

NORAM PLANT UPGRADE PROJECT OVERVIEW SHEETS

Plant Upgrade Project Overview

Client: Sulphuric Acid Plant - Fertilizer Complex

Plant Type: Sulphur Burning Plant

Plant Configuration: Double Absorption

Location: Wyoming, USA

Plant Capacity: 2100 STPD



NORAM SF™ hot sweep gas exchanger



NORAM SF™ hot sweep gas exchanger



NORAM Stainless steel converter

Summary

Since 1997, NORAM has provided various engineering studies in several stages and supplied equipment for replacement.

Equipment Supplied

- | | |
|---|------|
| • Acid cooler | 2001 |
| • NORAM SF™ hot sweep gas exchanger | 2003 |
| • HP saddles packing for an intermediate tower | 2015 |
| • Superheater duct connections | 2015 |
| • NORAM SF™ hot sweep gas exchanger | 2018 |
| • Stainless steel converter and 17 ducting segments | 2019 |

Engineering Work

- | | |
|---|------|
| • Debottlenecking study of the sulphuric acid plants | 1997 |
| • Capacity increase study, including budget cost estimates | 2000 |
| • Converter tray analysis study | 2001 |
| • Budget estimates for plant upgrade | 2001 |
| • Detailed engineering for acid cooler replacement | 2001 |
| • Detailed engineering for converter modifications | 2008 |
| • Engineering study for new expansion joints | 2010 |
| • Emission reduction study | 2011 |
| • Converter study | 2013 |
| • Detailed engineering for converter, economizers, gas exchanger, and ducting | 2018 |



NORAM HP saddles packing

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Plant Upgrade Project Overview

Client: Sulphuric Acid Plant – Copper Smelter Site

Plant Type: Smelter Sulphuric Acid Plant

Plant Configuration: Single-Absorption Plant Treating Gas with Fluctuating Concentrations from Teniente and Peirce Smith Converters

Location: Chile

Plant Capacity: 185,000 Nm³/h of process gas. 1500 to 2300 MTPD (as 100% w/w H₂SO₄)



Summary

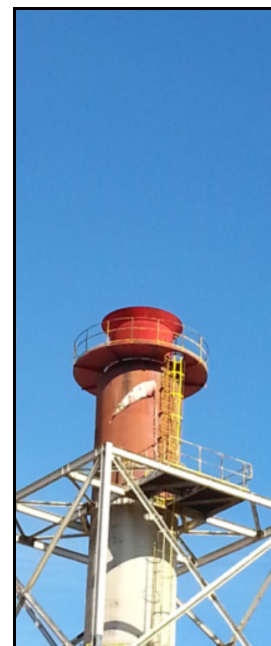
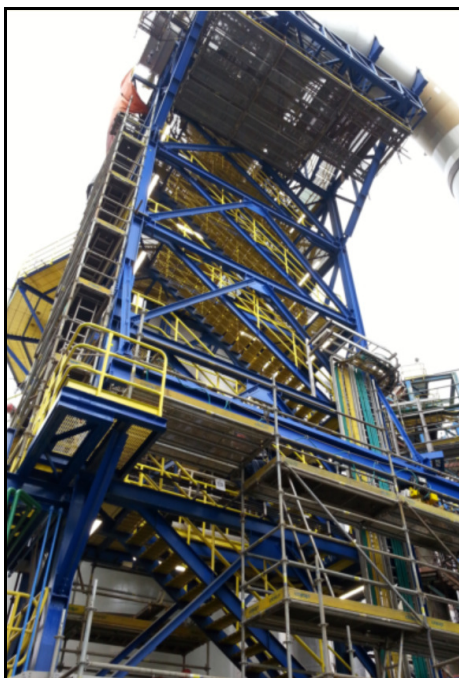
NORAM upgraded the absorption acid system for this copper smelter plant. The new acid system can treat up to 185,000 Nm³/h of metallurgical gases to capture essentially all SO₃ gas to produce commercial sulphuric acid product of 98.5 % w/w concentration. This allows for increased gas throughput and lower pressure drop, and lower emissions of SO₃ and H₂SO₄ (See stak photo in operation at 185,000 Nm³/h of process gas.

