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NEW PRODUCTS AND TECHNOLOGIES FOR THE SULFURIC ACID INDUSTRY

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RESUME

L'introduction de nouveaux produits et technologies dans l'industrie de l'acide sulfurique a permis des améliorations significatives dans la performance des unités. Monsanto Enviro-Chem a été leader dans l'application de ces améliorations à l'industrie. "L'acier inoxydable Sandvik SX" a totalement changé le point de vue de l'industrie sur les matériaux de construction. Cet acier inoxydable austénitique offre une telle résistance dans la fourchette 93-99 % de concentration d'acide, que la durée de vie de n'importe quel constituant en SX d'une unité devrait dépasser 20 ans avec un minimum d'entretien. Monsanto Enviro-Chem a conçu et installé plus de 200 tours, cuves de pompes, systèmes tubulaires et distributeurs en SX. Plusieurs de ces installations réussies seront présentées en détail dans cet exposé.

En utilisant le catalyseur ***dopé au césium*** *de Monsanto, beaucoup de producteurs d'acide sulfurique ont significativement réduit les émissions de SO_2 dans des unités à* ***simple absorption*** *aussi bien qu'à* ***double absorption****. Plusieurs exemples d'applications de* ***catalyseur au césium*** *seront présentés.*

Enfin, le système portatif d'analyse de gaz Monsanto Enviro-Chem ***(PeGASyS)*** *représente le fin du fin de la technologie pour l'évaluation de la performance d'une unité d'acide sulfurique. Plusieurs applications importantes de* ***PeGASyS*** *dans l'optimisation de la performance d'une unité grâce à l'évaluation du lit de catalyse et de l'échangeur de chaleur seront examinées dans cet exposé. Ces nouveaux produits et technologies fournissent aux producteurs d'acide sulfurique les outils nécessaires pour augmenter au maximum et rentablement la performance de leur unité.*

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BACKGROUND

As sulfuric acid plant operators move into the 21st century, environmental and legislative forces are bearing down upon them to pay closer attention to the issues of plant safety and operation. These forces coupled with the competitive drive to control costs, reliability and meet fiscal goals presents a challenging role for management. Social and fiscal responsibility dictate that the industry explore new ways of operating sulfuric acid plants. Monsanto Enviro-Chem is now providing three new products and technologies to address these crucial issues for their customers.

Sandvik SX sulfuric acid stainless steel™ offers a viable response to such issues of safety, reliability and maintenance. Outstanding corrosion resistance and welding properties make SX the preferred material of construction for 93% to 98% absorbing towers, acid pump tanks, acid piping systems, acid coolers, mist eliminators, sleeves, strainers and other components.

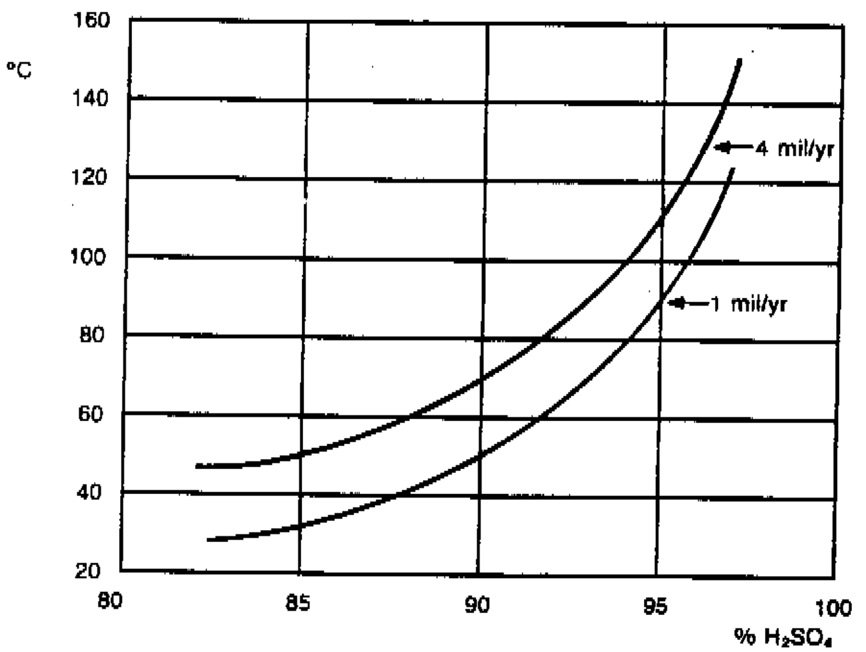
We will illustrate below the advantages of SX in applications that have traditionally been those where carbon steel brick lined vessels and cast iron piping systems have been the standard. The well known problems of acid seepage behind the brickwork, sulfate formation and leaks in the carbon steel shell are non existent with SX. During replacement of brick lined towers the problem of proper disposal of hazardous brick is an issue that must be dealt with carefully. SX vessels greatly extend the service life of the equipment. Catastrophic brittle failure and leaks in cast iron piping systems do not apply to SX piping systems where the number of flange connections are kept to an absolute minimum.

