Whether a facility focuses on the production of clean, potable water or treating effluent, Crowcon is proud to serve a wide variety of water industry clients, providing gas detection equipment that keeps workers safe around the world.

Gas detectors must be chosen to suit the specific environment in which they operate. The water industry frequently involves wet and dirty environments, with multiple toxic and flammable gas hazards and the risk of oxygen depletion.

European Commission Directive 2017/164 (EU Directive 2017/164) issued in January 2017, established a new list of indicative occupational exposure limit values (IOELVs, as the directive calls them). The list includes carbon monoxide, sulphur dioxide, hydrogen cyanide, manganese, diacetyl and many other chemicals. Member states were required to enact the relevant laws, regulations and administrative provisions to comply by late August 2018.

OELV (Occupational Exposure Limit Values)			
Substance	**Chemical Formula**	**LTEL (8hr TWA) ppm**	**STEL (15 min TWA) ppm**
Ammonia	NH_3	25	35
Carbon dioxide	CO_2	5000 (0.5% by vol)	15000 (1.5% by vol)
Carbon monoxide	CO	20 (30) *	100 (200)*
Chlorine	CL_2	0.3	0.5
Chlorine dioxide	CLO_2	0.1	0.3
Hydrogen sulphide	H_2S	5	10
Sulphur dioxide	SO_2	0.5 (2)*	1 (5)*
Ozone	O_3	0.1	0.2

*Note: * denotes change from previous revision.*

Potential buyers

- **Plant owners and contractors**
- **Consultants**
- **OEM suppliers**
- **Safety inspectors**

2. Water treatment

Water is crucial to our daily lives, for personal health and domestic uses as well as for industrial and commercial purposes. Crowcon is proud to supply gas detection equipment for many clients in the water industry, from those cleaning water for personal and/or commercial use to those who treat and process effluent. In doing so, we are keeping workers safe around the world.

The objective of water treatment is to produce water that is clear, odourless and safe for consumption. Water treatment plants operate 24/7 throughout the year, so equipment must be constantly maintained. The water industry generates many wet and dirty environments, with multiple toxic and flammable gas hazards as well as the risk of oxygen depletion.

Typical processes and associated gas detection issues

Collection and storage

Water is gathered from surface sources and stored in open reservoirs, or in below-ground basins.

Reservoirs allow the blending of newly collected water with existing levels, which dilutes incoming contaminants. Water is held to allow some water quality improvements, including debris settlement, with sunlight breaking down organic material and reducing bacteria.

The water is then pumped to treatment facilities.

Gas detection in collection and storage

The pipelines used to transport the water require regular cleaning and safety checks; during these operations, portable multigas monitors are used to protect the workforce. Pre-entry checks must be completed prior to entering any confined space and commonly O_2, CO, H_2S and CH_4 are monitored.

Confined spaces are by definition small, so portable monitors must be compact and unobtrusive for the user, yet able to withstand the wet and dirty environments in which they must perform. Clear and early indication of any increase in a gas being monitored, and/or any decrease in oxygen, is of paramount importance, with loud and bright alarms alerting the user.

Screening

Screening is used to remove floating objects from the incoming water. This water is often from open reservoirs and commonly includes items like branches, leaves and general rubbish – such as packaging waste or containers. Initial screening prevents these objects from causing problems further down the line.

Gas detection in screening

Screening areas may become clogged with the materials they are collecting, in which case cleaning and maintenance activities will be required. Due to the nature of these areas, each should be treated as a confined space, thus multigas monitors are needed to keep workers safe. Commonly monitored gases include O_2, H_2S and CH_4 and, depending on the specific site, various others.

Coagulation and flocculation

A chemical coagulant is often added, to bind together suspended material as ‘floc’. This process may be called ‘coagulation’ and/or 'flocculation', and it makes particles larger and therefore easier to remove prior to further processing. The 'floc' is removed, and the water is ready for the next stage.

Sedimentation and aeration

The water then passes through multiple sedimentation vessels. At each stage, heavy sediment settles at the bottom of the vessel, whilst clear water moves on.

Aeration is used to remove or reduce the level of unwanted compounds (e.g. H_2S and CO_2) from water, and/or to oxidise dissolved metals to ease removal.

Treatment facilities also use membrane filters to remove finer particles.

Gas detection in coagulation and flocculation and sedimentation and aeration

Sedimentation vessels are usually placed out in the open, so that they can be naturally ventilated. If this is not the case, then fixed and/or portable monitoring for O_2, H_2S and CH_4 as a minimum should contribute to maintaining a safe working environment. Of course, if during the site-specific risk assessment, other gases are highlighted in this area of the plant, then fixed and/or portable detectors may be required.

