MECS® Catalyst

How to Effectively Manage and Reduce Emissions in Sulfuric Acid Plants Using State-of-the-Art MECS® Catalysts

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Mesa Redonda de Plantas de Ácido Súlfurico
Punta Arenas, Chile

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Senior Catalyst Product Engineer

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Overview

• MECS® Catalyst Portfolio & Benefits
  • Lower SO₂ Emissions
  • Increased Acid Production
  • Energy Savings
  • Longer Production Cycles

• Innovative New Product Introductions
  • GEAR® Cesium Catalyst
  • Improved Formulation SCX-2000

• Case Studies Demonstrate Effective Performance
  • PCS Plant 7
  • Fluorsid II
  • Enami Plant 2
MECS® Catalyst Portfolio & Benefits
Drivers of Catalyst Technology Innovations

Innovations motivated by
- Sulfuric Acid Plant Operational Challenges
- Environmental Requirements
- Economic Factors
- R & D Advancements
Catalyst Advancements for Improved Performance

- Reduced SO$_2$ Emissions
- Lower Energy Consumption
- Improved Low Temperature Operation
- Faster Start-ups
- Better Dust Handling
Catalyst Evolution Fueled by Dedicated R&D Team

- 90 years of R&D focus
- Integrated with DuPont Central Research & Development
# MECS® Catalyst Portfolio

<table>
<thead>
<tr>
<th>Catalyst Type</th>
<th>GEAR®</th>
<th>XLP</th>
<th>SCX</th>
<th>XCs</th>
</tr>
</thead>
</table>
| **Advantage** | - Energy Savings  
- Longer Production Cycle  
- Energy Conscious  
- Proven Performance  
- Facilitates Ultra-low SO₂ Emissions  
- Increased Acid Production  
- Energy Conscious  
- Facilitates Ultra-low SO₂ Emissions  
- Increased Acid Production | - Proven Performance  
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- Increased Acid Production | - Greater Operating Flexibility  
- Faster Start-ups  
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- Greater Operating Flexibility  
- Faster Start-ups |
| **Shape** | Hexa-Lobed Ring  
Ribbed Ring  
Ribbed Ring  
Ribbed Ring | Ribbed Ring  
Ribbed Ring  
Ribbed Ring  
Ribbed Ring | Ribbed Ring  
Ribbed Ring  
Ribbed Ring  
Ribbed Ring | Ribbed Ring  
Ribbed Ring  
Ribbed Ring  
Ribbed Ring |
| **Operating Temp.** | 415°C - 650°C  
(780°F – 1200°F)  
415°C - 650°C  
(780°F – 1200°F)  
385°C - 500°C  
(735°F – 930°F)  
390°C - 650°C  
(735°F – 1200°F) | 415°C - 650°C  
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(735°F – 930°F)  
390°C - 650°C  
(735°F – 1200°F) | 390°C - 650°C  
(735°F – 1200°F) |
| **Image** | ![Image](image1.png)  
![Image](image2.png)  
![Image](image3.png)  
![Image](image4.png) | ![Image](image1.png)  
![Image](image2.png)  
![Image](image3.png)  
![Image](image4.png) | ![Image](image1.png)  
![Image](image2.png)  
![Image](image3.png)  
![Image](image4.png) | ![Image](image1.png)  
![Image](image2.png)  
![Image](image3.png)  
![Image](image4.png) |
## MECS® Catalyst Portfolio

<table>
<thead>
<tr>
<th>Catalyst Type</th>
<th>LP</th>
<th>T</th>
<th>Cs</th>
</tr>
</thead>
</table>
| **Uses**      | - Low Pressure Drop  
- Moderate Velocity Converters | - Moderate Pressure Drop  
- Low Velocity Converters | - Greater Operating Flexibility  
- Faster Start-ups  
- Moderate Velocity Converters |
| **Shape**     | Ring | Pellet | Ring |
| **Operating Temp.** | 415°C - 650°C  
(780°F – 1200°F) | 415°C - 650°C  
(780°F – 1200°F) | 390°C - 650°C  
(735°F – 1200°F) |
| **Image**     | ![Image](image1.png) | ![Image](image2.png) | ![Image](image3.png) |
G = Geometrically Optimized

E = Enhanced Surface Area

A = Activity Improvement

R = Reduced Pressure Drop

Results in reduced capital cost, lower emissions and/or increased acid production

Comsol Multiphysics Finite Element Modeling

Red - high concentration of SO₂
Blue - low concentration of SO₂
for Greater Dust Capacity & Lower Pressure Drop

G = Geometrically Optimized

E = Enhanced Surface Area

A = Activity Improvement

R = Reduced Pressure Drop

GEAR® improves catalyst spacing in the converter bed

Saves energy and extends operating time between plant turnarounds
Energy Savings Case Study

- The GEAR® products can offer lower pressure drop and result in extended operating time

