Hybrid Media Selection for Odour Control

A breakthrough-led framework for wastewater odour control units

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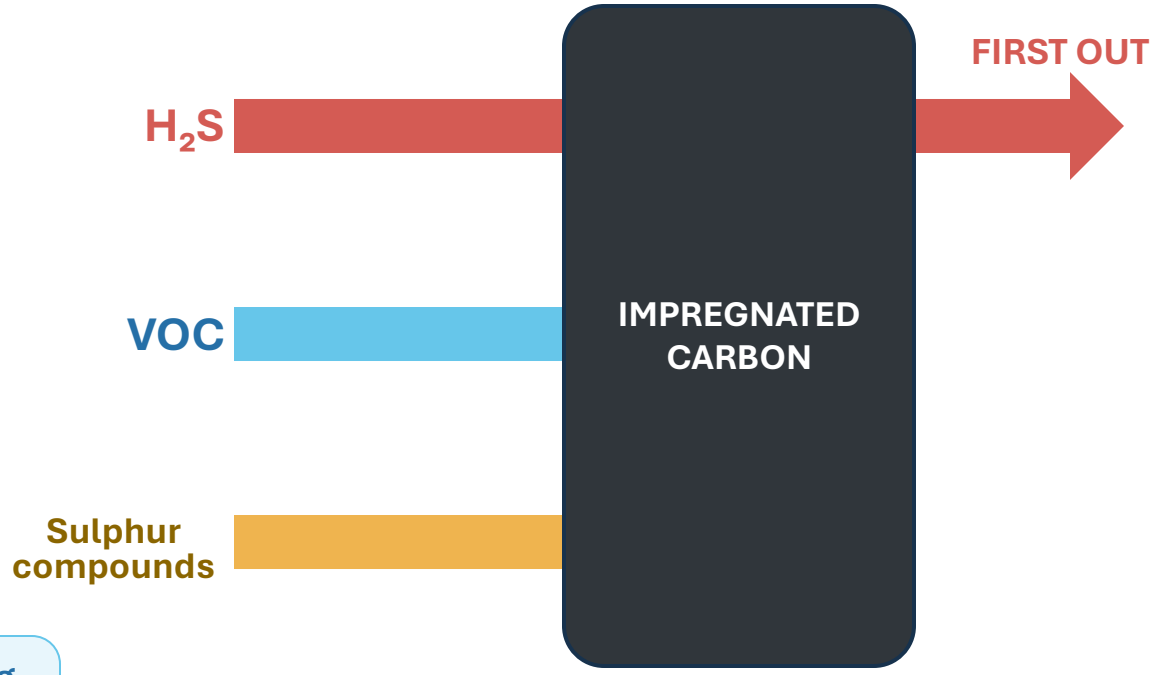
Bed life is set by the first breakthrough

One contaminant can end the useful cycle while capacity remains elsewhere in the bed.

That turns the unused capacity in the other media into stranded value - and drives another change-out.

The right question is: which contaminant is limiting this bed?



Impregnated carbon remains the safe default

Default media is a risk-control decision, not a claim that one material is optimal for every contaminant.

IMPREGNATED CARBON

- Broad-spectrum treatment envelope
- Familiar to utilities and operators
- Protects against mixed or uncertain odour profiles

TARGETED MEDIA

- Solves a repeated failure mode
- Protects higher-value polishing capacity
- Requires monitoring and periodic validation

Start broad-spectrum. Earn the right to specialise with data or experience.

Specialise only when the failure mode repeats or the risk is known

1 MEASURE

Inlet and outlet H_2S
VOCs and other
sulphur compounds

2 IDENTIFY

Which species
dominates
the outlet profile at
end of media life?

3 ADJUST

-Media type
-Layer order and
depth
-Monitoring plan

Repeat at the next change-out: every media cycle should improve the next design decision.

Breakthrough determines the media stack

Observed site condition	Recommended media strategy
Mixed or uncertain odour profile	Impregnated activated carbon as the base design
H_2S breaks through first	Iron hydroxide → impregnated activated carbon
VOCs break through first	Impregnated carbon + VOC-optimised virgin activated carbon
Only H_2S and VOCs confirmed; broader sulphur not material	Iron hydroxide → VOC-optimised virgin activated carbon
Poor humidity control; operation near 100% RH	Consider iron hydroxide for primary H_2S duty → impregnated carbon

Layer order for VOC-limited sites remains site-specific because VOCs may interact differently with the impregnated layer.

The media are complementary, not interchangeable

IRON HYDROXIDE

Selective bulk H_2S removal

$$2Fe(OH)_3 + 3H_2S \rightarrow Fe_2S_3 + 6H_2O$$

$$Fe_2S_3 + 1.5O_2 + 3H_2O \rightarrow 2Fe(OH)_3 + 3S$$

- Highly selective for H_2S
- Effective at saturated humidity
- Not a VOC or broad sulphur solution

IMPREGNATED CARBON

Broad-spectrum polishing and insurance

Caustic neutralisation
Catalytic oxidation
Physical adsorption

- H_2S and other odorous sulphur species
- VOC adsorption capacity
- Controls variable and uncertain profiles

