



T R I D E N T B U B B L E T E C H N O L O G I E S

In-Line H₂S Remediation Without H₂S Scavenger Chemicals.

It's Time to Rethink Your Sour Water Process.

Nanobubble oxygen injection for continuous H₂S oxidation in produced water and sour water systems.

No chemicals. No spent scavenger disposal. No liquid dosing.

Produced Water | Sour Water | Amine Pre-Treatment

www.tridentbubble.com

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THE OPERATIONAL REALITY OF CHEMICAL H₂S TREATMENT

If you manage sour water, you already know the problem. H₂S in your produced water or process water means chemical scavenger programs — and chemical programs mean ongoing costs and complexity that never stop.

Whether you're running triazine direct injection, contact towers, caustic scrubbing, or solid scavenger beds, the pattern is the same: continuous chemical consumption, spent material handling, and the infrastructure to manage both.

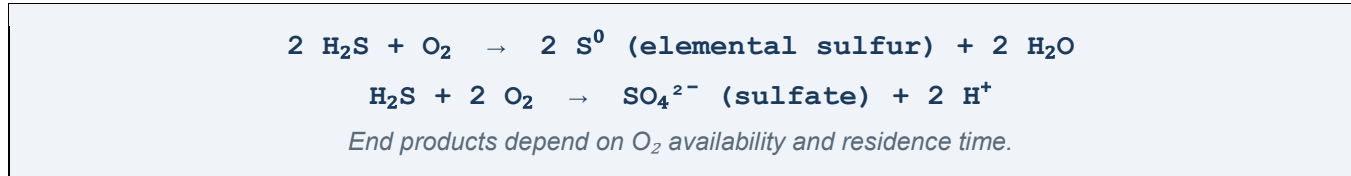
Chemical Consumption	Triazine dosing at 100–300 ppm per ppm H ₂ S scales directly with production volume. At high concentrations or water volumes, scavenger costs can reach \$1M–\$5M annually per facility.
Spent Material Disposal	Spent triazine produces dithiazine — an insoluble precipitate that plugs pipelines, separators, and disposal wells. Hauling spent scavenger costs \$7–\$30 per barrel. Some disposal well operators now refuse it entirely.
Solids & Fouling	Dithiazine precipitation and amorphous sulfur foul contact towers, heat exchangers, and injection equipment. This adds unplanned maintenance, downtime, and chemical overuse.
Supply Chain Risk	MEA triazine supply depends on ethylene oxide and MEA feedstock. The 2023 Louisiana EO plant explosion caused extended shortages and price spikes. Any upstream disruption hits your operation.
HSE Burden	Chemical deliveries, on-site storage, injection system maintenance, and personnel exposure to spent scavenger residue create cumulative HSE load, especially on remote or multi-pad operations.

The question is whether there's a way to eliminate dissolved H₂S without introducing scavenger chemicals into your water in the first place.

HOW NANOBUBBLE H₂S OXIDATION WORKS

Trident’s nanobubble generators dissolve oxygen into your process water as nanobubbles — gas-filled cavities typically 60–200 nm in diameter. At that size, bubbles don’t rise. They remain suspended in solution for days to weeks, creating a persistent oxidizing environment throughout the water.

When dissolved H₂S encounters this dissolved oxygen, the oxidation is direct:



The generator installs directly into your water line. Water flows through at process pressure, oxygen is introduced through Trident’s patented membrane at low pressure, and nanobubbles form in-line. Four generation mechanisms operate simultaneously: porous membrane diffusion, hydrodynamic cavitation, bubble fragmentation, and pressurized decompression.

No scavenger chemical injection point. No scavenger tank. No spent scavenger solution to haul. No dithiazine. The unit has no moving parts and requires no external power for nanobubble generation; it runs on line pressure alone.

