

SURE[®] oxygen enrichment portfolio for sulfur recovery in Claus plants.

Covering the full oxygen enrichment range for increased capacity, flexibility and reliability.



Need for greater refining efficiency.

Despite the growing share of renewables in today's energy mix, fossil fuels will continue to dominate the energy market for the foreseeable future. Profitability requirements, rising environmental concerns and increasingly strict legislation governing both maritime and automotive fuels are raising the bar for refining process efficiency.

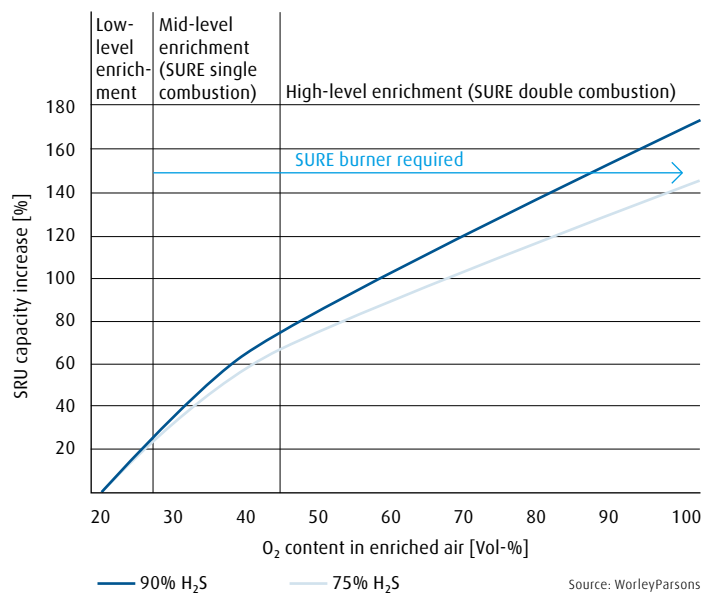
Higher H₂S emergence

Many refinery operators are currently faced with managing higher hydrogen sulfide (H₂S) emergence. One challenge is that dwindling reserves mean the average S-content of crude oil is on the increase in many regions. In addition, operators are more frequently reaching to the bottom of the barrel to convert heavier fractions into valuable "white products" such as gasoline and diesel. Furthermore, the H₂S content varies significantly depending on the original feedstock. Typically, oil refineries need to treat rich acid gas streams with H₂S content between 80 and 98 vol-percent.

Rising and fluctuating H₂S amounts are adding to refinery complexity. In particular, the increase in conversion activity is producing more H₂S and contaminants such as ammonia. This calls for greater sulfur removal capacity and contaminant destruction efficiency. Faced with cost and space restrictions, many operators are looking for low-CAPEX ways to boost the efficiency of existing Claus units while also raising flexibility to handle a wider operating envelope.

Flexibility is also essential to ensure uninterrupted operations in the event of maintenance work or an outage. To ensure operational reliability in these situations, refiners need a cost-effective way to put more redundant capacity in place.

Oxygen enrichment debottlenecking capability in Claus units



"The SURE double combustion process gives us maximum capacity increase and great flexibility. Off all the oxygen enrichment technologies applied in our Claus units, we consider SURE to be the most reliable and the easiest to operate."

Tariq Malik P.E.
Principal Refining Consultant
CITGO Petroleum Corporation

Oxygen enrichment (O₂e) in focus.

In many cases, the most economical route to incremental or greater sulfur recovery capacity lies in oxygen enrichment. The concept of oxygen enrichment is simple. Since air is approximately 79 percent nitrogen and 21 percent oxygen, the use of air to supply the oxygen for combustion of H₂S to SO₂ also introduces a large quantity of nitrogen, which has to be heated and does not contribute to the reaction. If air is replaced with oxygen-enriched air or pure oxygen, this eliminates the nitrogen ballast, also reducing the volume flow through the sulfur recovery unit (SRU). This means more acid gas can be fed into the system without the need for significant modifications to existing equipment.

Improvements you can count on – from low to high O₂e

Here at Linde, we have been working on the development and delivery of O₂e technologies for SRUs for over 25 years. Through our SURE oxygen enrichment portfolio, we cover the full spectrum from low to high end to meet all application and productivity needs during maintenance, modification and greenfield projects.

A higher level of oxygen enrichment leads to higher temperatures in the furnace. Accordingly, limitations arise which are mainly due to the temperature sensitivity of installed equipment like burner metallurgy and furnace refractory. The only way to overcome these limitations is to choose the most suitable technology for the particular application.