Controlled tests isolate the H_2S duty

Laboratory rig courtesy of HeGo Biotec International GmbH

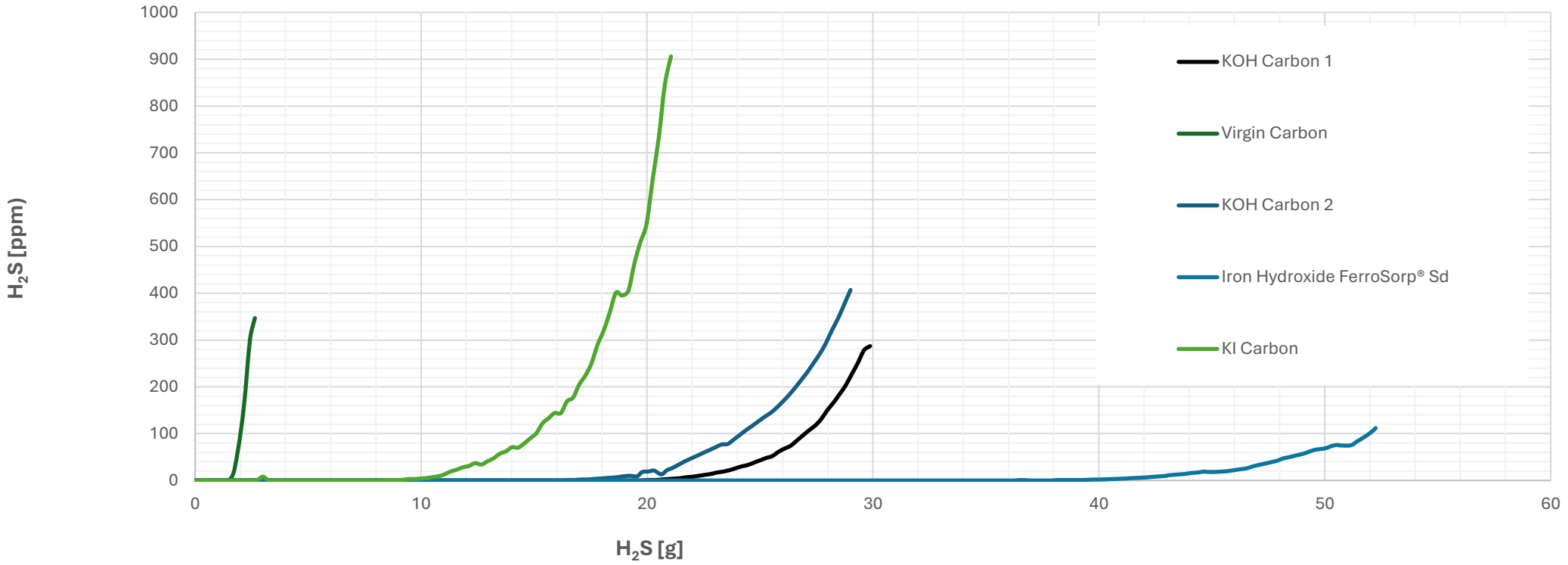
CONTROLLED VARIABLES

- Gas: defined H_2S and oxygen
- Moisture: controlled relative humidity
- Hydraulics: fixed contact time
- Comparison: parallel reactors
- Endpoint: defined breakthrough threshold

Comparative test ≠ field-life guarantee

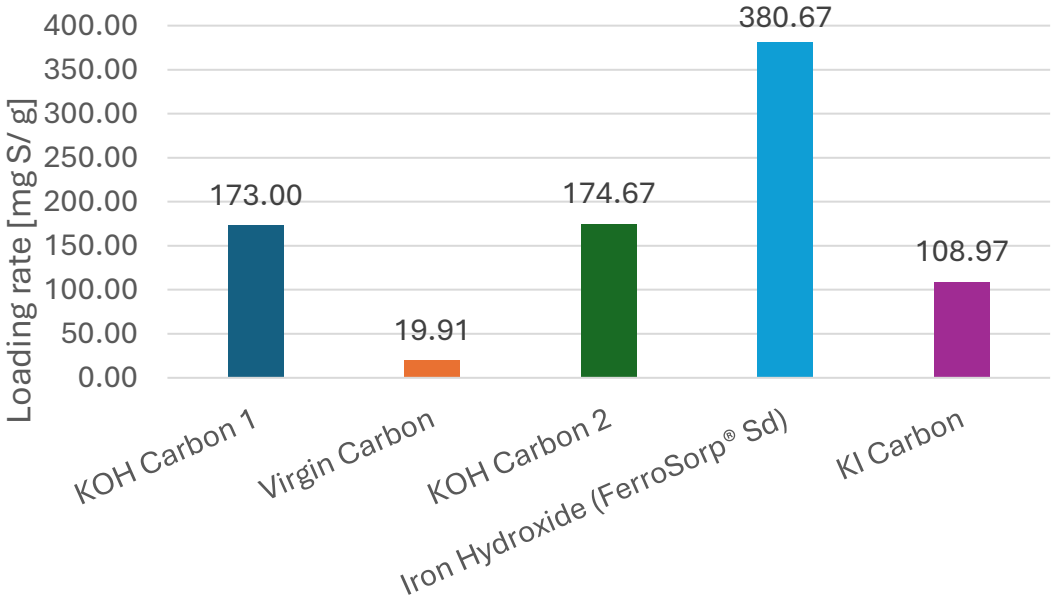
Field performance still depends on inlet variability, bed depth, humidity, pressure drop and maintenance.