Filtration

There are many different forms of filtration. Rapid gravity filtering passes the water through a tank of coarse sand, trapping unwanted particles. Slow sand filters pass the water slowly through finer sand, removing smaller particles. Granular activated carbon is an advanced system, used to remove pesticides, organic compounds, unpleasant tastes and odours.

Ozone is injected into the filtered water to break down pesticide and, organic compounds – ozone also has an anti-bacterial action.

Filtration clarifies the water, enhancing the effectiveness of the next stage.

Gas detection in filtration

When ozone is used as part of the filtration process, it is commonly generated on site. Ozone gas is toxic at very low levels and therefore requires careful monitoring. Fixed point detection near the site of generation or storage, linked to a localised control system providing audible and visual alarms will ensure prompt notification in the event of an escape. Due to the nature of ozone and the way it pools at ambient temperatures, best practice also indicates the use of portable detectors to monitor the breathing zone of users entering these areas.

Final treatment

Finally, the water flows into a chemical contact tank, where disinfectant chemicals are added to kill bacteria. Chlorine (Cl_2) remains the most common form of disinfectant. The addition of ammonia (NH_3) to chlorine forms longer-lasting chloramines. Chlorine dioxide (ClO_2) is principally used as a primary disinfectant for surface waters that generate odour and taste problems. Sodium hypochlorite is effective and reduces storage and handling risks. Ozone is a very strong oxidation medium, breaking down odours, bacteria and viruses.

Sulphur dioxide can also be used to treat chlorinated wastewater prior to release, to 'de-chlorinate' the water. The water is then pumped close to where it is needed and stored ready for use (e.g. in water towers).

All chemicals have specific storage requirements, and these are commonly set out in local or national regulations.

Gas detection in final treatment

Areas used for storage of the chemicals applied within the final treatment stage should be equipped with robust gas detection systems. Even very small escapes of chlorine, ammonia, sulphur dioxide or ozone can be extremely harmful. The behaviour of the gas in question must be considered when placing fixed detectors, taking into account all likely escape points and resulting dispersion. Remote alarms and the ability to take executive action (e.g. ventilation fan turn-on, automatic valve actuation) can be employed should a leak be detected. Portable monitors with the relevant toxic sensor(s) should be used in these areas, to ensure worker safety.

When considering clean water, the largest requirement is for the monitoring of storage areas. These usually house large drums of disinfectant chemicals. Increasingly, chlorine and ozone are generated as needed, but monitoring is still required at the point of use.

Ammonia and sulphur dioxide are added to remove the disinfectant chemicals. Chlorine is a very heavy gas and readily absorbed by most materials. The behaviour of chlorine makes it a very difficult gas to detect –the use of environmental sampling units is the best way to detect it and minimises the number of detectors required.

The water industry has applications that demand both fixed and portable gas detectors. Portables are generally used in confined spaces, while fixed systems are used around the plant and offices.

Storage areas for chemicals used within the final treatment stage should have robust gas detection systems installed; even small escapes of Cl_2, NH_3, SO_2 or O_3 can be extremely harmful.

Fixed gas detection is needed for the monitoring of storage areas, these are commonly linked to external alerts (sounders and beacons) to ensure workers are notified of any increase in gas levels. Such detectors may also have the capability to drive executive actions, such as the activation of ventilation fans.

The XgardIQ with remote sensor is very suitable, since the transmitter can be mounted up to 15 m away.

Summary of detectors required

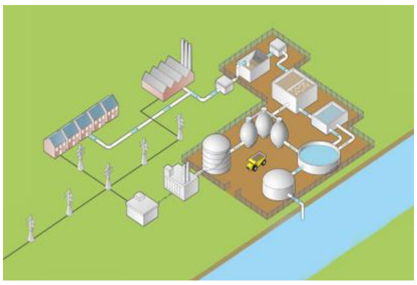
Pipelines used to transport the water require regular cleaning and safety checks and during these operations, portable multigas monitors are used, to ensure the safety of the workforce. Pre-entry checks should be completed prior to entering any confined space and commonly O_2, CO, H_2S and CH_4 are monitored. Confined spaces are small, so portable monitors must be compact and unobtrusive for the user, yet able to withstand the wet and dirty environments in which they must perform. Clear and prompt indication of any increase in gas monitored (or any

decrease for oxygen) is of paramount importance – loud and bright alarms are effective in raising the alarm to the user.