Equipment Replaced

Absorption sulphuric acid tower (brick-lined)	2018
Trough-type acid distributor made of NORAM SX™	2018
NORAM HP ceramic saddle packing	2018
NORAM SX™ tower inserts and internals	2018
3 external in-line strainers at pump suction	2018
NORAM SX™ acid piping system	2018
Acid valves, circulation pumps and ancillaries	2018
Acid Mist Eliminators	2018

Engineering Work

- Engineering and, site services for the absorption system.
- Commissioning and Start-up assistance.



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Plant Upgrade Project Overview

Client: Sulphuric Acid Plant – Oil Refinery Site
Plant Type: Sulphuric Acid Regeneration Plant
Plant Configuration: Double-Absorption Plant
Location: California, USA
Plant Capacity: 480 STPD (as 100% w/w H₂SO₄)



NORAM Split Flow Preheater Exchanger



NORAM Stainless Steel Converter



NORAM SX® Alloy Acid Tower



NORAM SX® SMART™ Acid Distributor

Summary

NORAM provided engineering studies and supplied the plant preheat system. NORAM supplied HP saddle packing for multiple towers. Three towers and a converter were replaced. NORAM provided technology, engineering design, procurement, advisory services, and supplied specialized equipment manufactured at AXTON (NORAM's own fabrication shop).

Equipment Supplied

- | | |
|--|------|
| • HP saddles packing for Drying, Interpass Absorption, and Final tower | 2003 |
| • Split flow preheater exchanger | 2016 |
| • NORAM SX® Piping and Valves | 2019 |
| • NORAM SX® Drying Tower and Ducting | 2019 |
| • NORAM SX® Interpass Absorption Tower | 2019 |
| • NORAM SX® Crossflow Stripping Tower | 2019 |
| • Catalytic Converter and Ducting | 2020 |

Engineering Work

- Process study on replacing the preheater and add new start up ducting
- Developed a dynamic simulation to demonstrate the decrease in plant heat up time with the new preheat exchanger and develop start up procedures using the new exchanger and ducting
- Performed the detailed design of a replacement split flow preheater exchanger and associated ducting
- Performed detailed engineering associated with the design of a replacement converter and three SX® Towers

Plant Upgrade Project Overview

Client: Sulphuric Acid and Liquid Sulphur Dioxide Producer

Plant Type: Sulphur Burning Plant

Plant Configuration: Double-Absorption Plant with Liquid Sulphur Dioxide Production

Location: British Columbia, Canada

Plant Capacity: 210 MTPD Sulphuric Acid (as 100% w/w H₂SO₄) and 90 MTPD Sulphur Dioxide



NORAM Sulphur Furnace



NORAM Sulphur Furnace and Converter



NORAM Dry and Final Acid Towers



NORAM Intermediate Acid Cooler

Summary

NORAM upgraded the entire acid plant in several stages.

Equipment Replaced

• SMART™ Acid Distributor for Final Tower	1992
• SMART™ Acid Distributor for Intermediate Tower	1997
• NORAM HP™ Ceramic Saddles for IP Tower	1997
• NORAM HP™ Ceramic Saddles for SO ₃ Scrubber	2002
• NORAM HP™ Ceramic Saddles for Final Tower	2003
• SMART™ Acid Distributor for Final Tower	2006
• SMART™ Acid Distributor for Intermediate Tower	2007
• NORAM HP™ Ceramic Saddles for IP Tower	2007
• Sulphur Furnace & Sulphur Guns	2007
• Stainless Steel Converter	2008
• All S.S. Ducting To/From Converter	2008
• Final Acid Tower & NORAM HP™ Ceramic Saddles	2009
• SMART™ SX Acid Distributor for Final Tower	2009
• Dry Acid Tower & NORAM HP™ Ceramic Saddles	2010
• SMART™ SX Acid Distributor for Dry Tower	2010
• Intermediate Acid Cooler	2010
• Dry and Final Acid Cooler	2011
• Product Acid Cooler	2011
• Product Acid Pump Tank	2011
• Redesigned Acid Piping System	2011
• NORAM HP™ Ceramic Saddles for IP Tower	2012

Engineering Work

- Engineering work for plant optimization. Basic design, detailed engineering, site services, and fabrication advisory services.