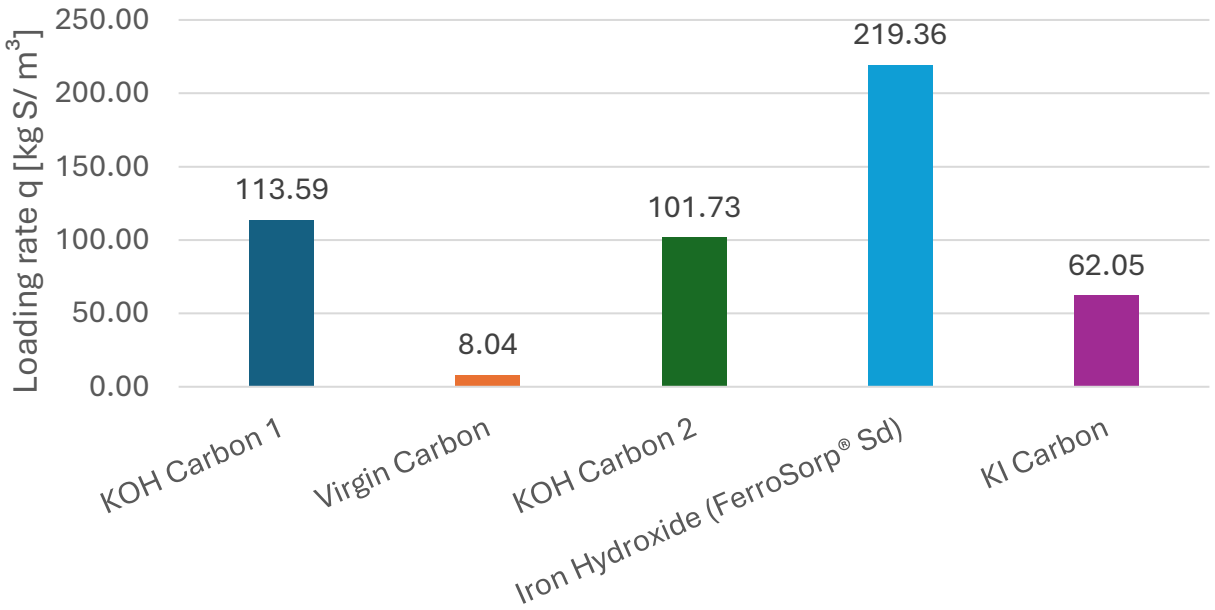
Breakthrough curve from tests – biogas focused testing



Test condition comparison to ASTM D6646-03, 2022.		Test Conditions	ASTM D6646-03, 2022
Relative humidity	%	50	80
H_2S-concentration	ppm	4,512	10,000
Threshold for removal rate	%	98	99.5
O_2-concentration	ppm	19,000	163,000
Contact time	s	4.75	4.8

Loading rates - biogas focused testing

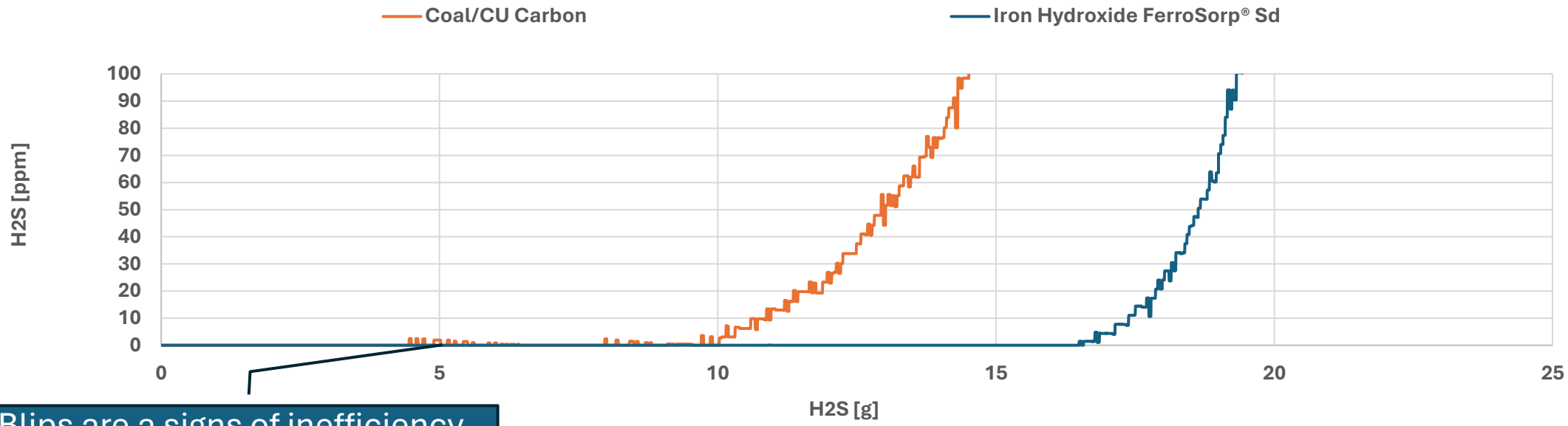




Product	Inverse Mass Loading Ratio	Inverse Volume Loading Ratio
Activated carbon KOH (1)	2.20	1.93
Virgin activated carbon	19.12	27.29
Activated carbon KOH impregnated (2)	2.18	2.16
FerroSorp® Sd	1.0	1.0
Activated carbon KI-impregnated	3.49	3.53

- Iron hydroxide is similar or cheaper than KoH/KI
- Higher massed based loading, means lower media spend per annum
- Higher volume loading translates to longer bed life