Process Area	Hazards	Measurement type
Collection	LEL, H_2S, O_2	Personal detector for confined space
Screening	LEL, H_2S, O_2	Personal detector for confined space
Coagulation/ Flocculation	LEL, H_2S, O_2	Personal detector for confined space
Sedimentation	LEL, H_2S, O_2	Personal detector for confined space
Filtration	LEL, H_2S, O_2	Ambient monitoring, personal detector
Final Treatment - Testing laboratories	CL_2, O_3, NH_3, HF	Ambient monitoring, personal detector

3. Sewage treatment

Typical processes and associated gas detection issues



Pumping station

The preliminary treatment process removes debris. Pumping stations and lift stations are usually unmanned and designed to handle raw sewage that is fed from underground gravity distribution pipelines.

The waste is fed into and stored in an underground pit, commonly known as a wet well. Traditional sewage pumping stations incorporate a wet and a dry well, separated by an internal divide. Pumps are installed below ground level on the base of the dry well, with inlets below the water level on pump start. When the sewage level rises to a pre-determined point, pumps lift the sewage into a gravity manhole and thus on to the next station.

Gas detection in pumping stations

As many pumping and lift stations do not have permanent personnel, both fixed and portable monitoring methods are commonly employed. Fixed systems with localised control panels offer visible and audible alerts to dangerous gas levels, and have the capability to drive executive actions, such as the activation of ventilation fans. Fixed application-focused solutions can monitor gas levels directly above varying wet well water levels, alerting the workforce to hazards before they enter the lift station.

Dry wells are confined spaces underground and require the use of appropriate multigas monitors that comply with the company's or local region's confined space entry requirements

Screening

After passing through multiple pumping stations, the wastewater enters the treatment plant. At this point, it includes physical items picked up along the way, such as wood, rocks and packaging materials. The initial screening process removes this contamination, preventing objects from causing problems further down the line.

Gas detection in screening

If screening areas become clogged, then cleaning and maintenance activities will be required. Due to the nature of the areas, they should be treated as a confined space, thus multigas monitors are needed to keep workers safe. Commonly monitored gases include O_2, H_2S and CH_4 and, depending on the site, other gases may form part of the overall requirement.

Settling tanks/primary clarifiers

Water flows through, very slowly, across large tanks called primary clarifiers. Solid pollutants suspended in the wastewater settle at the bottom of those tanks.
Lighter materials, such as scum and grease, float to the surface of the tank and are collected and combined with the sludge for further treatment.

Aerobic digestor or surface aerator

The wastewater is mixed with a culture of micro-organisms, known as activated sludge, in an aerated tank.

Air is pumped through the water – as organic matter decays, it uses oxygen, and aeration replenishes the oxygen and keeps the activated sludge in working condition.

By the time the water reaches the end of the aeration tanks, most pollutants have been absorbed by the micro-organisms. The mixture of sludge and the treated water is then channeled into the final clarifiers.

Secondary clarifiers

Here, the sludge settles out of the wastewater and is pumped out of the tanks. The clear supernatant water at the top of the tank is collected and discharged from the tanks as final effluent.
A portion of the sludge is constantly returned into the aeration tanks, to sustain the optimal bio-reaction process.

Secondary treatment

The wastewater then enters a series of long, parallel concrete tanks. Each tank is divided into two sections. The settlement tank allows solid matter to sink, with the top water running over a divider. The water is then shaken up and exposed to air; this causes some of the dissolved gases, such as hydrogen sulphide, to be released from the water.

Air is pumped through the water because, as organic matter decays, it consumes oxygen – aeration replenishes the oxygen, thereby ensuring that dissolved gasses continue to be released. Bubbling oxygen through the water also keeps the organic material suspended while it forces 'grit' to settle out. This grit is pumped out of the tanks and taken to landfill sites.

Gas detection in sedimentation vessels

Sedimentation vessels are usually placed out in the open, which provides natural ventilation. If this is not the case, then fixed and/or portable monitoring for O_2, H_2S and CH_4 as a minimum should contribute to maintenance of a safe working environment. If, during any site-specific risk assessment, other gases are highlighted in this area of the plant, then fixed and/or portable detectors may be required.

Final effluent

Finally, the wastewater flows into a chemical contact tank, where chemicals (e.g. chlorine) are added to kill bacteria that could pose a health risk. The chlorine is mostly eliminated as the bacteria are destroyed, but sometimes it must be neutralised by adding other chemicals. This activity protects fish and other marine organisms as the treated water (called effluent) is then discharged to local rivers or the ocean.

In Singapore, the final effluent is further treated using UF membrane and reverse osmosis technologies to generate high-grade water known as NEWater.