SURE oxygen enrichment technologies for Claus plants

- SURE low-level oxygen enrichment (O₂ content up to 28 percent):
Our custom OXYMIX[®] gas injection devices and OXYMIX flowtrain control system for oxygen dosing offers up to 30 percent increases in capacity.
- SURE mid-level oxygen enrichment (O₂ content up to 45 percent):
Our SURE burner based on single combustion technology enables a capacity boost of up to 75 percent.
- SURE high-level oxygen enrichment (O₂ content up to 100 percent):
Our SURE burner based on double combustion technology delivers up to 170 percent capacity increases.

For added flexibility, operators can also combine these various modes to support short-term boosts in capacity during maintenance or repair work.

Surprisingly small changes with a surprisingly big impact.

The switch from air to oxygen-enriched air or pure oxygen as the oxidant offers a number of far-reaching benefits. These are outlined in the following.

Capacity & footprint

Oxygen enrichment is a cost-effective and flexible way of increasing a plant's sulfur handling capacity and thus removing bottlenecks without increasing the Claus footprint or investing in new Claus units. In the case of new builds, SURE has the added bonus of reducing the footprint of plant components such as reactors and also tail gas treatment. This, in turn, lowers power and fuel consumption.

Flexibility

With our SURE portfolio, operators are free to modify their existing plant or invest in a new burner depending on the level of process intensification required. Especially with low-level enrichment, this is a low-CAPEX, rapid-payback route that does not even require any changes to the

furnace structure. To accommodate fluctuations in feed throughput, SURE burners can be easily switched from air to oxygen on demand. And the oxygen volume in the process air can be adjusted to react to feed fluctuations in an appropriate way.

Reliability & redundancy

In addition, oxygen enrichment improves process reliability by addressing the problems associated with contaminants such as ammonia via more effective ammonia destruction. And oxygen enrichment can build greater redundancy into plant designs, particularly with multi-train systems. If one train fails, operators can increase the oxygen flow to another train or switch it over entirely to oxygen to maintain capacity levels.



SURE burner.



End-to-end service.

We support our customers' sulfur recovery projects at every step of the solution lifecycle, whether it be a maintenance, conversion or new build project. Extending far beyond best-in-class process technologies and complete gas supply schemes, our end-to-end service offering includes consultation, trials and installation. Regardless of the enrichment level required, our customers can rely on us for a seamless, one-stop service. For mid and high levels of enrichment, we collaborate with our partner WorleyParsons.

Drawing on our in-depth understanding of the entire Claus process, we start out with a detailed consultation to establish the most effective oxygen enrichment strategy for each project, also with a view to optimising the thermal section. As part of our SURE ammonia service, this includes ammonia sampling to analyse current conversion efficiency levels. Based on these findings, we advise customers on how to optimise ammonia conversion through oxygen enrichment. We simulate the proposed process flow and enrichment levels using a specially developed and validated tool. This can be complemented by field trials (please contact your local Linde representative) and customisation of the SURE burner, along with complementary training and safety support services.

Our vast experience and wide reference base give customers the reassurance that they are partnering with the market and innovation leader in oxygen enrichment technologies for Claus plants. To date, we have over 50 successful references for mid- and high-level enrichment projects, many of which are based on SURE double combustion technology. We also have over 40 success stories in low-level enrichment.

"All our services build on the synergised expertise we have gained as an engineering and gases player, coupled with the hands-on experience and insights we have acquired through the operation and maintenance of countless plants for our customers worldwide."

Walter Hocker
Head of market segment chemicals & environment at Linde Gas

SURE hardware highlights.

OXYMIX

OXYMIX is an oxygen injector for low-level O₂ enrichment. Based on Computational Fluid Dynamics (CFD) and testing with particle image velocimetry (PIV), it is customised to each individual enrichment project, injecting oxygen into the air flow at a certain angle through a circle of nozzles. It ensures thorough mixing over a short distance and avoids high oxygen concentrations near the air pipe wall for added safety. Highlights include a compact, maintenance-free design.

Flowtrain

OXYMIX flowtrain is our automated measurement and control system for safe and reliable oxygen dosing. It adds oxygen to the process air until the desired oxygen concentration is reached. In the case of liquid gas supplies, a pressure control system is installed upstream. It can be integrated into the refinery's DCS.