NORAM Dry/Final and Product Acid Coolers



NORAM Converter

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Plant Upgrade Project Overview

Client: Sulphuric Acid Plant – Oil Refinery Site

Plant Type: Sulphuric Acid Regeneration Plant

Plant Configuration: Single-Absorption Plant with Tail Gas Scrubber

Location: California, USA

Plant Capacity: 450 MTPD (as 100% w/w H₂SO₄)

Summary

NORAM modernized this sulphuric acid plant, and replaced all gas-side pieces of equipment in three stages, requiring three turnarounds to complete the project.

Equipment Replaced

• SF™ Split Flow Preheat Heat Exchanger	2010
• RF™ Radial Flow Hot Heat Exchanger	2010
• All S.S. Ducting To/From Converter	2010
• RF™ Radial Flow Cold Heat Exchanger	2013
• RF™ Radial Flow Intermediate Heat Exchanger	2013
• All S.S. Ducting Between Heat Exchangers	2013
• Stainless Steel Converter	2015
• Converter Preheat Ducting System	2015

Engineering Work

- Engineering work for basic design, detailed engineering, site services, and fabrication advisory services for several equipment replacement projects.
- Acid plant optimization and capacity increase study.
- Basic engineering for new economizer and steam system review.
- Engineering services, site services, operator training, HAZOP and fabrication advisory services for new catalytic converter.



NORAM Preheat Heat Exchanger



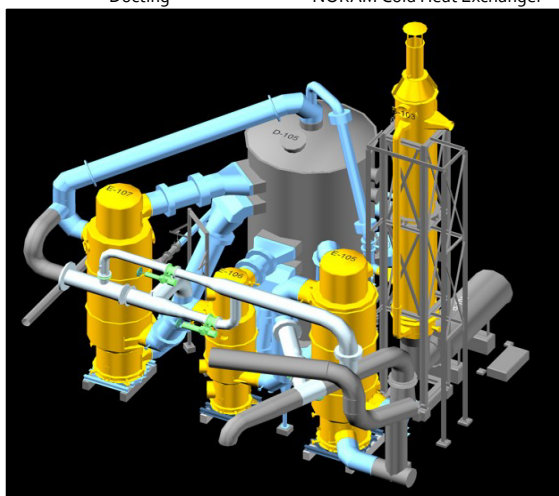
NORAM Hot Heat Exchanger



Ducting



NORAM Cold Heat Exchanger



NORAM 3D Model of Plant



NORAM Converter Fabrication



NORAM Preheater Heat Shield

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Plant Upgrade Project Overview

Client: Sulphuric Acid Plant – Zinc Smelter Site

Plant Type: Smelter Sulphuric Acid Plant

Plant Configuration: Double-Absorption Plant Treating Gas with Fluctuating Concentrations from Smelter Operations

Location: Mexico

Plant Capacity: 1100 MTPD (as 100% w/w H_2SO_4)



Acid Tower

Summary

NORAM upgraded two gas exchangers and the complete final acid system for this zinc smelter plant. The new design allows for increased gas throughput and lower pressure drop. The new final acid tower captures essentially all SO_3 gas to produce commercial sulphuric acid product of 98.5 % w/w concentration. The acid system was fabricated in NORAM SX™ alloy.

Equipment Replaced

Radial Flow Stainless Steel Gas-to-Gas Heat Exchanger	2002
Radial Flow Stainless Steel Gas-to-Gas Heat Exchanger	2005
Final Sulphuric Acid Tower	2012
Pump Tank	2012
Acid cooler (bullet-style)	2012
Final Tower Pipe Acid Distributor - NORAM SX™	2012
Final Tower NORAM HP™ Ceramic Saddle Packing	2012
Acid Mist Eliminators	2012

Engineering Work

- Engineering work for basic design, detailed engineering, site services, and fabrication advisory services.



Pump Tank



Distributor with HP™ packing below



Vertical Acid Cooler



Radial Flow Stainless Steel Gas-to-Gas Heat Exchanger

Plant Upgrade Project Overview

Client: Sulphuric Acid Plant

Plant Type: Sulphur Burning Plant

Plant Configuration: Double Absorption

Location: Israel

Plant Capacity: 2400 MTPD and 4100 MTPD



NORAM Gas Exchanger with Hot Sweep Installation



NORAM Gas Exchanger with Hot Sweep Tube Bundle



NORAM Acid Pump Tank Fabrication

Summary

NORAM provided engineering studies for plant capacity increase for both plants as well as plant improvement include plant pressure drop reduction, increased catalyst conversion, the addition of a booster blower, and recommendations on equipment modification or replacement. NORAM also upgraded multiple pieces of equipment.