WHAT CHANGES IN YOUR OPERATION

What You Stop Doing	What You Start Getting
Ordering and storing scavenger chemicals	A fixed unit with no liquid scavenger chemicals; only O ₂ or compressed air supply
Managing injection rates and metering	Passive in-line treatment that operates continuously with flow
Hauling spent triazine at \$7–\$30/barrel	No spent scavenger solution; oxidation products remain dissolved or may be removed as elemental sulfur, depending on operating conditions
Cleaning dithiazine from equipment	No dithiazine formation. Sulfur handling depends on oxidation conditions. Reduced plugging risk.
Scheduling chemical deliveries to remote pads	A unit that runs unattended with no supply chain dependency
Managing SRB biocide programs separately	Elevated DO from nanobubbles can suppress SRB activity in oxygenated surface-water circuits

HOW IT COMPARES TO WHAT YOU'RE RUNNING TODAY

Every H₂S treatment method has trade-offs. This compares nanobubble O₂ injection against the methods most commonly deployed for dissolved H₂S in produced water and sour water.

Method	Scavenger Chemical Use	Spent Material Disposal	Solids / Fouling Risk	Unattended Operation	OPEX Profile
Triazine Direct Injection	High — continuous	Yes — hauling	High — dithiazine	Low	High recurring
Triazine Contact Tower	High — continuous	Yes — hauling	High — dithiazine + fouling	Moderate	High recurring
Caustic Scrubbing	High — NaOH/KOH	Yes — spent caustic	Moderate — salts	Moderate	High recurring
Iron Sponge / Metal Oxide	Periodic — media	Yes — spent media	Low	High between changes	Moderate lumpy
Liquid Redox (LO-CAT)	Moderate — chelate	Sulfur cake	Moderate — sulfur	Moderate	Moderate recurring
Sour Water Stripper	None	Acid gas to SRU	HC/solids fouling	High	High CAPEX
TNS Nanobubble O₂	None	No spent scavenger	Low to moderate	High	Low

WHERE IT FITS IN YOUR PROCESS

<p>Produced Water</p> <p>Install upstream of disposal wells, tanks, or recycling. Oxidize dissolved H₂S before it causes corrosion or safety hazards. Reduce or eliminate scavenger programs on multi-well pads.</p>	<p>Amine System Feed</p> <p>Reduce dissolved H₂S burden in selected upstream configurations. Any integration ahead of amine systems should be validated case by case for oxygen compatibility, solvent chemistry, and corrosion control.</p>	<p>Sour Water Stripper Feed</p> <p>Pre-oxidation ahead of a stripper may reduce dissolved H₂S load in selected configurations, subject to materials review, corrosion review, and pilot validation.</p>
<p>Tank Batteries & Storage</p> <p>Maintain elevated DO in tank battery circuits. Can suppress anaerobic SRB activity in oxygenated surface-water circuits, subject to site-specific biological and corrosion conditions.</p>	<p>EOR Injection Water</p> <p>Treat H₂S-laden water before reinjection at elevated pressure. The TNS-HPT operates at up to 200 bar, enabling treatment near the point of injection, subject to oxygen-corrosion management and field validation.</p>	<p>Water Recycling & Reuse</p> <p>Treat frac flowback or produced water for recycling. O₂ nanobubbles remove dissolved H₂S and can suppress biological souring, potentially reducing biocide and scavenger needs.</p>

VARIABLE COST PER KILOGRAM OF H₂S REMOVED

The most direct way to compare treatment economics is the recurring variable cost per kilogram of H₂S actually removed from your water. This isolates what you spend every day to treat H₂S — independent of facility size, equipment age, or site layout.

