HYDROGEN SULPHIDE GAS IN SEWERS –
THE CHALLENGES OF ODOUR AND CORROSION

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39th Annual WIOA
Queensland Water Industry Operations Conference and Exhibition
Logan Metro Indoor Sports Centre, Logan
3 to 5 June, 2014

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ABSTRACT

The presence of Hydrogen Sulphide gas (H_2S) in sewers can result in hazardous work environments, odour complaints and accelerated corrosion of assets. In the water industry, we are all familiar with the impacts of H_2S gas in sewers, pump station wells, discharge manholes and treatment plants.

H_2S gas problems generally occur after the infrastructure has been built. Therefore, operators are typically the front line when odour complaints are received or H_2S gas is detected.

This paper discusses the challenges operators face due to H_2S gas, how it is generated, how H_2S gas corrodes our assets, odour and corrosion examples, accepted removal/treatment technologies, what can be done to reduce H_2S gas generation and typical repair techniques.

Controlling H_2S gas and repairing corroded infrastructure is achieved by the combined efforts of operators and engineers. Treatment and reduction options can be developed by knowing how much and how often the H_2S gas occurs. Examples of H_2S gas management are presented. Practical, low cost strategies in reducing H_2S gas are also discussed.

1.0 INTRODUCTION

Once released from the sewage (i.e. the liquid phase), H_2S gas can be toxic to sewer workers, even at low concentrations, and cause nuisance odours. Under certain conditions H_2S gas can be converted to sulphuric acid which can corrode the internal walls of sewers, manholes, pump stations and other concrete and steel structures.

H_2S gas impacts include:

- Release from the sewage at manholes, vents, pump stations and channels into the atmosphere, resulting in odour problems
- H_2S gas is denser than air so it may sit at the bottom of maintenance structures such as tanks, wells, enclosures, pits, buildings, storage areas etc.
- H_2S gas can be oxidised within the sewer headspace on the sewer pipe wall resulting in the generation of sulphuric acid, which is corrosive, especially to concrete or concrete lined pipe.

Practice has shown that very low concentrations of H_2S gas in solution, for example 1mg/L, can produce a concentration of hundreds of ppm by volume in air. This has been observed in sewer 'headspaces' and wet wells.

The whole of life cost of corroded sewer assets has been estimated at many thousands of dollars per km resulting from H_2S gas. Cesca et al. state that "*The cost associated with premature deterioration of sewer assets has been estimated at over $12,000 per km for a hydrogen sulphide concentration of 100 ppm in a 300 mm diameter sewer*".

2.0 DISCUSSION

2.1 How is H_2S Gas Generated

The following describes the H_2S gas generation process:

"Hydrogen sulphide is formed under anaerobic conditions at low flow velocities and warm temperatures. The rate of release is increased at points of high turbulence and at the outlets of inverted syphons and pressure mains."(H_2S *Control Manual*, Water Services Association of Australia)

Inputs to H_2S gas generation include available oxygen, suphates, organic matter, inadequate slime stripping velocities, detention time, temperature (e.g. tradewastes versus domestic sewage) and insufficient planning (e.g. catchment growth outstripping hydraulic capacity)

Mechanisms for the creation and release of H_2S gas occur when sulphate or oxygen is used/depleted to produce sulphide. The resulting hydrogen sulphide gas can remain in solution or under certain conditions can be released to the atmosphere.

2.2 How is H_2S Gas Measured

H_2S gas can be measured using the following methods:

- OU's – Odour Units (i.e. refer AS/NZS 4623) – odour sample needs to be captured and scientifically tested. Reported as OU/m^3
- ppmV – the volume of H_2S gas in proportion to the total air volume in parts per million. H_2S gas loggers and proprietry software are available for logging and analysing data
- Sulphide concentration modelling (i.e. predictive only):