Equipment Supplied

- Cold Interpass Gas to Gas Heat Exchanger with NORAM 2018 Hot Sweep and Associated Ducting
- Final & Interpass Absorbing Tower Combined Acid Pump 2018 Tank

Engineering Work

- Debottlenecking Study for capacity increase by 17% for 2016 both plants
- Detail engineering for gas exchanger and acid pump 2017 tank



NORAM Gas Exchanger with Hot Sweep Fabrication



NORAM Acid Pump Tank on Site

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Plant Upgrade Project Overview

Client: Sulphuric Acid Plant at Fertilizer Complex

Plant Type: Sulphur Burning Plant

Plant Configuration: Double-Absorption Plant

Location: Alberta, Canada

Plant Capacity: 850 MTPD (as 100% w/w H₂SO₄)



NORAM Acid Tower



NORAM Economizer



NORAM S.S. Converter



Converter Preheat Ducting



NORAM Cold Heat Exchanger



NORAM Sulphur Furnace



NORAM Pump Tank



NORAM Acid Heater

Summary

NORAM upgraded the acid plant in several stages.

Equipment Replaced

- Drying Tower with NORAM HP™ Ceramic Saddles and SMART™ Acid Distributor 1997
- Interpass Tower with NORAM HP™ Ceramic Saddles and SMART™ Acid Distributor 1998
- Final Tower with NORAM HP™ Ceramic Saddles and SMART™ Acid Distributor for Final Tower 1999
- Final Pump Tank 1999
- Boiler Feed Water Heater 2001
- Product Pump Tank 2003
- RF™ Radial Flow Cold Heat Exchanger 2003
- Dry/Intermediate Acid Cooler 2004
- Stainless Steel Converter 2005
- RF™ Radial Flow Hot Heat Exchanger 2005
- Final Acid Cooler & Product Acid Cooler 2007
- Economizer 2007
- NORAM HP™ Ceramic Saddles for Interpass Tower 2009
- Sulphur Furnace 2010
- SMART™ SX Acid Distributor for Final Tower 2012
- Vent Scrubber 2012
- Start-up Acid Heater 2013

Engineering Work

- Engineering work for plant optimization. Basic design, detailed engineering, site services, and fabrication advisory services for several equipment replacement projects.

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Plant Upgrade Project Overview

Client: Sulphuric Acid Plant - Copper and Gold Mining Enterprise

Plant Type: Metallurgical

Plant Configuration: Double-Absorption Plant

Location: Mid-West USA

Plant Capacity: 3,850 MTPD Sulphuric Acid (as 100% w/w H₂SO₄)



Ducting Modifications



New Converter Ducting Modifications



NORAM Cold Interpass Heat Exchanger

Summary

NORAM has provided engineering services for this client for many years. The scope of engineering includes mechanical upgrades, and replacement of key equipment.

Equipment Replaced

• Superheater	2002
• Converter Nozzle and Ducting Replacement	2004
• SF™ Split Flow Cold Heat Exchanger	2006
• Converter Nozzle and Ducting Replacement	2007
• Converter Nozzle and Ducting Replacement	2010
• RF™ Radial Flow Hot Heat Exchanger	2010
• Converter Nozzle and Ducting Replacement	2011
• RF™ Radial Flow Cold Interpass Heat Exchanger	2014
• Superheater	2014

Engineering Work

- Numerous detailed engineering projects to redesign converter nozzles and ducting to reduce maintenance costs.
- Study of superheater upgrade for a 140,000 SCFM acid plant producing approximately 3,850 STPD of acid. Based on study results, client implemented proposed changes including co-current flow design for superheater, process control upgrade, change from steam to gas side bypass, and material upgrades.
- Engineering associated with installation of new superheater and heat exchangers. Engineering included preparing a dynamic model of the entire acid plant including controllers and equipment, Computational Fluid Dynamic (CFD) modelling of gas flow to superheater and to the second pass, and finite element analysis (FEA) of converter nozzle modifications.



NORAM Exchanger Assembly



Heat Exchanger Baffle Plates

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Plant Upgrade Project Overview

Client: Sulphuric Acid Plant – Large Fertilizer Producer.