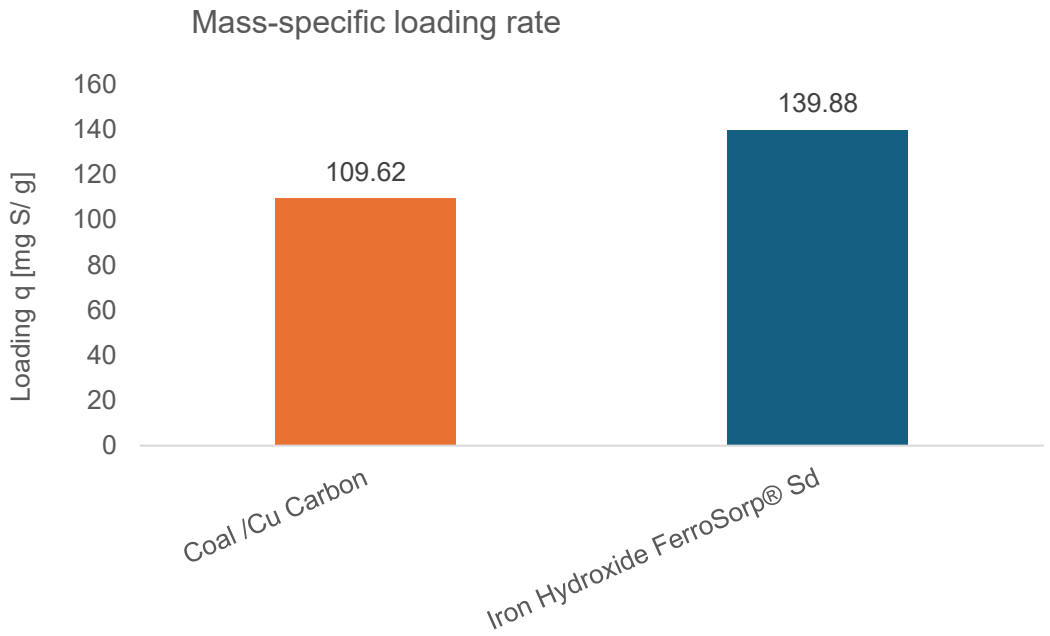
Breakthrough curve from tests – ASTM D6646-03, 2022 testing

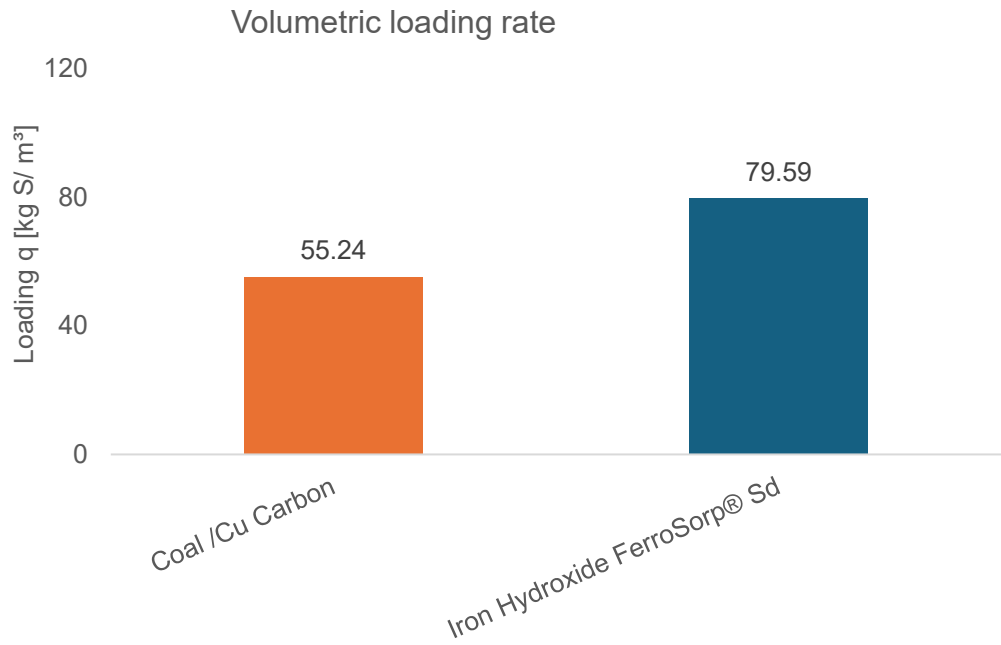


Blips are a signs of inefficiency

Test condition comparison to ASTM D6646-03, 2022.		Test Conditions	ASTM D6646-03, 2022
Relative humidity	%	72	80
H_2S-concentration	ppm	10,000	10,000
Threshold for removal rate	%	99.5	99.5
O_2-concentration	ppm	163,000	163,000
Contact time	s	4.68	4.8

Loading rates - ASTM D6646-03, 2022 testing





Product	Inverse Mass Loading Ratio	Inverse Volume Loading Ratio
FerroSorp® Sd	1	1
Activated carbon Cu Impregnated	1.28	1.44

- Iron hydroxide is cheaper than the Cu Impregnated
- Higher massed based loading, means lower media spend per annum
- Higher volume loading translates to longer bed life

In September, we will be testing two different KoH carbons and a different Cu carbon, these samples sourced in Australia which are commonly utilised here

Lower price and higher loading compound the saving

~50%

higher retail price for coal/Cu carbon

+28%

higher mass loading for iron hydroxide

48%

lower media expenditure

Copper impregnated coal-based carbon commonly available in the Australian market retails at around 50% more than iron hydroxide media. The mass-based loading for the iron hydroxide media was 28% higher, when combining these two factors, using iron hydroxide media would reduce the expenditure on media by 48% based on the lab test results.

Illustrative result using the typical retail-price relationship and laboratory loadings stated in the paper. Site lifecycle cost must include disposal, labour, access and downtime.

Media change out frequency

+44%

longer volumetric bed life

~30%

fewer change-outs over the same operating period

There is a significant cost associated with the change out of media, based on the volume based loading, the bed life would be 44% longer.

This would mean that for a given bed size, the media change out events over the life of the bed would reduce by 30%.

The reduced bed change out events has a several benefit:

1. A reduction in the operational costs associated with the change out:
2. Reduced workload on maintenance team per annum; and
3. Since odour complaints are most common close to time when the media is changed, a potential for a 30% reduction in odour complaints.