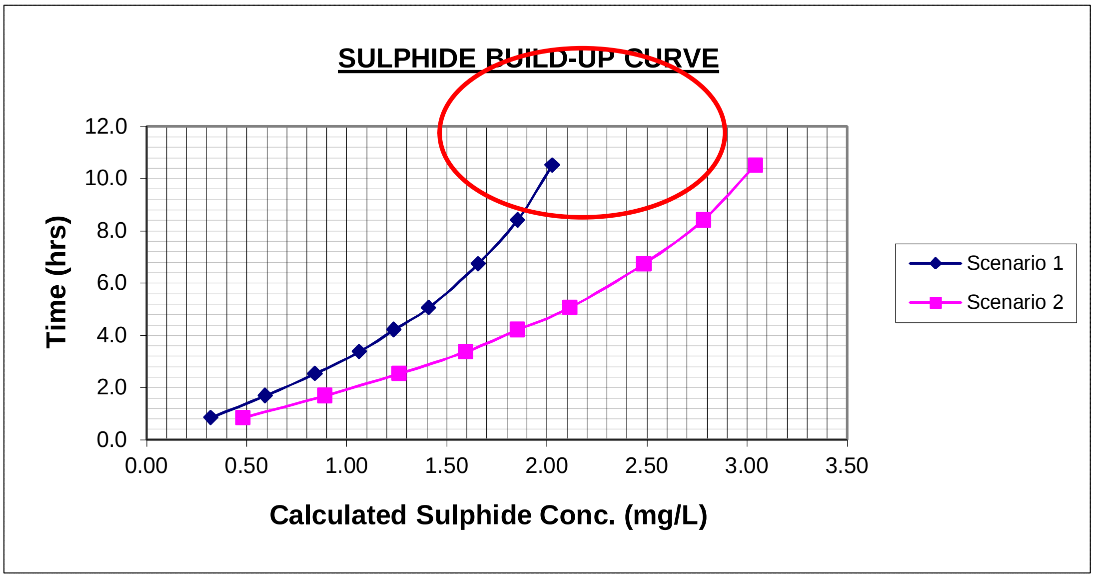

Figure 1: ***Predicting sulphide concentration in a sewer***

- H_2S gas dispersion modelling (i.e. predictive only) – assumed or measured concentrations are predicted from environmental inputs using proprietry software.

2.3 Health Effects of H_2S Gas

Tables 1 & 2 show the health effects and recommended limits for H_2S gas exposure

Table 1: ***H_2S gas levels and impacts***

Level in air (ppm)	Impacts & Health Effects
0.008	Odour threshold (with some individual variability)
>0.008	Increasing possibility of annoyance and headache, nausea, fatigue
2	Bronchial restriction in some asthmatics
4	Increased eye complaints
5-10	Minor metabolic effects
20	Neurological effects including memory loss and dizziness

Table 2: ***Exposure limits***

Limit (ppm)	Exposure Time
2	30 minutes
0.1	24 hours
0.014	90 days

(*Hydrogen Sulpide and Public Health*, Department of Health, WA Government, 2009)

Concentrations of H_2S gas greater than 150 ppm become undetectable to the olfactory system. Concentrations greater than 300 ppm can cause loss of consciousness and death. Very high concentrations greater than 1000 ppm can result in immediate collapse after a single breath (Wikipedia, search: sewer gas, March 2014, http://en.wikipedia.org/wiki/Sewer_gas).

2.4 Removal of H_2S Gas

H_2S gas reduction or removal usually depends on where in the sewerage system the appropriate method can be applied. The H_2S gas problem can be attacked in the dissolved or undissolved form:

Liquid phase:

- Dosing to precipitate out the sulphur containing compounds. For example, dosing ferric chloride, where H_2S gas will react with metal ions in the liquid to produce metal sulfides that are not water soluble
- Dosing for biological and/or chemical conversion/capture, for example, the addition of microbes that consume enzymes, oxygen injection, pH adjustment (e.g. magnesium hydroxide)
- Masking agents/deodorising

Gas phase:

- Sealing the system – usually silicon based products such as Sikaflex™
- Ventilation – induct/educt of air (i.e. dilution over time)
- Extraction - wind assisted or fan extracted
- Adsorption – activated carbon (usually impregnated for H2S gas removal), other media types include plastics, coconut husks, timber mulch
- Biological and/or chemical conversion/capture
- Burning off.

In more recent times, the following reduction methods have been found to be the most effective, based on longevity and not necessarily cost.