Plant Type: Sulphur Burning Acid Plant

Plant Configuration: Double Absorption Plants

Location: Morocco

Plant Capacity: 2 x 2,650 MTPD (as 100% w/w H₂SO₄)

Summary

NORAM upgraded the acid system of two identical plants for one of the largest fertilizer producer in the world. A total of 6 acid towers were replaced (dry, interpass and final towers for two plants). NORAM provided technology, engineering design, procurement, advisory services, and supplied specialized equipment manufactured at AXTON (NORAM's own fabrication shop).

Equipment Replaced

• 2 x Dry Sulphuric Acid Towers – Made of NORAM SX™	2015 - 2016
• 2 x Dry Tower Smart TM Acid Distributors - NORAM SX™	2015 - 2016
• 2 x Dry Tower NORAM HP Ceramic Saddle Packing	2015 - 2016
• 2 x Interpass Sulphuric Acid Towers – Made of NORAM SX™	2015 - 2016
• 2 x Interpass Tower Smart TM Acid Distributors - NORAM SX™	2015 - 2016
• 2 x Interpass Tower NORAM HP Ceramic Saddle Packing	2015 - 2016
• 2 x Final Sulphuric Acid Towers – Made of NORAM SX™	2015 - 2016
• 2 x Final Tower Smart TM Acid Distributors - NORAM SX™	2015 - 2016
• 2 x Final Tower NORAM HP Ceramic Saddle Packing	2015 - 2016
• 2 x Plant Stacks	2015 - 2016
• Interconnecting gas ducting	2015 - 2016
• Acid piping	2015 - 2016



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Plant Upgrade Project Overview

Client: Sulphuric Acid Plant – Copper Smelter

Plant Type: Smelter Sulphuric Acid Plant

Plant Configuration: Double Absorption

Location: Arizona, USA

Plant Capacity: 2840 MTPD



Summary

NORAM provided engineering studies and design in several stages, which includes gas handling capacity increase from 120,000 to 150,000 SCFM, detailed engineering for design and fabrication of cold gas exchanger replacement and installation of new preheater furnace system.

Equipment Supplied

- | | |
|--|------|
| • Cold interpass gas-to-gas heat exchanger | 2012 |
| • Cold gas-to-gas heat exchanger | 2014 |
| • Preheater furnace | 2018 |
| • Preheater gas-to-gas heat exchanger | 2018 |
| • Preheating system to 4 beds of catalyst | 2018 |

Engineering Work

- | | |
|--------------------------------------|------|
| • Debottlenecking study | 1992 |
| • Blower recycle study | 2004 |
| • Gas exchangers and ducting designs | 2012 |



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Plant Upgrade Project Overview

Client: Sulphuric Acid Plant

Plant Type: Sulphuric Acid Regeneration

Plant Configuration: Double-Absorption Plant

Location: Louisiana, USA

Plant Capacity: 2400 STPD (as 100% w/w H₂SO₄)



All welded all stainless steel construction



Stainless steel ring & post design



Catenary shaped catalyst support plates

Summary

NORAM upgraded the converter for this sulphuric acid regeneration plant with a replacement (new) 39' diameter x approximately 64'-7" overall height NORAM proprietary converter built as modules delivered to site.

Equipment Supplied

- Stainless Steel Converter, including ducting, and internals 2019

Engineering Work

- Process Study for plant expansion
- Detailed engineering for replacement converter consisting of:
 - Material supply and Modular Fabrication Drawings for a 39' Ø NORAM Converter Design
 - Oval to Round Stainless Steel Transition Ducts
 - All Stainless Steel Tie-in Ducting c/w:
 - Expansion joints, dampers, duct supports, etc.
 - Structural steel grillage supports
 - Demolition and Installation Drawings



Site assembled, insulated, ready to move into position

Plant Upgrade Project Overview

Client: Sulphuric Acid Plant – Copper Smelter Site

Plant Type: Smelter Sulphuric Acid Plant

Plant Configuration: Double-Absorption Plant Treating Gas with Fluctuating Concentrations from Teniente and Peirce Smith Converters

Location: Chile

Plant Capacity: 1300 MTPD (as 100% w/w H_2SO_4)



Summary

NORAM upgraded the final acid system for this copper smelter plant. The new final acid tower can treat up to 150,000 Nm^3/h of metallurgical gases to capture essentially all SO_3 gas to produce commercial sulphuric acid product of 98.5 % w/w concentration. This allows for increased gas throughput and lower pressure drop. The environmental performance of the plant was significantly improved since the emissions of SO_3 and H_2SO_4 mist to the stack were reduced by more than 90%.