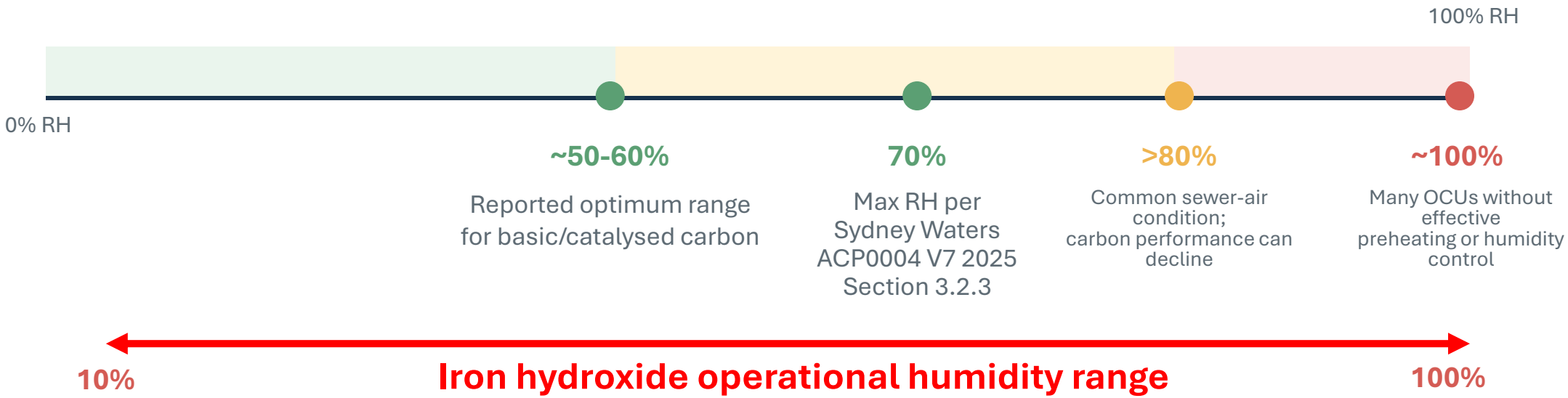
Humidity can overturn a sound media choice

Activated carbon

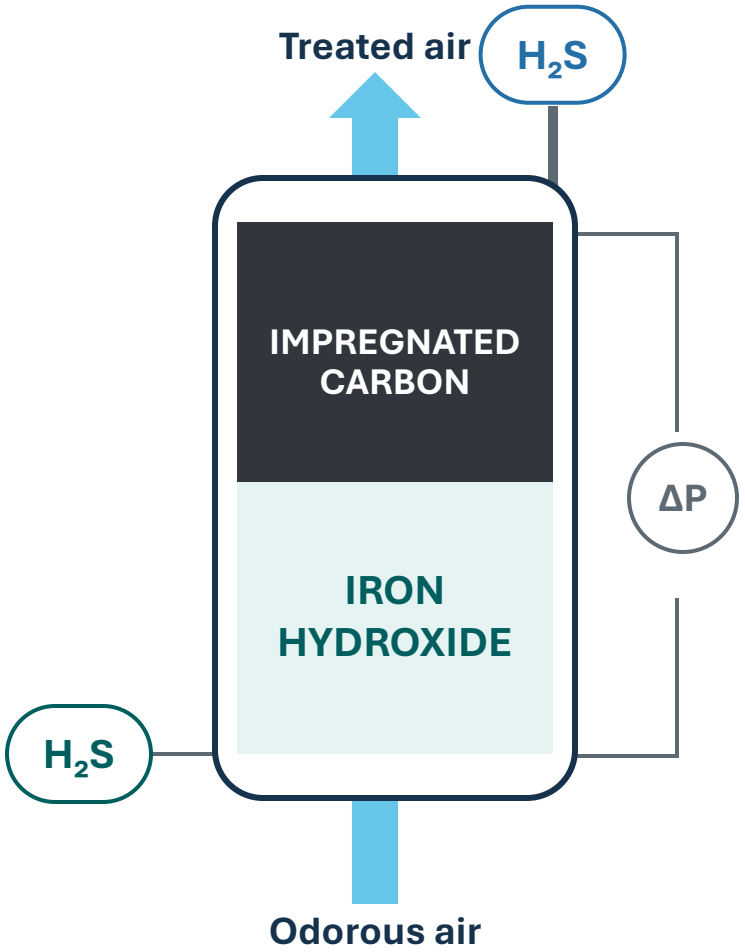
Moisture supports H_2S chemistry - but excess water blocks pores and impacts the impregnates.

Iron hydroxide

Effective for H_2S at saturated conditions; a useful primary layer where preheating is absent or unreliable.



Let each media layer do its best work



H_2S-limited site

1. Bulk duty: iron hydroxide removes the dominant H_2S load
2. Polishing: impregnated carbon controls residual H_2S and broader odours
3. Validation: inlet/outlet H_2S, and periodic VOC/sulphur sampling

Protect the broad-spectrum layer from being consumed as a bulk H_2S reagent.