<table>
<thead>
<tr>
<th></th>
<th>GR-330</th>
<th>XLP-110</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clean Pressure Drop</td>
<td>85 mm W.C.</td>
<td>100 mm W.C.</td>
</tr>
<tr>
<td>24 Months Operating</td>
<td>500 mm W.C.</td>
<td>700 mm W.C.</td>
</tr>
<tr>
<td>27 Months Operating</td>
<td>900 mm W.C.</td>
<td>900 mm W.C.</td>
</tr>
<tr>
<td></td>
<td>Blower Limit</td>
<td>Blower Limit</td>
</tr>
</tbody>
</table>

* SB Plant: 25 ppm Ash in Sulfur
* MET/SAR Plant: Typical Gas Cleaning System Performance
## Energy Savings Case Study

<table>
<thead>
<tr>
<th>Plant Type</th>
<th>Plant Size</th>
<th>Estimated Energy Savings (USD/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spent Acid Regeneration</td>
<td>200 MTPD</td>
<td>$2200</td>
</tr>
<tr>
<td>Sulfur Burning</td>
<td>2000 MTPD</td>
<td>$17000</td>
</tr>
<tr>
<td>Metallurgical</td>
<td>3500 MTPD</td>
<td>$28000</td>
</tr>
</tbody>
</table>

### Energy Savings: Lower Clean Pressure Drop & Slower Pressure Drop Build-up

- Calculation for Pass 1 only
- XLP-110 vs. GR-330
- 2 year screening schedule
- 10.0¢/kwh electricity price
- Additional benefit: the value of the additional acid production during the extended operating time (not included in above calculation)
Innovative New Product Introductions
GEAR® Cesium Catalyst

GR-Cs combines low temperature benefits of cesium promoted catalyst with low pressure drop and dust handling capability of GEAR® Catalyst shape

- Superior dust handling (especially in pass 1)
- Energy savings
- Increase plant throughput
- Proven cesium formula / advanced GEAR® shape

Available Immediately
Improved Formulation SCX-2000

Super cesium formulation modification to enable ultra-low SO$_2$ emissions

- Application - last converter pass
- Significantly better than competitor’s cesium product based on
  - Extensive lab testing
  - Trial production runs
- Case studies planned at CNOOC in China and DuPont Borderland in U.S. to quantify actual performance improvement
Improved Performance of SCX-2000 Super Cesium Catalyst

Pass 4 Conditions for Typical U.S. Sulfur Burning Plant

- SCX-2000 at 390 C
- Improved SCX-2000 at 390 C

Improved SCX-2000 Reduces SO₂ Emissions

Δ 80 ppm
Improved Performance of SCX-2000 Super Cesium Catalyst

Less Catalyst Required with Improved SCX-2000
Case Studies Demonstrate Effective Performance
Plant Evaluation & Data Collection for Case Studies - PeGASyS Gas Testing

- PeGASyS provides an all-encompassing view into the gas side of a sulfuric acid plant
- Portable gas chromatograph delivers accurate, on-site analysis
- Evaluation and recommendations based on over 100 years sulfuric acid knowledge
- PeGASyS offers:
  - Maintenance Planning
  - Conversion Improvement
  - Gas/Gas Heat Exchanger Leak Detection
  - Increased Production
  - Troubleshooting

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Assessing Converter Bed Performance with PeGASyS

This sketch has been generated to represent basic plant gas stream to aid in sampling, and does not necessarily include all actual elements in the plant.

Sprhtr
From Sulfur Burner & Boiler

Pass 1
Pass 2
Pass 3
Pass 4

Hot IP HEX
Cold IP HEX

HRS
FAT

To Stack

S = sample point
Case Study 1: PCS Plant 7  
*Catalyst Success on a Mega Scale*

- Grass roots, large scale (4082 MTPD) sulfur burning plant designed by MECS
- Plant included MECS® proprietary equipment:
  - ZeCor® Final Tower
  - UniFlo® Acid Distributors
  - Brink® Mist Eliminators
  - MECS® Heat Recovery System (HRS™)
  - MECS® Catalyst

**Catalyst Design Requirements:**

- Robust design to overcome gas distribution, \( \text{SO}_3 \) removal and \( \text{SO}_2 \) emissions challenges in a large plant
- High conversion, low pressure drop design
Case Study 1: PCS Plant 7
*Catalyst Success on a Mega Scale*

MECS® Catalyst provides engine for largest SB acid plant in North America

- At 105% of design capacity, measured SO$_2$ emissions were 75% of maximum allowable level

<table>
<thead>
<tr>
<th></th>
<th>Design</th>
<th>Demonstrated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant Capacity (MTPD)</td>
<td>4082</td>
<td>4282</td>
</tr>
<tr>
<td>SO$_2$ Emissions (kg/MTPD)</td>
<td>1.00</td>
<td>0.725</td>
</tr>
</tbody>
</table>

- MECS preferred partner in mega-projects with 30 plant designs exceeding 3000 MTPD