Equipment Replaced

Final Sulphuric Acid Tower	2015
Smart TM Acid Distributor Made of NORAM SX TM	2015
NORAM HP Ceramic Saddle Packing	2015
NORAM SX TM Tower Inserts, Internals and Strainer	2015
Acid Mist Eliminators	2015

- NORAM provided technical support to the client with respect to the balance of system including piping, acid coolers, instrumentation and pumps .

Engineering Work

- Engineering work for basic design, detailed engineering, site services, and fabrication advisory services for the final acid tower.
- Start-up engineering assistance for the plant start-up under upgraded conditions.



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Plant Upgrade Project Overview

Client: Sulphuric Acid Plant - Uranium Producer

Plant Type: Sulphur Burning Plant

Plant Configuration: Double-Absorption Plant

Location: Northern Canada

Plant Capacity: 175 MTPD Sulphuric Acid (as 100% w/w H₂SO₄)



NORAM Circulation Acid Cooler



NORAM Dry, Interpass and Final Absorption Towers



Ducting



Absorption Tower Outlet Ducting



Absorption Tower Platform



NORAM Converter

Summary

NORAM upgraded this sulphuric acid plant, and replaced most pieces of equipment in two stages, requiring two annual turnarounds to complete the project.

Equipment Replaced

• S.S. Converter with Internal Hot Heat Exchanger	2010
• Cold Interpass Heat Exchanger	2010
• Dry Tower & NORAM HP™ Ceramic Saddles	2011
• SMART™ Acid Distributor for Dry Tower	2011
• Interpass Tower & NORAM HP™ Ceramic Saddles	2011
• SMART™ Acid Distributor for Interpass Tower	2011
• Final Tower & NORAM HP™ Ceramic Saddles	2011
• SMART™ Acid Distributor for Final Tower	2011
• Circulation Acid Cooler	2011
• Circulation Acid Pump Tank	2011
• Dilution Product Acid Cooler	2011
• Dilution Product Pump Tank	2011

Engineering Work

- Feasibility study associated with the upgrade of a complete acid plant.
- Detailed engineering associated with the installation and design of NORAM equipment, ducting, piping and instrumentation.

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Plant Upgrade Project Overview

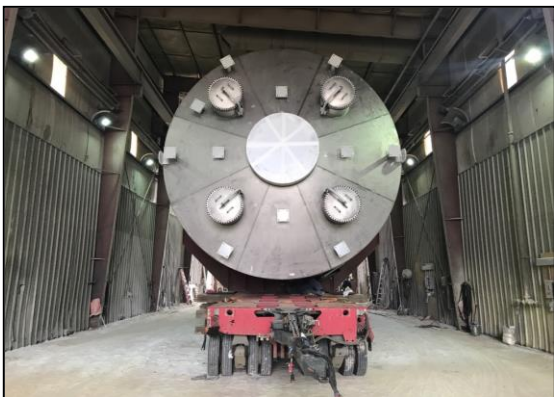
Client: Sulphuric Acid Plant in Phosphate Facility

Plant Type: Sulphur Burning Plant

Plant Configuration: Double Absorption

Location: Alberta, Canada

Plant Capacity: 2200 STPD



Summary

NORAM carried out various engineering studies and supplied new pieces of equipment for replacement and upgrades of two acid plants.

Equipment Supplied

- | | |
|--|------------|
| • SMART™ acid distributor | 2000 |
| • NORAM HPT™ ceramic saddles packing | 2000, 2017 |
| • Anodic protection IP acid cooler | 2008 |
| • Acid drying tower | 2012 |
| • NORAM SX™ acid cooler | 2014 |
| • Cold interpass gas exchanger | 2017 |
| • NORAM SX™ trough acid distributor | 2017 |
| • Brick-lined interpass absorption tower | 2018 |

Engineering Work

- | | |
|--|------|
| • Plant capacity increase study | 1997 |
| • Computational Fluid Dynamics (CFD) study for converter | 2015 |
| • Site services | 2018 |



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Plant Upgrade Project Overview

Client: Sulphuric Acid Plant – Large Fertilizer Producer.