SURE burners

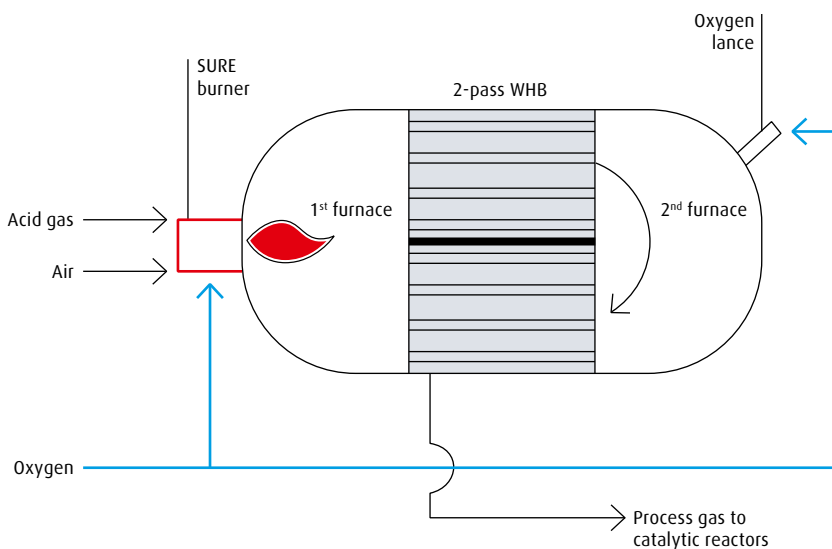
SURE burner is a tip-mixed burner, designed and developed through pilot plant testing. We tailor every burner design to the acid gas feed composition, oxygen enrichment level and furnace geometry of each project. CFD modelling is used to verify the burner design with the furnace and waste heat boiler assembly. This ensures that the temperature in the furnace is high enough for effective contaminant destruction while avoiding high temperature damage to the refractory as a result of oxygen use.

For enrichment levels above 45 percent O₂, SURE double combustion process overcomes the temperature limitations of single furnace operation by splitting the heat release into two separate reactors with cooling in between. This SURE double combustion process is currently the only available technology that provides full capability of O₂e at up to 100 percent oxygen – in an uncomplicated process that is easy to install, operate and maintain.

Choice of supply modes

We offer a number of oxygen supply modes to suit individual volume and budgetary requirements. These range from bulk deliveries to on-site generation units using pressure swing adsorption or cryogenic technologies. In the case of greenfield projects running only on oxygen, a direct connection to an air separation unit might even be the most cost-effective solution. Our experts would be glad to advise you on the mode best suited to the volume and enrichment needs of your Claus sulfur recovery process.

Double combustion process setting with 2-pass waste heat boiler (WHB)



Increasing efficiency in lean acid gas Claus processing (within gasification & sour natural gas plants).

As well as sulfur recovery from acid gases rich in H_2S content (as is usual in refineries), Claus processing is also used in industries where the gaseous feed is characterised by a lower H_2S concentration. Ranging from 20 to 60 vol-percent, such lean acid gas mainly occurs at production sites where sulfur-rich resources are partially oxidised (for example by gasification of heavy residues or petcoke), or where H_2S is separated from sour natural gas. As well as their CO_2 content, lean acid gases typically contain aromatic trace compounds (BTX). These can often pose a challenge to Claus units because they cannot be properly destroyed without a sufficiently high furnace temperature.

As lean acid gas is a significantly diluted fuel source, the furnace temperature is often too low for adequate performance in air-only operation. This can be countered by measures like co-firing of fuel. However, such temperature increases come with a reduction in Claus capacity as significant additional gas volume is added to the Claus process gas.

Maximising efficiencies – also in cost

The SURE O_2 enrichment process can overcome such challenges, in particular in revamp projects. The resulting temperature rise not only avoids capacity loss, but also allows for increased feed throughput.

This in turn also means that new Claus installations can be built considerably smaller when O_2 enrichment is implemented from the beginning – thus saving substantial investment costs as the reduced inert content of the process gas enables designs with smaller pipes and apparatus.

SURE oxygen enrichment for lean acid gas treatment

In the case of lean acid gases, the application of the SURE technology over the whole range of O_2 enrichment (up to 100 percent of O_2) can be based on single combustion because the resulting temperatures in the Claus furnace do not compromise limitations of refractory endurance. Even in cases where the acid gas to be treated is so lean that Claus operation is not stable any more in the air-only mode, O_2 enrichment has the potential to enable reliable processing.

Oxygen enrichment is a fast and reliable way to minimise capital expenditure while improving process efficiency.

For more information on SURE oxygen enrichment, please contact us:
refineries@linde-gas.com



Getting ahead through innovation.

With its innovative concepts, Linde is playing a pioneering role in the global market. As a technology leader, it is our task to constantly raise the bar. Traditionally driven by entrepreneurship, we are working steadily on new high-quality products and innovative processes.

Linde offers more. We create added value, clearly discernible competitive advantages, and greater profitability. Each concept is tailored specifically to meet our customers' requirements – offering standardised as well as customised solutions. This applies to all industries and all companies regardless of their size.

If you want to keep pace with tomorrow's competition, you need a partner by your side for whom top quality, process optimisation, and enhanced productivity are part of daily business. However, we define partnership not merely as being there for you but being with you. After all, joint activities form the core of commercial success.

Linde – ideas become solutions.



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