The hybrid concept is operating in practice

IRON HYDROXIDE → ACTIVATED CARBON

370

m^3/h gas flow

350

ppm inlet H_2S

90-100%

relative humidity

Passive OCU in Germany

Spent-media data show a simpler contaminant profile

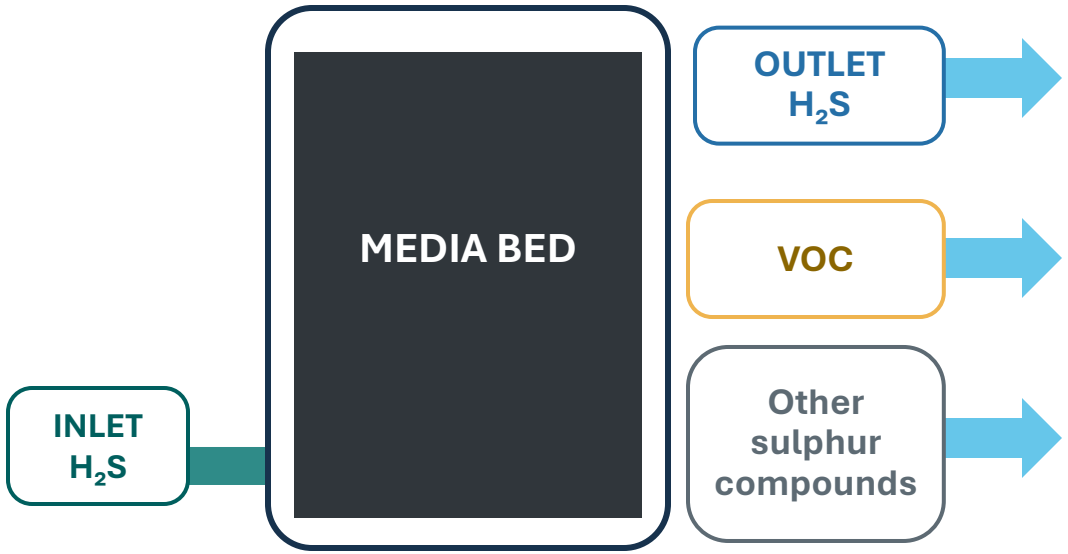
Analyte	Iron hydroxide	Downstream carbon filters
Total VOC loading	16.24 mg/kg	16,045.52 / 5,143.65 mg/kg
D4 siloxane loading	0.16 mg/kg	950 / 600 mg/kg

Hundreds to thousands of times lower non-target loading on iron hydroxide in this installation

- Potentially simpler waste classification and landfill handling
- Beneficial reuse may be possible where regulation and testing permit

Single wastewater installation; the analysis describes contaminant loading and disposal implications, not comparative odour-removal performance.

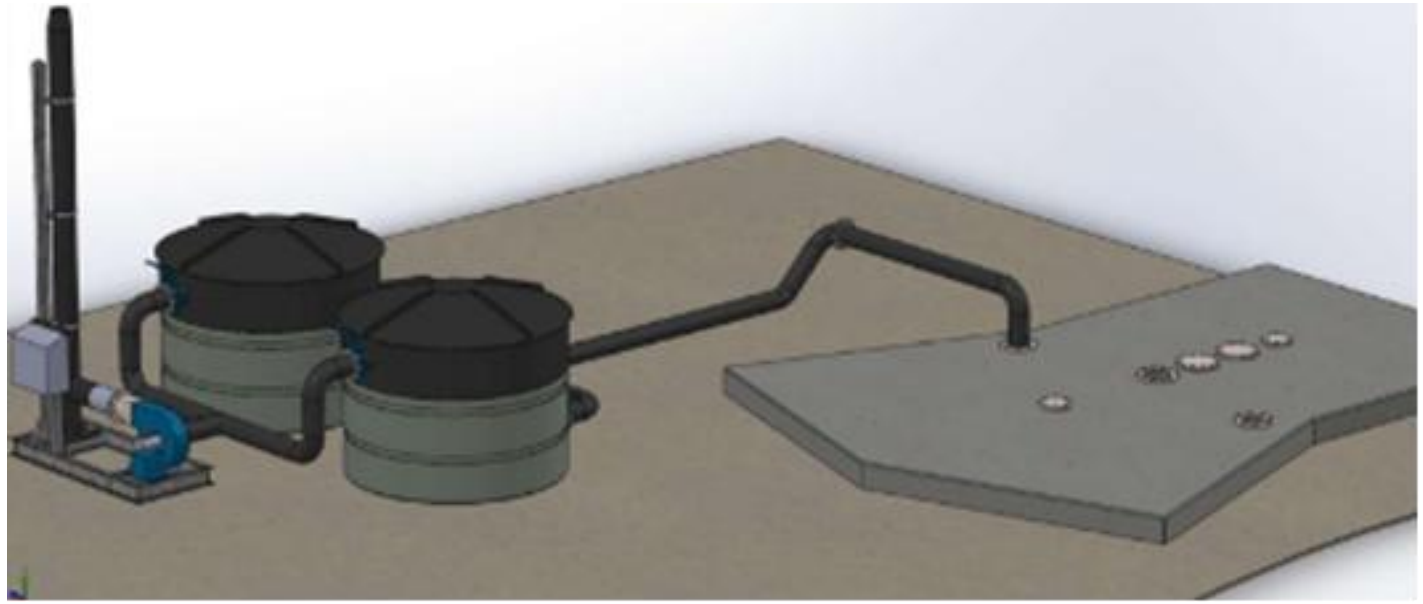
Each change-out should improve the next design



1. **Observe**
   Track breakthrough, bed life and pressure drop
2. **Validate**
   Sample VOCs and non-H_2S sulphur before change-out
3. **Diagnose**
   Identify the species driving the outlet odour profile
4. **Refine**
   Adjust media, layer depth and monitoring for the next cycle

