NORAM

SULFURIC ACID

Products and Services

NORAM CLEAN START™ PROCESS

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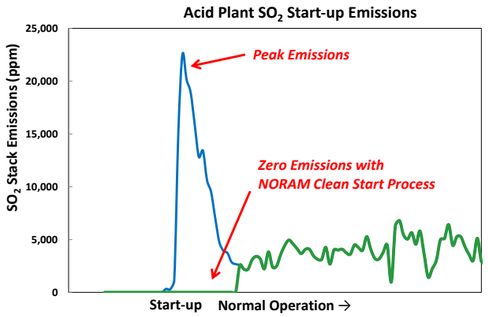
NORAM Clean Start™ Process greatly reduces the start-up or transient conditions emissions through the transfer of tail gases of one plant to a neighboring plant. The emissions caused by a sulfuric acid plant peaks during start-up and it is difficult to avoid. Since multiple plants are commonly seen in the sulfuric acid industry, this process is an ideal solution to eliminate start-up emissions with low cost and effective results.



Start-up Emissions

- The start-up plume of a sulfuric acid plant is difficult to avoid, especially when the plant is executing a cold start-up.
- Emissions contain SO_2 gas in the range of 1,000-10,000 ppm. In some cases levels can exceed 20,000 ppm.
- The gas may contain acid mist (formed from SO_3 carryover or H_2SO_4 emissions).
- Plume travels with the wind, and can be seen for long distances.
- Inversion can occur and the plume can fall onto the ground, affecting people.
- Emissions can cause health and environmental emergencies during plant upsets and plant start-ups.

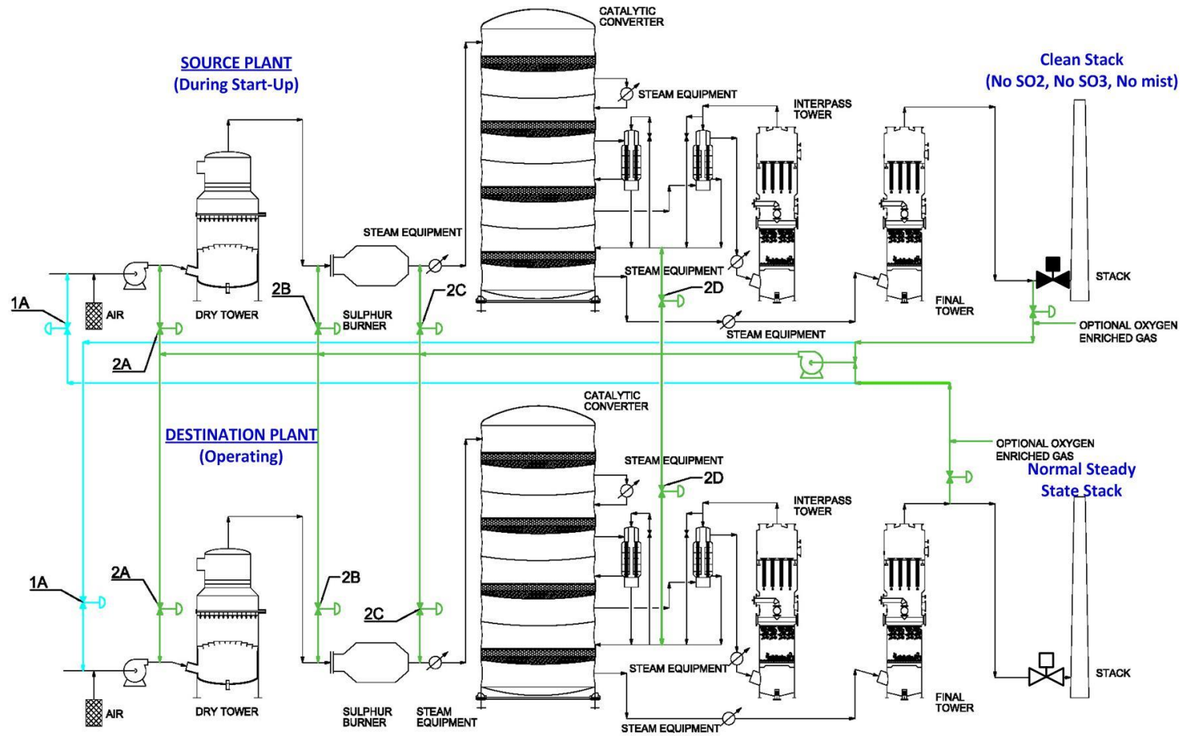
Benefits of NORAM Clean Start Process

- Elimination of start-up emissions
- No need for a tail gas scrubber
- Faster start-ups are possible
- Higher overall acid production during start-up period
- Relatively simple process and simple implementation
- Low capital and operating cost

Comparison of Technologies — Green = Preferable

Variable	No Mitigation	Chemical Scrubbing	Absorption-Desorption Scrubbing	NORAM's New Emissions Reduction Process
Plant requirements	None	Tail gas scrubbing plant **(new)**	Tail gas absorption-desorption plant **(new)**	Neighbouring plant **(existing) - See footnote**
Number of plants on site	1 or more	1 or more	1 or more	2 or more
Suitable for single plants	Yes	Yes	Yes	No
Process water consumption	No	High	High	No
Steam consumption	No	No	High	No
Consumption of chemicals	No	Yes	Yes	No
Production of by-products or waste	No	Yes	Yes	No
Allows for fast start-up	N/A	Yes	Yes	Yes
Equipment familiarity for operators	Familiar	Not familiar	Not familiar	Familiar
Requires O_2 enrichment	N/A	No	No	No (Optional)
Public perception	Poor High emissions	Visible plume caused by water vapour	Visible plume caused by water vapour	No visible plume, no start-up emissions
Energy consumption	N/A	Increased blower energy cost due to increased plant pressure drop. Electrical power to run pumps.	Increased blower energy cost due to increased plant pressure drop. Electrical power to run pumps. Steam use.	Minimal energy required to transfer gas from one plant to another
Equipment required	N/A	Scrubber column, circulation pumps, product pumps, reagent pumps and tanks, piping, reagent and product storage tank, instrumentation.	Pre-scrubber, absorber column, regenerator column, amine cooler, amine heat exchanger, reboiler, amine purification unit, instrumentation.	Gas ducting (length defined by distance between plants), dampers, valves, instrumentation.
Capital cost	N/A	High	High	Low
Operating cost	N/A	High	High	Low
Tail gas SO_2 concentration during start-up	Up to 20,000 ppm	10 to 100 ppm	10 to 100 ppm	Negligible

Note: NORAM's process also can be utilized for a single acid plant with partial recycle of tail gas to the feed of the same plant, with other benefits during preheating and start-up.



Example of Tail Gas Transfer Configurations For Parallel Sulfur burning Sulfuric acid plants

Possible Feed Points

Configuration	Feed point Location in Receiver Plant
1A	Upstream of main blower
2A	Downstream of main blower Upstream of Dry Tower
2B	Downstream of Dry Tower Upstream of Sulphur Burner
2C	Downstream of Sulphur Burner Upstream of Bed 1
2D	Upstream of Bed 4

Requirements for NORAM's Process

NORAM's process requires the following equipment:

- Gas ducting (length defined by distance between plants)
- Dampers
- Valves
- Instrumentation

In most cases, it may require only one major duct and a set of gas dampers. Engineering is required for the control system. For this reason, this new process is considered a low capital investment solution that is expected to be attractive from technical, economic and environmental perspectives.

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