Treatment Method	Variable Cost per kg H ₂ S	What's Included
MEA Triazine — chemical only	\$6.60–\$8.80	Scavenger chemical at \$1.50–\$2.00/kg at field utilization rates
MEA Triazine — total variable cost	\$8.00–\$16.00	Chemical + spent triazine disposal + dithiazine fouling remediation
TNS Nanobubble — O ₂ via PSA	~\$0.25	Electricity to generate O ₂ on-site via industrial PSA concentrator
TNS Nanobubble — compressed air	< \$0.05	Air compression energy only

26–35x lower variable cost per kg H₂S removed
 on chemical cost alone — before disposal and fouling savings

COSTS THAT EXIST ONLY ON THE CHEMICAL SIDE

Spent chemical hauling	\$7–\$30 per barrel. Requires scheduling, water hauler availability, and operator time. Some disposal well operators now refuse spent triazine entirely.
Dithiazine fouling	Unplanned maintenance on contact towers, heat exchangers, separators, and injection wells. Adds downtime and remediation costs that are difficult to predict or budget.
Chemical storage & delivery	On-site tank infrastructure, delivery scheduling to remote locations, injection system calibration, and pump maintenance.
Supply chain exposure	MEA triazine pricing tied to ethylene oxide and MEA feedstock markets. Subject to shortage events, regional disruptions, and seasonal price volatility.

These chemical-specific costs are avoided in the TNS operating model. Recurring operating costs primarily relate to oxygen supply or air compression energy, plus normal monitoring and maintenance. Equipment CAPEX is a one-time investment amortized over the operating life of the unit.

WHY TRIDENT TECHNOLOGY

Most industrial gas injection equipment is built with stainless steel or carbon steel internals. In sour service, that is a liability. H₂S attacks metal surfaces through sulfide stress cracking, pitting corrosion, and hydrogen-induced cracking, leading to premature equipment failure, unplanned shutdowns, and safety risk.

Trident's generators are built differently. **All wetted parts are ceramic composite and PVC** — materials that are inherently resistant to H₂S attack. There is no metal in the fluid path to corrode, crack, or degrade. The ceramic composite membrane at the core of every TNS unit is chemically inert across the full pH and temperature range of sour water service, and the PVC housings and fittings provide the same corrosion immunity. This means the equipment that treats your H₂S is not itself vulnerable to H₂S.

Beyond material compatibility, the TNS platform was designed for environments where simplicity and uptime matter most. The generator has no moving parts, requires no external power for nanobubble generation, operates on line pressure alone, and imposes approximately 0.1 bar of head loss. Trident manufactures its membranes in-house, maintaining full control over quality and supply. Every unit is modular and scalable, from a single 1 m³/h bench unit to multi-unit arrays handling thousands of m³/h.

KEY FEATURES



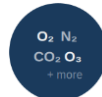
>85%+ Gas Transfer Efficiency
Industry-leading gas dissolution



Zero Moving Parts
No wear, easy to clean



Adjustable Bubble Size
Tunable bubble size for targeted, optimized outcomes.



Multi-Gas Compatible
O₂, ozone, CO₂, N₂, and more



High Zeta Potential
Maximizes distribution of O₂ in water, better oxidation



No Internal Power
No electricity required



Self-Cleaning / Anti-Fouling
Fouling-resistant, no chemical CIP needed



H₂S-Resistant Wetted Parts
Ceramic composite and PVC, no metal corrosion

TNS PLATFORM: TWO PRODUCT LINES

Trident manufactures two product families. Both use our patented nanobubble generator process and generate nanobubbles using four simultaneous mechanisms.

TNS-CORE Series Standard Duty	TNS-HPT Series High Pressure & High Temperature
<p>Temperature: ≤55°C (131°F)</p> <p>Pressure: ≤10 bar (up to 145 psi)</p> <p>pH Range: 2 - 12</p> <p>Variants: CORE-XE for environments with high levels of abrasive solids.(sand, dirt).</p> <p>For ambient and moderate-temperature produced water, surface water, and low-pressure process streams.</p>	<p>Temperature: ≤120°C (248°F)</p> <p>Pressure: ≤200 bar (up to 2,900 psi)</p> <p>pH Range: -1 to 14 (XE variant)</p> <p>Variants: HPT-XE for environments with high levels of abrasive solids.(sand, dirt).</p> <p>For HPHT produced water, sour water strippers, rich amine, EOR injection, geothermal, mineral leaching.</p>