NEXT MEDIA CYCLE

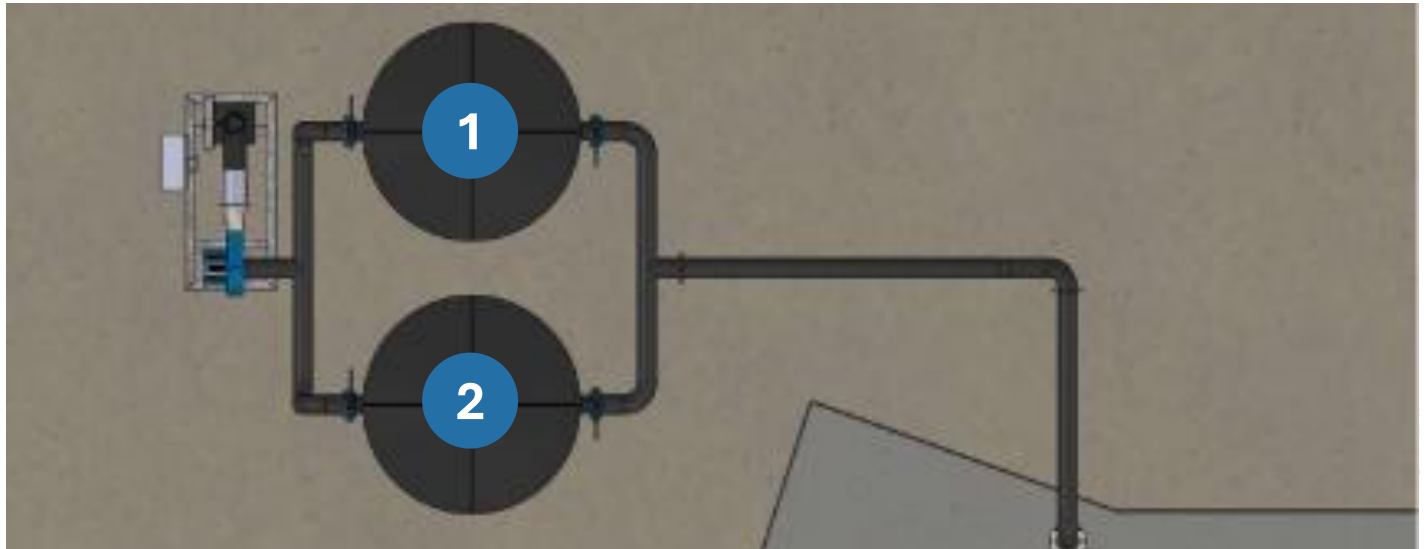
Planned Trial at an Australian Water Utility



1. **Impregnated Activated Carbon**
2. **FerroSorp® Sd Iron Hydroxide**

Trial Plan

Alternate between the online and offline vessel over a period of six months to ensure both types of media have equal conditions



Future investigations

The approach presented is very conservative for non H_2S sulphur species, but operational data from sites is showing interesting results

	Sample point	FerroSorp Inlet		FerroSorp Oultet		Virgin AC + UV outlet	
	Test A / B	A	B	A	B	A	B
H_2S	mg/m3	92	123	< 1	< 1	< 1	< 1
Methylmercaptan	mg/m3	188	222	17.7	17.3	2.8	1.6
DMDS (Dimethyl disulphide)	mg/m3	13.7	16.9	64.9	54.1	7.4	1.5
DMTS (Dimethyltrisulphide)	mg/m3	2	2.4	7.8	9.8	2.1	0

1. FerroSorp® significantly reduced the H_2S
2. FerroSorp® significantly reduced the Methylmercaptan
3. FerroSorp® increased the DMDS and DMTS

Methyl Mercaptan conversion to dimethyl disulfide and dimethyl trisulfide

Methyl Mercaptan
"Based on the results of a differential heat adsorption study, Tandaha and Boki (1978) concluded the adsorption of methyl mercaptan on virgin activated carbon is due to volume filling of micropores and the adsorption of monolayers or multilayers on transition pores. ***Catalytic oxidation of methyl mercaptan adsorbed in the carbon pores also occurs in wet conditions****. According to Bashkova et al. (2002), the removal of methyl mercaptan follows two possible reaction pathways that are dependent on the pH of the system.*

If the pH is less than the pKa of methyl mercaptan (pKa= 10.3), the adsorbed methyl mercaptan is dissolved into the aqueous solution or oxidised into dimethyl disulfide which is then strongly adsorbed in carbon pores. ***Methyl mercaptan is readily oxidised to dimethyl disulfide on the carbon surface, with the almost doubled molecular weight yielding an increased capacity for physical adsorption*** *(Turk et al., 1989)."*

Le-Minh, N., Sivret, E., Shammay, A., Stuetz, R.M., 2018, Factors affecting the adsorption of gaseous environmental odors by activated carbon: A critical review, Critical Reviews in Environmental Science and Technology, 48(4):1-35.

Dimethyl disulfide and dimethyl trisulfide removal with virgin activated carbon

Dimethyl disulfide

“As mentioned previously, dimethyl disulfide, [CH3SSCH3] is formed by the decomposition of methyl mercaptan and its formation is enhanced in the presence of water. **It is believed that dimethyl disulfide is more strongly adsorbed on the surface of activated carbon than water; thus it possibly replaces water from the carbon surface as well as weakly adsorbed compounds** (Bansal and Goyal, 2005).“

Carbon disulfide and dimethyl trisulfide

“Carbon disulfide and dimethyl trisulfide are two other odorous reduced sulfur compounds commonly found in sewer air. **Adsorption with activated carbon is reported to be a superior technique for removal of carbon disulfide since activated carbon has great affinity for carbon disulfide** (Ross and Jeanes, 1974). **The use of granular activated carbon to effectively remove dimethyl trisulfide in water was studied Zhang et al**. (2011). Although there is no study in the surveyed literature specifically investigating the removal mechanisms of carbon disulfide in air by activated carbon, it is expected that sulfuric acids and elemental sulfur would be the
products formed after the binding of reduced sulfur compounds onto activated carbon (Bandosz, 2006). “

Le-Minh, N., Sivret, E., Shammay, A., Stuetz, R.M., 2018, Factors affecting the adsorption of gaseous environmental odors by activated carbon: A critical review, Critical Reviews in Environmental Science and Technology, 48(4):1-35.