Other forms of disinfectant are also used, including chloramines, chlorine dioxide, sodium hypochlorite (hypo) and ozone.

Gas detection in final effluent

All chemicals have specific storage requirements, which are commonly set out in local or national regulations. Even very small escapes of chlorine, ammonia, sulphur dioxide or ozone can be extremely harmful. Fixed gas detection is needed to effectively monitor storage areas, and these fixed detectors are commonly linked to external alerts (sounders and beacons) to make sure workers are notified of any increase in gas levels.

Such fixed detectors may also have the capability to drive executive actions, such as the activation of ventilation fans. There should be a strong focus on the site-specific risk assessment, including gas behaviours; for example, chlorine is 2.3 times heavier than air and tends to pool, staying close to the ground, and can be absorbed by porous materials. Because of this, portable monitors with the capability to monitor specific gases are needed for storage areas.

Sludge thickening

Raw sludge collected from the primary sedimentation tanks, and excess activated sludge from the secondary treatment process, contain a high percentage of water. The water content of the sludge is reduced by the use of a dissolved air flotation thickener or centrifuge. The thickened sludge is fed into

anaerobic sludge digesters for further treatment. The final effluent can be further treated using advanced membrane and reverse osmosis technologies, to generate high-grade water for use in industrial processes.

Sludge is a consequence of sewage treatment – it comprises the residual organic matter and dead bacteria used in the treatment process or bio-solids removed from the wastewater being treated. Sludge is commonly transferred to anaerobic digesters, where it is heated to encourage bacteria, which in turn create biogas that has many constituent gases.

Gas detection in sludge thickening

While digestion takes place in sealed vessels, the high levels of CH_4 and H_2S mean pellistor methane detectors will be ineffective, should there be an escape. The use of infra-red methane detection is needed in this environment to ensure safety. The use of both fixed and portable monitors in this area of the plant is commonplace.

Sludge digestors

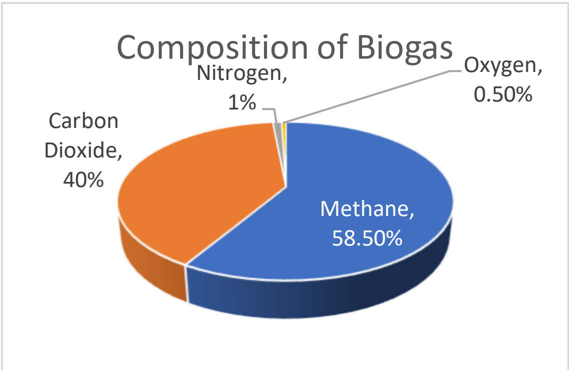
Activated sludge is transferred to anaerobic digesters, where it is mixed with a different culture of micro-organism, which thrives in an oxygen-deficient environment and further breaks down the sludge into biogas. This process takes 20 to 30 days.

Biogas is high in CH_4 (54%) & CO_2 (40%), but it also has over 3000 ppm of H_2S. High levels of H_2S can cause corrosion and mechanical failure in generators, so biogas must be treated before it can be used as a source of energy.

Sludge dewatering

The digested sludge is dried via dewatering centrifuges. The sludge is then incinerated, and the ashes sent to landfill.

Gas detection in biogas



There are many constituent gases in biogas; the more significant ones are:

- **Methane 58.5%**
- **Carbon Dioxide 40%**
- **Nitrogen 1%**
- **Oxygen 0.5%**
- **Hydrogen Sulphide. 3000 ppm**
- **Hydrogen 40 ppm**

Power generation

Water companies have become increasingly involved in the generation of electricity from sewage sludge, as the high level of methane represents a rich source of energy. Some facilities have an on-site power station (combustion engines) and use it to convert the biogas into electricity. The resultant electricity can be used on-site and sold to the national grid. Alternatively, the biogas may be used directly, to provide fuel to heat the digesters. The high level of methane in either form is a valuable energy source.

Gas detection in power generation

The biogas generated through the digestion process must be stored and 'cleaned' before use. This creates a need for fixed and portable detection. Regular 'leak detection' surveys must take place, to ensure the integrity of storage vessels and distribution pipes.

Digester gas monitoring

Water companies have become increasingly involved in revenue-generating activities outside their core business. An example of this is the generation of electricity from sewage sludge, with the electricity thus produced being used both on site and for sale to the national grid. Combustion engines are used to generate the electricity, using a gas the national grid. Combustion engines are used to generate the electricity, using a gas fuel called biogas that is generated from sewage sludge in an oxygen-free tank or digester. Because the process is oxygen-free, it is said to be anaerobic.