Corporate pollution reduction commitments as well as government regulatory requirements are responsible for the continuing trend to develop new and cost effective technologies to further reduce the SO_2 emission levels from sulfuric acid plants. Although both single and double absorption sulfuric acid plants are generally operating within authorized conversion limits, many companies are striving to reduce the SO_2 emissions as much as is technically and economically feasible. Until recently, the technologies to accomplish this goal were limited; improvements were made, but further advances were limited by thermodynamic, kinetic, and technological barriers. In this paper, we will present discussions of a new cesium-promoted catalyst which eases some of the aforementioned limitations and improves the overall conversion in sulfuric acid plants, resulting in significantly less SO_2 emissions to the stack. We will discuss several case histories of Monsanto cesium (Cs) catalyst installations and present new potential applications for the Cs catalyst technology.

We will also discuss the application of the Monsanto Enviro-Chem Portable Gas Analysis System (***PeGASyS***) in the optimization of sulfuric acid plant converter/heat exchanger performance. Using this state-of-the-art technology, we can quickly and easily identify catalyst or process problems which have resulted in poor plant performance. The ***PeGASyS*** service has become widely utilized throughout the world to characterize plant operations and reduce stack emission levels. In this paper, we will present a discussion of the ***PeGASyS*** technique and provide several examples of the application of the technology in plant environments.

SX sulfuric acid stainless steel

The most attractive feature of SX is the low corrosion rates that it exhibits in strong sulfuric acid. **Figure 1** illustrates the corrosion rates for SX in typical strong acid applications.



Isocorrosion diagram 1 mil/yr & 4 mils/yr for **SX** under static conditions

FIGURE 1 : Isocorrosion curve for SX under static conditions

As you can see from this curve, SX displays corrosion rates of less than 0.1 mpy (0.0025 mm/yr) in typical absorbing tower applications and less than 1 mpy (0.025 mm/yr) in most 93% drying tower applications. **Figure 2** illustrates the relative performance of SX as compared to other alloys used for 98% sulfuric acid applications in the past.