Correlation of molecular weight and boiling points

Table 3.2 Activated carbon adsorption capacity for volatile organic compounds
Adapted from (Shepherd, 2001)

Organic Compound	Molecular Weight	Boiling Point (°C)	Carbon Capacity (%)
Nitrobenzene	123	211	51
Tetrachloroethane	166	147	40
Tetrachloroethylene	165	121	35
Styrene	104	145	25
Xylene	106	138	21
Napthalene	128	217	20
Toluene	92	111	20
Benzene	78	80	12
MTBE	88	55	12
Hexane	86	68	7
Ethyl acrilate	100	57	5
Dichloroethane	99	99	7
Methyl ethylketone	72	80	4
Methylene chloride	84	40	2
Acrylonitrile	53	74	2
Acetone	58	56	0.8
Vinyl chloride	62	-14	0.7
Chloroethane	64	12	0.5
Bromotrifluoromethane	149	-58	0.13
Methane	16	-161	0.0003

Compound	Molecular Weight
DMTS	126
DMDS	94
DMS	62
Methyl Mercaptan	48
H_2S	34

Malodorous compounds and the concentrations

Future investigations

Further testing is required to understand the potential for iron hydroxide and virgin carbon to be a complete solution for sulphur and VOC species

FerroSorp®

Virgin Carbon

Virgin Carbon

Virgin Carbon

Conversion/removal on FerroSorp® then Virgin carbon

If present, ammonia and amine targeted carbons

Table 3.1 Typical malodorous compounds and their concentration ranges near the facilities associated with wastewater treatment processes

Compound	Concentration range (mg/m³)	Sampling location	Reference
H_2S	1.57 – 16+ (1)	Main intake	(Patria et al., 2001)
	34.8 – 47.1	Sewage creek	(Muezzinoglu, 2003)
	2.8 – 18.2	Inlet structure	(Al-Shammiri, 2004)
	37.2 – 66.5 (1)	Grit chamber outlet	(Cooper et al., 2001)
	0.04 – 0.76	Pump stations	(Dincer and Muezzinoglu, 2007)
	0.0001 – 0.033 (1)	Primary settling basin	(Jeon et al., 2009)
	0.00004 – 0.038 (1)	Aeration basin	(Jeon et al., 2009)
DMS	0.0007 – 0.0075	Primary treated sewage	(Ras et al., 2008)
	0.0004 – 0.61	Sludge handling facilities	(Ras et al., 2008)
	< 0.0016 (1)	Primary settling basin	(Jeon et al., 2009)
	< 0.01 (1)	Aeration basin	(Jeon et al., 2009)
	0.0034 – 0.037	Nearby WWTPs	(Leach et al., 1999)
DMDS	0.0087 – 0.040	Primary treated sewage	(Ras et al., 2008)
	0.0011 – 0.86	Sludge handling facilities	(Ras et al., 2008)
	0.00007 – 0.29 (1)	Primary settling basin	(Jeon et al., 2009)
	0.0018 – 0.033 (1)	Aeration basin	(Jeon et al., 2009)
	0.002 – 0.039	Nearby WWTPs	(Leach et al., 1999)
CDS	0.0003 – 0.42	Primary treated sewage	(Ras et al., 2008)
	< 0.66	Sludge handling facilities	(Ras et al., 2008)
MM	0.00001 – 0.01 (1)	Primary settling basin	(Jeon et al., 2009)
	< 0.0024 (1)	Aeration basin	(Jeon et al., 2009)
	0.0033 – 0.068	nearby WWTPs	(Leach et al., 1999)
TMA	< 0.004 (1)	Primary settling basin	(Jeon et al., 2009)
	< 0.001 (1)	Aeration basin	(Jeon et al., 2009)
Ammonia	0.48 – 1.47	Primary settling basin	(Jeon et al., 2009)
	0.069 – 0.39	Aeration basin	(Jeon et al., 2009)

(1) Converted from ppm to mg/m³

CDS: carbon disulfide DMDS: dimethyl disulfide DMS: dimethyl sulfide
MM: methyl mercaptan TMA: trimethyl amine

Three rules for a breakthrough-led OCU

1

Keep broad-spectrum carbon as the default

It is the risk-controlled starting point for mixed, variable or uncertain odour profiles.

2

Target the contaminant that repeatedly breaks through

Use iron hydroxide upstream when H_2S is demonstrably consuming the bed life.

3

Optimise lifecycle performance, not media price

Compare cost per kilogram of sulphur removed, change-out frequency, humidity and end-of-life handling.

Measure first. Specialise only when the data repeats.

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Questions?

SCAN ME

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Appendix: references

Key references

- ASTM International (2003), ASTM D6646-03.
- Sydney Water Corporation (2025), Technical Specification - Odour Control Unit, ACP0004, Version 7.
- HeGo Biotec International GmbH (2026), comparative laboratory presentation, unpublished.
- Le-Minh, N. et al. (2018), Critical Reviews in Environmental Science and Technology 48(4):1-35.
- Bharti (n.d.), technical note on VOC and siloxane loading in spent media.
- Iori, G. et al. (2020), Sydney Water's innovations to improve OCU performance, Chemeca 2020.

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Full paper: Hybrid media selection for extending activated carbon bed life in odour control units

Appendix: comparative test conditions

Parameter	Screening test	Closer comparison	ASTM D6646 reference
Relative humidity	50%	72%	80%
H_2S concentration	4,512 ppm	10,000 ppm	10,000 ppm
Removal threshold	98%	99.5%	99.5%
O_2 concentration	19,000 ppm	163,000 ppm	163,000 ppm
Contact time	4.75 s	4.68 s	4.8 s

The closer comparison matched ASTM on H_2S, O_2 and breakthrough threshold; RH and contact time were close but not identical.