Table 3: ***Accepted H_2S gas reduction methods***

Prevention	Containment	Treatment
Calcium nitrate	Magnesium hydroxide	Carbon filters
Ferric nitrate	Sodium hydroxide	Bio-filters
Oxygen injection	Ferric chloride	Chemical scrubbers

2.5 Reducing H_2S Gas Generation

Some practical H_2S gas reduction methods include:

- Reduce turbulence in MH's and inlet structures
- Venting – designed induct and educt ideally
- Increase pumping frequency and/or flow
- Improve slime stripping velocities
- Submerge inlets where possible – discharge MH's and wet well inlets
- Vent outlets at high points
- Flush mains with long detention times or low velocities
- Reduce fats, oils and greases in wet wells
- Choose materials to suit the amount of potential H_2S gas e.g. high CAC cement lining, HDPE pipe and liners, epoxy liners
- Saw tooth rising mains:
    - Automatic air release valves on high points
    - Monitor long 'falling main' sections
    - Condition inspection – wall thickness, non-destruction or coupon/cut-out sampling and testing to track deterioration (N.B. testing can be expensive); hardness testing; cover tests; chemical or physical analysis
    - Where possible, don't build them
- Improve quality by reducing H_2S gas producing tradewastes – high BOD, high temperature, high sulphur containing wastes e.g. food manufacturers
- Monitor and track H_2S gas concentrations at critical points e.g. pump stations, discharge MH's, inlet structures, pressure mains
- Map odour complaints versus seasonal changes.

In practice even retic gravity sewers or small diameter rising mains have the potential to generate high H_2S gas concentrations, usually due to long detention times. But how can we vent sewers near houses and businesses without adversely affecting customers? Some form of treatment combined with dispersion is usually required. Figures 2 and 3 show some relatively low cost treatment and dispersion options.

Figure 2: ***Typical AC filter & vent***

Figure 3: ***Biotrickling filter***

Figure 4: ***Chemical scrubber***

2.6 Corrosion, Prevention and Repair

When H_2S gas is converted by microbes to sulphuric acid (e.g. on the pipe wall), its corrosive effects can cause long term loss of wall thickness or even complete failure/collapse.

The extent of corrosion depends on the asset type, materials, system design and operational decisions. Examples of H_2S gas corrosion include:

- Concrete – microbial induced corrosion via acid attack (refer figure 5)
- Asbestos cement pipe – lime leaching making pipe susceptable to cyclic failure (refer Figure 6)
- Ferrous – found in older pipes and fittings, knifegate valves, penstocks, inlets etc.
- Plastic – not likely but some evidence of pock-marks in HDPE pipe

<u>Figure 5:</u> ***Corroded concrete pipe***

<u>Figure 6:</u> ***AC Sewer rising main-internal leaching due to H_2S gas***

2.6.1 H_2S gas Corrosion Protection

Protective coatings are the most common H_2S gas prevention technique. Some typical coatings used in the water industry include:

- Cement mortar – trowelable or spray-on
- Epoxy spray-on
- HDPE liner
- Cement-based spray-on liner e.g. gunite

It should be noted that the success of protective coatings is dependent on the material type, surface integrity and preparation.

2.6.2 Repair Techniques

Some proven H_2S gas corrosion repair techniques include:

- Pipe relining – CIP liners, spiral liners, structural liners
- Patching/clamping (small dia.) – internal or external (e.g. pressure main repair bands)
- Patching (large dia.) – reline shorts for large pipe
- Repair wraps e.g. resin-soaked fibreglass bandage
- Sand blasting, priming and re-coating

Renewal or complete replacement as a result of H_2S gas corrosion are generally an expensive exercise that may have been avoided if monitoring and adequate repairs were in place. At the very least, a successful repair will afford time to determine the most cost effect renewal as well as time to procure the specialist contractors that are usually required.

3.0 CONCLUSION

The role of the operator in managing the challenges of H_2S gas includes:

- Ensuring that operating and maintenance work is conducted safely when H_2S gas has the potential to exist
- Note any conditions or changes that may increase the likelihood of H_2S gas generation
- Identify and report H_2S gas and corroded assets
- Implement a repair solution that will maintain service until rehab/renewal is done.

Key messages for the operator to consider:

- How is H_2S gas generated
- What are the conditions that may increase H_2S gas
- How is H_2S gas concentration measured and what units are used
- What are the exposure levels and relative health impacts
- What are some proven treatment and removal techniques
- What actions can be taken to reduce the likelihood of H_2S gas generation
- What are the typical forms of corrosion
- What are some typical repair techniques

4.0 ACKNOWLEDGEMENTS

I wish to acknowledge the assistance of David Jobberns and Noel Southern from McBerns for their valuable input.

5.0 REFERENCES

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