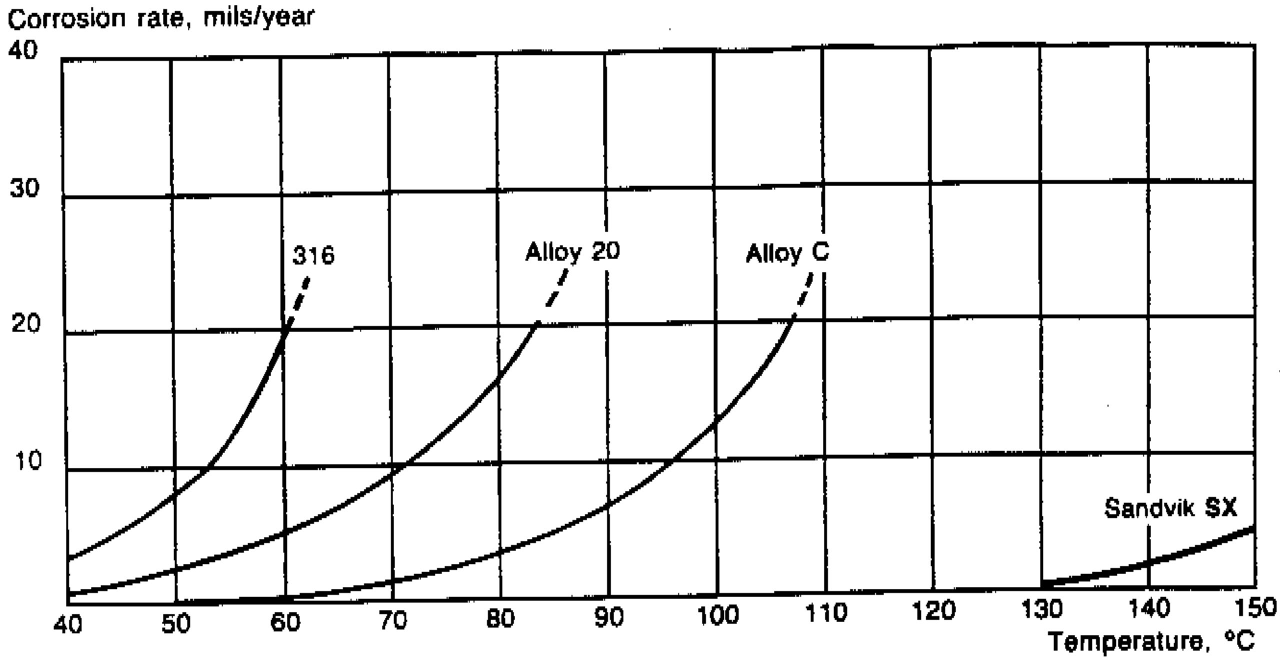


FIGURE 2: Approximate corrosion rates for various alloys in 98% sulfuric acid

APPLICATIONS FOR SX SULFURIC ACID STAINLESS STEEL

SX is now being widely used in the fabrication of towers, pump tanks, acid distributors, coolers and other components of an acid plant. The low corrosion rates referred to above are not affected by variations in velocities, temperatures or acid concentrations typical in a sulfuric acid plant. For high temperature applications such as Heat Recovery Systems (HRS), 310M stainless steel is the recommended alloy.

a) Acid distributors

By combining the corrosion characteristics of SX with the unique features of our trough and downcomer acid distributor design, we are able to offer a distinct advantage for acid distribution in a tower. Some of the benefits are:

- Improved acid distribution
- Improved operating reliability
- Improved safety
- Less maintenance
- No sulfate buildup
- No pluggage
- Longer life
- Lower installation costs

To date, we have over 75 such systems installed worldwide. This new design is now exclusively used in all new MEC acid plants. MEC's unique design eliminates the well known problems associated with traditional cast iron systems. Sulfates that collect in the tower packing are a well-known source of increased pressure drop across the tower and mist eliminators. This in turn results in mist carryover and SO_3 slippage due to higher gas velocities, resulting in lower production rates. The MEC acid distributor eliminates these problems.

Figure 3 (left) shows the appearance of the MEC acid distributor after years of service. The downcomer tubes can be directed in any pattern required to meet the desired distribution. The top portion of the tubes are slotted in a weir arrangement to ensure uniform and consistent flow. This design allows for tubes to be placed closer together and subsequently more downcomers can be accommodated in a given area. The net result is that fewer troughs are required as compared to the old cast iron systems. Because of the flexibility of adding up to 4.0 distribution points per square foot (43 pts/m^2), we can lower the packing height considerably, resulting in lower pressure drop and increased energy savings. Tower packing and/or chips will not restrict the flow through any downcomer tube. These troughs can be observed through the manway and should not require any maintenance once installed. Because of this, personnel safety is greatly enhanced. Since we assemble most of these troughs in the fabrication shop, the installation time is minimal. In addition the light weight of these distributors allow for easier handling.

FEATURE	ADVANTAGE	BENEFIT
Low corrosion rates	Corrosion rates for SX are less than 1 mpy (0.025 mm/yr) compared to cast iron rates of 30-100 mpy (0.76-2.5 mm/yr) .	Expected life of SX distributors is 20+ years compared to 5-7 years for cast iron.
Design of Trough distributors	Larger open area (80% vs. 50-60% for cast iron distributors).	■ Lower gas velocities. ■ Reduced mist generation by factor of 10.
	Weir type flow- precise control of acid flow.	■ Consistent acid flow throughout tower.
	No pluggage due to packing or brick chips.	■ No additional pressure drop.
	Maximum distribution of 4.0 pts./ft^2 vs. 1.3 pts./ft^2 (43 pts/m^2 vs. 14 pts/m^2) for cast iron systems.	■ Uniform distribution. ■ No SO_3 slippage.
	Fewer trough.	■ Lower installation costs. ■ Easier installation.
Safety and maintenance	No corrosion/Sulfate buildup	■ Virtually no maintenance. ■ Reduced chance of operator injuries.