Plant Type: Sulphur Burning Acid Plant

Plant Configuration: One Double Absorption Plant and One Single Absorption Plant

Location: Morocco

Plant Capacity: 1,750 MTPD & 2,650 MTPD (as 100% w/w H_2SO_4)

Summary

NORAM upgraded the acid system of two plants in two important sites for one of the largest fertilizer producer in the world. The dry, interpass and final acid towers were replaced in the first plant while the dry and absorption towers were replaced for the second site (A total of 5 acid towers). NORAM provided technology, engineering design, procurement, advisory services, and supplied specialized equipment manufactured at AXTON (NORAM's own fabrication shop).

Equipment Replaced

• Dry Sulphuric Acid Tower – Brick-Lined	2010 - 2011
• Interpass Sulphuric Acid Tower – Brick-Lined	2010 - 2011
• Final Sulphuric Acid Tower – Brick-Lined	2010 - 2011
• Dry Sulphuric Acid Tower – Made of NORAM SX™	2010 - 2011
• Interpass Sulphuric Acid Tower – Made of NORAM SX™	2010 - 2011
• 5 x Acid Tower Trough Acid Distributors	2010 - 2011
• 5 x Acid Tower NORAM HP Ceramic Saddle Packing	2010 - 2011



Plant Upgrade Project Overview

Client: Sulphuric Acid Plant – Oil Refinery Site
Plant Type: Sulphuric Acid Regeneration Plant
Plant Configuration: Double-Absorption Plant
Location: Louisiana, USA
Plant Capacity: 300 MTPD (as 100% w/w H₂SO₄)



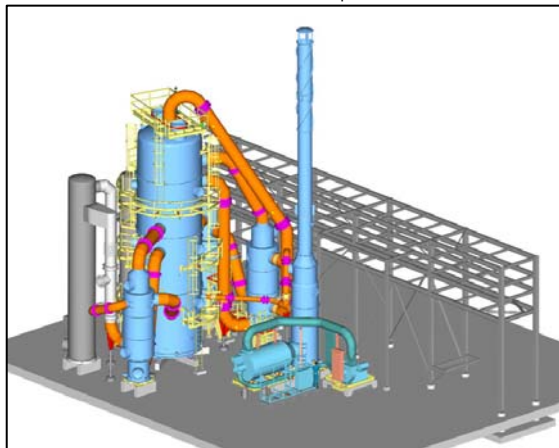
NORAM Converter



Stainless Steel Ducting



NORAM Gas Damper



NORAM 3D Model of Plant

Summary

NORAM upgraded the acid plant in a single stage, requiring a single plant shutdown. All major gas-side equipment were replaced.

Equipment Replaced

• Stainless Steel Converter	2013
• Preheat Furnace	2013
• SF™ Split Flow Preheat Heat Exchanger	2013
• SF™ Split Flow Cold Heat Exchanger	2013
• RF™ Radial Flow Hot Heat Exchanger	2013
• SF™ Split Flow Hot Interpass Heat Exchanger	2013
• All S.S. Ducting To/From Converter	2013
• Stainless Steel NORAM Gas Dampers	2013

Engineering Work

- Preliminary and basic engineering for the replacement of a converter, two gas exchangers and a preheater.
- Performed detailed engineering associated with the design and installation of a replacement converter, three gas exchangers and a preheater system. The design included the equipment and ducting.



NORAM Preheater



Preheater Furnace

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Plant Upgrade Project Overview

Client: Sulphuric Acid Plant – Large Fertilizer Producer.

Plant Type: Sulphur Burning Acid Plant

Plant Configuration: Double Absorption Plants

Location: Morocco

Plant Capacity: 2 x 2,650 MTPD (as 100% w/w H₂SO₄)

Summary

NORAM upgraded the acid system of two identical plants for one of the largest fertilizer producer in the world. A total of 4 acid towers were replaced (dry, and final towers for two plants). NORAM provided technology, engineering design, procurement, advisory services, and supplied specialized equipment manufactured at AXTON (NORAM's own fabrication shop).