The high level of methane present represents a rich source of energy; however, the high level of hydrogen sulphide – which at 3000 ppm will readily cause corrosion and mechanical failure of the generating engine – is problematic.

One technique employed to combat the high concentrations of hydrogen sulphide is the use of a scrubber, which chemically absorbs the hydrogen sulphide and is situated between the digester and the engine. Obviously, there is a need to measure the levels of hydrogen sulphide before and after the scrubber to monitor its efficiency, shutting the engine off or switching to an alternative fuel supply if the level rises too much or if the methane concentration drops below pre-set limits.

Crowcon supplies gas sampling systems for this application. It is necessary to condition the gas before presenting it to the measuring detectors, and water is removed by hydrophobic water barriers. Flow fail monitoring is provided by a pressure transducer. Alarm levels can be set that correspond to both blocked gas paths and leaking components within the system. The biogas is usually at atmospheric pressure, so a pump is needed to retrieve the sample from the digester.

Two different types of gas sensor are used to monitor the biogas – infrared for methane and electrochemical for hydrogen sulphide. The methane measurement is in the range 0-100% by volume and is continuous.

The hydrogen sulphide concentrations are too high for the normal use of electrochemical sensors, so a sample/purge arrangement using two detecting heads must be employed to maximise sensor performance. The fresh air purge allows the electrochemical sensor to recover from its exposure to the gas. If required, two H2S detectors can be used sequentially to prolong sensor life.

If you have requirements of this type, please talk to a Crowcon representative to find out how you can offer sampling solutions to your customers.

4. Summary

Crowcon has over 50 years of experience in supplying gas detection equipment to water and wastewater facilities around the world, including China, Hong Kong, Kuwait, Singapore and the UK. A reference list is available upon request.

For more information visit our website www.crowcon.com

5. Summary of Crowcon detectors suitable for use in water, wastewater and associated application

			Crowcon Products									
Gas	**Overview**	**Areas**	**Clip SGD**	**Gasman**	**T3**	**Gas-Pro**	**T4**	**Xgard**	**Xgard IR**	**Xgard Bright**	**IRmax**	**ESU**
Hydrogen sulphide	Caused by the breakdown of organic matter	All	✓	✓	✓	✓	✓	✓		✓		✓
	Intensified during sludge digestion	Digester										
Methane	Result of anaerobic decay of organic matter	All		✓	✓	✓	✓	✓	✓	✓	✓	✓
	Intensified during sludge digestion	Digester										
	Used to heat the digesters and stored for use	Storage and pipework										
Oxygen	Used during the aeration cycle	Storage and pipework	✓	✓	✓	✓	✓	✓		✓		✓
	Displacement by carbon dioxide and/or methane	Confined spaces										
Chlorine	Used during water disinfection	Storage and dosing		✓		✓		✓		✓		✓
Sulphur dioxide	Used to treat chlorinated water prior to release	Storage and dosing		✓	✓	✓		✓		✓		✓
Flammable vapours	Flammable liquids washed in with rain/ wastewater	Inlet, wet wells and screening		✓	✓	✓	✓	✓	✓	✓	✓	✓
Carbon monoxide	Engine and heater by-product	Wet and dry wells, confined spaces	✓	✓	✓	✓	✓	✓		✓		✓
Carbon dioxide	Oxygen displacement	Confined spaces, digester		s	s	✓		✓	✓	✓		✓
Ozone	Used during filtration and disinfection	Storage, filtering and dosing		✓	✓	✓		✓		✓		✓
Ammonia	Used during water disinfection	Storage and dosing		✓	✓	✓		✓		✓		✓
Chlorine dioxide	Used during water disinfection	Storage and dosing		✓		✓		✓		✓		✓

CROWCON
Detecting Gas Saving Lives

ABOUT CROWCON

For over 50 years, Crowcon has been developing and manufacturing high-quality gas detection products, securing a reputation for reliability and technical innovation that continuously improves efficiency and safety. Globally respected, and part of FTSE 100 Halma, today, over 500,000 Crowcon devices are in use around the world.

Our vision is to grow a safer, cleaner, healthier future for everyone, every day, by providing best in class gas sensing solutions. The Crowcon range offers both fixed and portable gas detection equipment enhanced with Crowcon Connect, our digital solution, which protects people and places in industries including petrochemical, oil and gas, water, industrial manufacturing and food production. In every case, we combine our expertise with emerging technologies to develop process insights and protection for our customers, improving their operational efficiency and creating safer, cleaner and healthier workplaces.

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