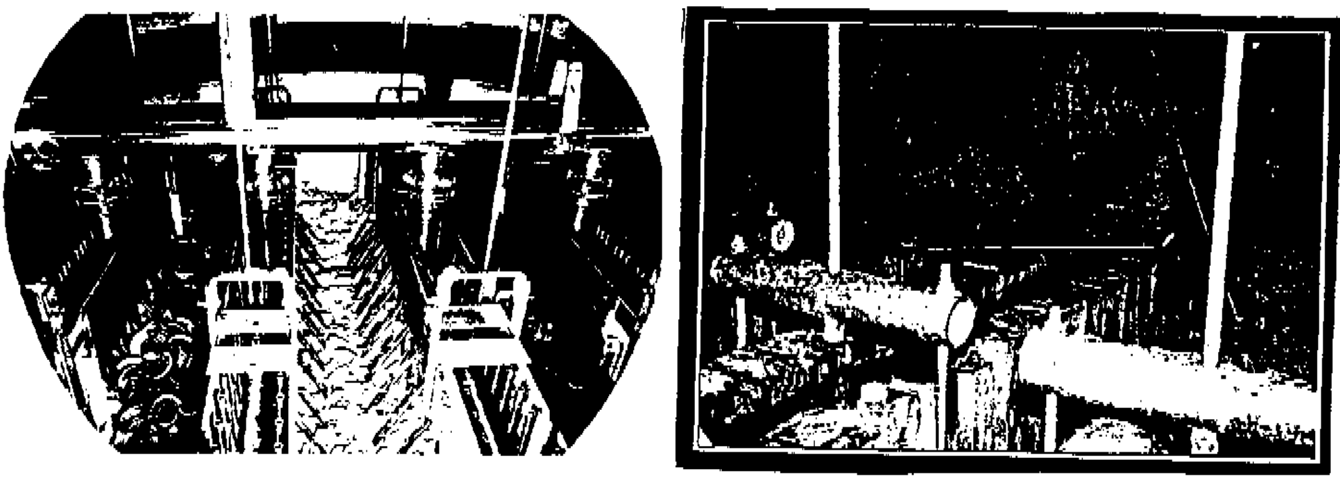


FIGURE 3: The advantages of SX trough distributors over traditional cast iron distributors

b) SX Vessels

SX towers and pump tanks (**Figure 4**) offer very long operational life with little or no maintenance required. Maintaining the integrity of the brickwork in carbon steel vessels can be costly and time consuming. This is not an issue with SX vessels. Acid pumps will also operate without the possibility of damage due to brick chips. Because these vessels are prefabricated in shippable modules in the shop, they can be field assembled or installed in a very short period of time thus reducing lengthy and costly shutdowns.

FEATURE	ADVANTAGE	BENEFIT
Low corrosion rates	Corrosion rates of < 1 mpy (< 0.025 mm/yr) No maintenance required	■ Vessel life of 20+ years ■ Reduced maintenance and costly shutdowns attributed to failure of brick work and carbon steel repairs.
Light weight construction	SX vessel will weigh considerably less than brick lined vessel.	■ Lower installation cost. ■ Lower foundation costs.
One piece construction Short lead times	Quick installation	■ Reduced downtime during shutdown.
Design	Smaller towers	■ Lower costs. ■ Reduced SO_x slippage. ■ Increased production rates