Equipment Replaced

• 2 x Dry Sulphuric Acid Towers – Made of NORAM SX™	2011 - 2013
• 2 x Dry Tower Smart TM Acid Distributors - NORAM SX™	2011 - 2013
• 2 x Dry Tower NORAM HP Ceramic Saddle Packing	2011 - 2013
• 2 x Final Sulphuric Acid Towers – Made of NORAM SX™	2011 - 2013
• 2 x Final Tower Smart TM Acid Distributors - NORAM SX™	2011 - 2013
• 2 x Final Tower NORAM HP Ceramic Saddle Packing	2011 - 2013



Plant Upgrade Project Overview

Client: Sulphuric Acid Plant in Phosphate Facility

Plant Type: Sulphur Burning Plant

Plant Configuration: Double Absorption

Location: Idaho, USA

Plant Capacity: 1550 STPD



Summary

NORAM provided engineering studies and design in several stages, which includes SO₂ emission reduction study, ducting design and various advisory services. NORAM also upgraded multiple pieces of equipment.

Equipment Supplied

- Drying tower with NORAM HP™ ceramic saddles 2007
packing
- Mesh pad mist eliminator 2007
- SMART™ acid distributor 2007
- NORAM SX™ final acid tower with HP™ ceramic saddles packing 2010
- New main blower with inlet air filter and turbine drive 2014

Engineering Work

- Detailed engineering for drying and final acid towers 2007
- Tie-in ducting design 2010
- SO₂ emission reduction study 2012
- Installation engineering 2014
- Blower steam piping and electrical control systems 2014

Plant Upgrade Project Overview

Client: Sulphuric Acid Plant – Copper Smelter

Plant Type: Smelter Sulphuric Acid Plant

Plant Configuration: Single Absorption

Location: Texas, USA

Plant Capacity: 966 MTPD



Summary

NORAM successfully provided process engineering study to expand the handling capacity of the one of the two sulphuric acid plants from 120,000 to 150,000 SCFM. NORAM also performed detailed engineering and supplied equipment replacement in the plant.

Equipment Supplied

- Five radial flow gas exchangers, including: 1995
 - Cold
 - Intermediate
 - Hot
 - Reheat exchangers
- HP Ceramic saddles 1995
- Preheater furnace 1996
- Interpass tower upgrade 1996
- Preheater gas-to-gas heat exchanger 1997
- Hot gas exchanger 1997

Engineering Work

- Ducting design and engineering 1995
- Start-up assistance 1996
- Upgrade of acid system for capacity increase 1996
- Study for process options 1997



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Plant Upgrade Project Overview

Client: Sulphuric Acid Plant – Copper Smelter

Plant Type: Smelter Sulphuric Acid Plant

Plant Configuration: Double Absorption

Location: Sonora, Mexico

Plant Capacity: 2614 MTPD



Summary

NORAM provided engineering studies and design in several stages, which includes capacity increase study and detailed engineering for design and fabrication of gas exchangers.

Equipment Supplied

- | | |
|---|------|
| • Acid distributor (3 pieces) | 1995 |
| • NORAM RF™ gas exchanger (2 pieces) | 1997 |
| • NORAM RF™ gas exchanger (2 pieces) | 2005 |
| • Downcomers and venturi nozzle for final tower | 2000 |

Engineering Work

- | | |
|--|------------|
| • Capacity increase study | 2000 |
| • Detailed engineering for plant modernization | 2000 |
| • Detailed engineering for gas exchangers | 2005 |
| • Site services | 2005, 2011 |



Plant Upgrade Project Overview

Client: Sulphuric Acid Plant – Lead Roaster

Plant Type: Smelter Sulphuric Acid Plant

Plant Configuration: Single Absorption Plant

Location: Montana, USA

Plant Capacity: 500 MTPD



Summary

NORAM provided various engineering studies and designs in several stages. That leads to successful SO₃ emission reduction during start-up, capacity increase engineering study, and conversion from double to single absorption to further reduce SO₂ emissions due to low SO₂ concentration in the smelter gas.

Engineering Work

- Engineering conversion from double to single absorption (in order to better handle dilute gases) 1993
- Capacity increase engineering study 1993
- Design of radial flow gas exchanger 1996
- Ducting design and engineering 1994
- Operator training 1995
- Study for reduction of preheater use and reduction of NOx emissions 1996
- Sulphur furnace study 1996
- NORAM anodically protected acid cooler 1996
- Acid plant water balance study 1997
- Weak acid piping design 1999
- Acid cooler for weak acid in gas cleaning 1999
- Mothballing study 2001