* XLP-220 retired, now use XLP-110
Case Study 2: Fluorsid II
High Performance Catalyst Meets Customer’s Design Requirements

Catalyst Design Requirements:

- **Low CAPEX**
  - To save engineering costs
  - Plant 2 converter same size as existing Plant 1 converter

- **Low SO₂ Emissions**
  - Significantly lower SO₂ emissions requirement for Plant 2

- **Maximize Acid Production**
  - Expectation to operate at 110% of design capacity

<table>
<thead>
<tr>
<th></th>
<th>Plant 1</th>
<th>Plant 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant Rate (MTPD)</td>
<td>400</td>
<td>400</td>
</tr>
<tr>
<td>Inlet SO₂ (%)</td>
<td>11.5</td>
<td>11.5</td>
</tr>
<tr>
<td>SO₂ Emissions Guarantee (ppm)</td>
<td>400</td>
<td>140</td>
</tr>
</tbody>
</table>
Case Study 2: Fluorsid II
High Performance Catalyst Meets Customer’s Design Requirements

MECS Engineering Challenge:

- Converter size & catalyst volumes fixed
- No flexibility to add converter passes or additional catalyst to meet
  - Low SO$_2$ Emissions
  - Desired Acid Production

Catalyst design is critical in achieving SO$_2$ emissions
Case Study 2: Fluorsid II
High Performance Catalyst Meets Customer’s Design Requirements

GEAR® and Super Cesium Catalyst for maximum acid production with minimal SO₂ emissions

- Plant rate exceeded customer expectations
- Low SO₂ emissions after 10 months operation

<table>
<thead>
<tr>
<th></th>
<th>Design / Expected</th>
<th>After 10 Months</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant Capacity (MTPD)</td>
<td>400 / 440</td>
<td>448</td>
</tr>
<tr>
<td>Inlet SO₂ (%)</td>
<td>11.5</td>
<td>10.95</td>
</tr>
<tr>
<td>SO₂ Emissions (ppm)</td>
<td>140</td>
<td>85</td>
</tr>
</tbody>
</table>
Case Study 2: Fluorsid II
High Performance Catalyst Meets Customer’s Design Requirements

Exceptional Pressure Drop and Dust Handling

<table>
<thead>
<tr>
<th></th>
<th>Start-Up (August 2013)</th>
<th>Start-Up Values Normalized</th>
<th>PeGASyS (June 2014)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant Rate (MTPD)</td>
<td>411</td>
<td>448</td>
<td>448</td>
</tr>
<tr>
<td>Inlet SO₂ (%)</td>
<td>11</td>
<td>10.95</td>
<td>10.95</td>
</tr>
<tr>
<td>Pass 1 dP (mm w.c.)</td>
<td>90</td>
<td>105</td>
<td>102</td>
</tr>
<tr>
<td>Pass 2 dP (mm w.c.)</td>
<td>70</td>
<td>82</td>
<td>92</td>
</tr>
<tr>
<td>Pass 3 dP (mm w.c.)</td>
<td>105</td>
<td>123</td>
<td>133</td>
</tr>
<tr>
<td>Pass 4 dP (mm w.c.)</td>
<td>90</td>
<td>105</td>
<td>122</td>
</tr>
<tr>
<td>Total dP (mm w.c.)</td>
<td>355</td>
<td>414</td>
<td>449</td>
</tr>
</tbody>
</table>

After 10 months operation…

• No pressure drop build-up in Pass 1
• 8% overall pressure drop increase
Case Study 3: Enami Plant 2  
*Catalyst Revamp Revitalizes Plant*

- **Catalyst Design Requirement:**
  - Maximize efficiency and reduce emissions in existing single absorption plant
- Revamp with all new MECS® Catalyst (XLP-110 & XCs-120) to improve conversion
- PeGASyS testing (included with catalyst order) proved plant was performing well

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<th>Demonstrated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant Capacity (MTPD)</td>
<td>756</td>
<td>758</td>
</tr>
<tr>
<td>Conversion</td>
<td>96%</td>
<td>96.1%</td>
</tr>
</tbody>
</table>

- PeGASyS report recommended catalyst bed temperature optimization for better conversion and catalyst screening plan for next turnaround
- Local support from Holtec Ltda and excellent customer service benefits vital to project success
Case Studies Demonstrate Exceptional Results

Integration of high performance catalyst & MECS® technologies generates results that exceed customer expectations

  • Maximize conversion with new catalyst in existing plant
  • Energy conscious, low emissions designs
  • Greater acid production than design

Solutions for challenging engineering designs

Effective collaboration with local sales representatives
What Can MECS Offer?

- Innovative new catalysts that upgrade plant operations
- Catalyst designs for optimal plant performance
  - Meet low SO₂ emission requirements
  - Increase acid production
  - Reduce pressure drop
  - Extend production campaign
  - Improve dust handling
- World class knowledge of sulfuric acid
- Technical services for troubleshooting, maintenance, and optimization
The miracles of science™