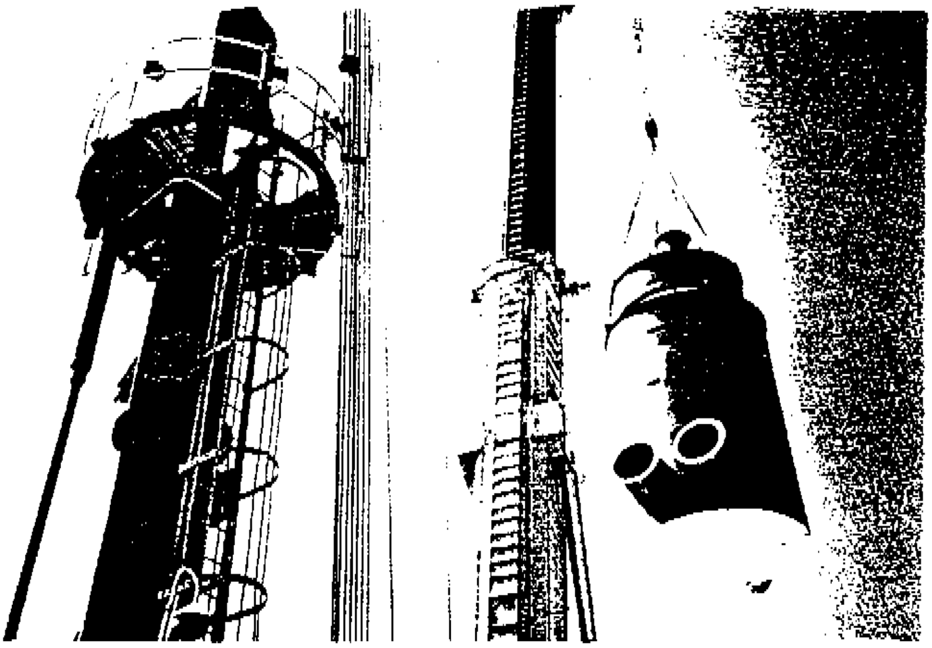


FIGURE 4: The advantages of SX vessels over carbon steel brick lined vessels

c) SX Piping Systems

Acid piping circuits are one of the most critical areas of concern in an acid plant. Traditional cast iron piping systems are bulky and require a large number of flange connections. Cast iron pipe under these conditions are susceptible to catastrophic brittle failures which can be very costly and dangerous. Because SX is very resistant to velocity erosion, piping systems can be downsized considerably based on allowable pressure drop. With SX, most of the flange connections associated with cast iron are eliminated completely. SX piping systems are maintenance free and alleviate the safety concerns of dealing with cast iron. SX provides a very real practical and economic advantage for such applications.

FIGURE 5: SX- vs. cast iron piping systems

ITEM	CAST IRON	SX
Acid leaks	Potential for serious acid leaks due to large number of flange connections.	■ No acid leaks. ■ Minimal number of flange connections.
Corrosion	Up to 100 mpy (2.5 mm/yr)	■ Less than 1 mpy (0.025 mm/yr)
Installation	Bulky and heavy cast iron pipe . High cost of installation.	■ Light weight. All pipe is pre spooled for easy installation.
Maintenance	Routine and costly maintenance associated with acid leaks.	■ Minimal maintenance. ■ All repairs can be performed using conventional welding techniques.
Acid flow velocities	Susceptibility to velocity erosion causes cast iron pipe sizes to be large.	■ SX pipe will be several diameters smaller in size.
Safety	Low ductility presents high risk of failure.	■ High ductility results in minimizing risk.

d) Acid Coolers

Monsanto Enviro-Chem offers acid coolers for all applications in a sulfuric acid plant. We have successfully installed over 150 acid coolers worldwide in the industry to date. Both anodically protected and non-anodically protected (SX) coolers are available based on the operating conditions and parameters in both fresh water and sea water applications. Typical service life of these coolers is 20+ years. All coolers are built to meet or exceed TEMA "C" and ASME Sec. VIII, Div. 1 standards for heat exchangers and pressure vessels.

As a world leader in sulfuric acid technology, Monsanto Enviro-Chem is in a unique position to offer a total systems approach to all equipment in an acid plant. Each cooler is designed with full understanding of the overall plant processes. As a result, the cooler is guaranteed to provide an optimum and trouble free service life.