VERIFIED PERFORMANCE

Metric	Value
Gas Transfer Efficiency	Tunable up to 99.9%
Nanobubble Concentration	Up to 40 trillion NB/mL (Nanoscale journal, peer-reviewed)
Bubble Size Range	Down to 60 nm (instrument limit ~10–40 nm)
Zeta Potential	-36.94 mV (Malvern Zetasizer)
Concentration per Pass	Up to hundreds of billions per pass
Mode Size Distribution	60–1000 nm (user defined)
Head Loss	~0.1 bar
Min Operating Pressure	0.25 bar water / 0.3 bar gas (reduced performance)
Recommended Pressure	1 bar both for >80% GTE at advertised gas flow rates
External Power	None for nanobubble generation
Generation Mechanisms	4 simultaneous: membrane diffusion, cavitation, fragmentation, decompression

SOUR WATER VALIDATION PROGRAM

30% discount for all sour water validation & trial systems (up to 2 units).

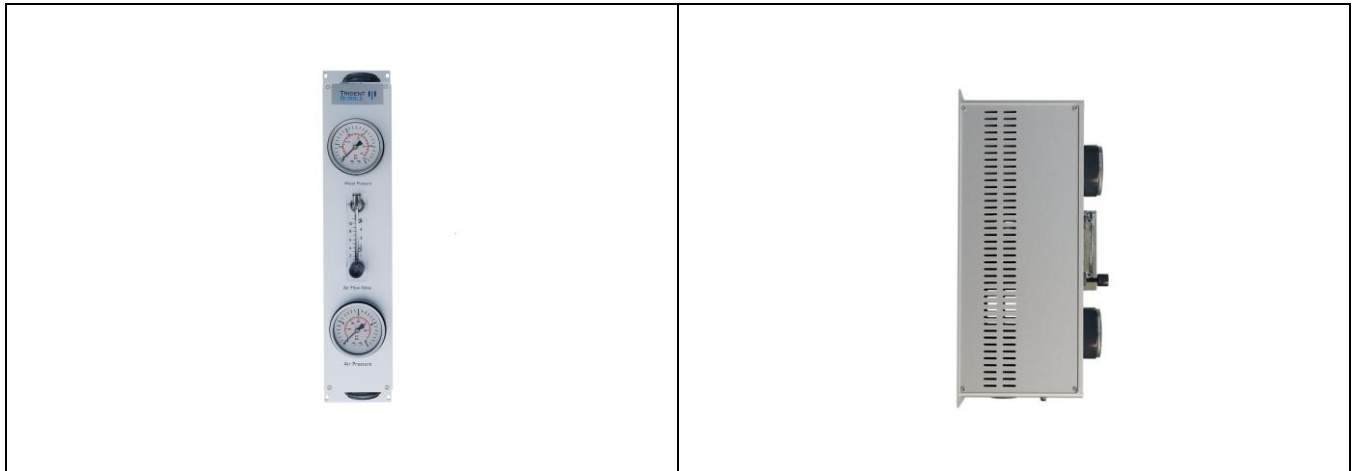
Try our Lab Scale TNS-1 Nanobubble Generator | Water Flow 1 - 3 m³/h (4 -13 GPM)

~~\$3,995~~ **\$2,796**

Contact us for a no-obligation solution design and quote.

VALIDATE WITH YOUR OWN WATER: TRIAL-FRIENDLY TNS-1

The TNS-1 is Trident's lab and pilot-scale generator, and operates at 1 m³/h (4 GPM) water flow. Run controlled H₂S oxidation trials with your actual process water, at your facility, under your conditions. Measure dissolved H₂S before and after. The data you generate is the basis for an informed scale-up decision.



TNS-1 Nanobubble Generator — Front and Side Views



TNS-1 Nanobubble Generator — Lab installed with tank



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