Cs CATALYST DEVELOPMENT AND APPLICATIONS

In the contact sulfuric acid process, there is often an interest in lowering the inlet temperatures to the various adiabatic catalyst beds in order to provide more favorable equilibrium conditions. The addition of cesium (Cs) to the conventional alkali-vanadium sulfuric acid catalyst has long been known to enhance the low temperature properties of the catalyst **(1)**. The cesium salt promoter stabilizes the vanadium + 5 oxidation state at temperatures below 420°C (790°F) and keeps the vanadium species solubilized in the melt and available for reaction. In the conventional K-V catalyst, vanadium compounds precipitate out of the molten salt at lower temperatures, causing loss of catalyst activity **(2,3)**. At high temperatures(>430°C/806°F), the activity of the conventional catalyst and the cesium-promoted catalysts are fairly similar. However, near 410°C (770°F), the reaction rate of the conventional catalyst drops off dramatically due to the precipitation of vanadium compounds, while the Monsanto Cs catalyst maintains its activity level. As the temperature is further lowered, the cesium-promoted catalyst maintains a significantly higher reaction rate until the temperature drops well below 400°C (750°F). Although the reaction rate of the cesium-promoted catalyst drops off at relatively low temperatures, it is still sufficiently high to generate good conversion at acceptable catalyst loadings. Over the last several years, Monsanto Enviro-Chem has utilized its strong base in cesium catalyst studies **(4,5,6,7)** to develop an optimized and affordable cesium promoted catalyst (Cs-120 and Cs-110). These products contain the optimum levels of alkali metal salts (potassium and cesium) to provide excellent **low and high** temperature performance in the converter. Following extensive lab development and field testing, the products were commercialized in 1989 and have been installed in over 30 sulfuric acid plants worldwide.

There are many applications for the cesium-promoted catalyst in sulfuric acid plants. The smaller 9.5 mm (3/8 in) Cs-110 rings can be loaded into the lower beds and allow for lower bed inlet temperatures and higher overall conversion. **Figure 6** shows a graphical display of the advantage of using the Cs-110 catalyst opens a larger thermodynamic "window" which permits greater overall conversion. This higher level of conversion is not possible with the conventional catalyst at the lower inlet temperature as the catalyst loadings would have to be extremely high creating excessive pressure drop. A similar scenario can be devised for the lower beds of double absorption plants, resulting in lower stack emissions **(Figure 7)**.

Another cesium-promoted catalyst application involves installing a 33-50% cap of Cs-120 rings in the first pass of a sulfuric acid plant. This catalyst configuration will dramatically lower the required inlet temperature for good conversion in this bed. **Figure 8** shows that the conversion versus bed depth profile for a capped Cs-120 bed with an inlet temperature of 380°C (715°F). A full bed of conventional catalyst will produce very little conversion with this low inlet temperature at any reasonable catalyst loading. The lower first pass inlet temperature is advantageous for plants with very high inlet SO_2 strength. In this case, the lower inlet temperature will lead to a lower outlet temperature, therefore extending the life of the first pass exit posts and grids.

Furthermore, the overall conversion in the first pass will also be increased over that possible with conventional catalyst. The use of the Cs-120 rings in Pass 1 will also reduce the need for gas pre-heating in spent acid and metallurgical plants after short shutdowns.

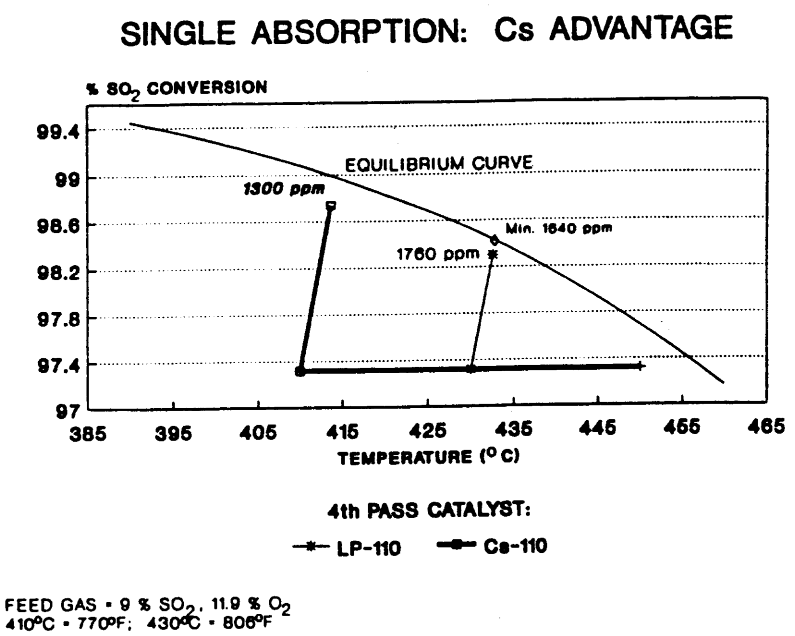


FIGURE 6: Cs-110 catalyst conversion advantage: Single Absorption Plant

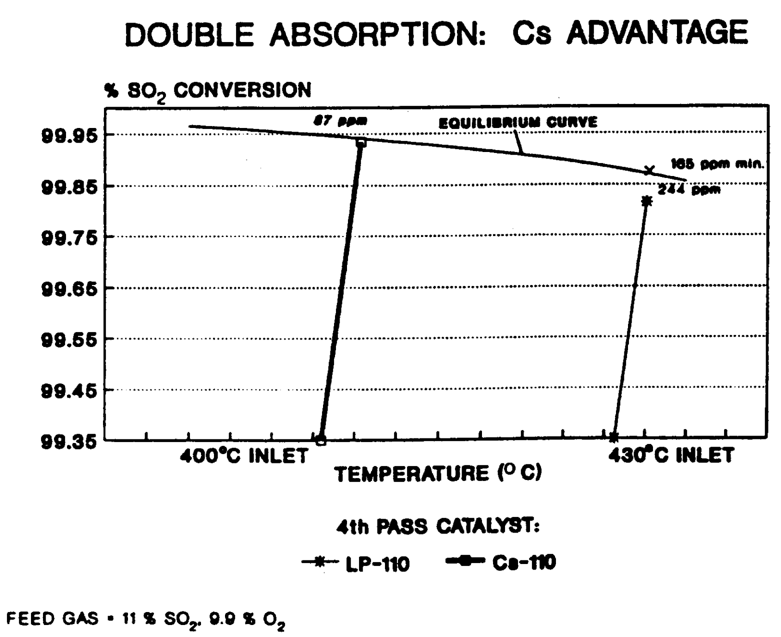


FIGURE 7: Cs-110 catalyst conversion advantage: Double Absorption Plant

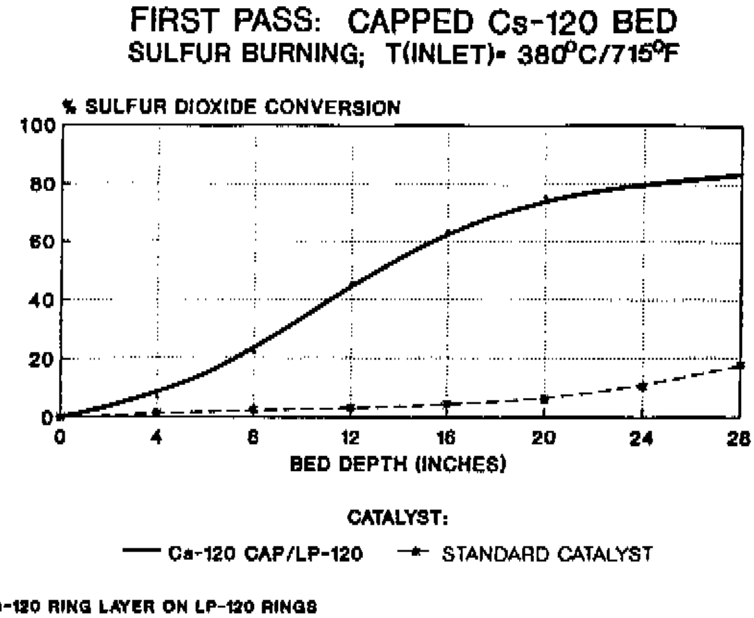


FIGURE 8: Conversion Profile: 1st Pass with Cs-120 Catalyst

The cesium-promoted catalyst can also be utilized in situations where heat exchanger deficiencies (undersized or plugged) limit the inlet temperatures to lower passes. The Cs-110 rings can effectively operate at the reduced temperatures and hence maintain the needed conversion in the lower beds. Also, the Cs-120 first pass caps and the full beds of Cs-110 in the lower passes can greatly reduce the time required to startup the sulfuric acid plant. The cesium catalyst beds will ignite at much lower temperatures than conventional catalyst beds and hence require less pre-heating. Also, due to the high activity at low temperatures, the cesium catalyst beds help to minimize the stack SO_2 emissions during plant startup operations. We will show examples of several of these cesium catalyst applications in subsequent sections.

Cs-110/Cs-120 CATALYST APPLICATIONS

The applications of the Cs-110 and Cs-120 catalysts in reducing SO_2 emissions will be presented as a series of case histories. Although the applications vary from plant to plant, the common threads in each case are lower stack emissions and improved operating versatility. Here we present four examples of Monsanto cesium-promoted catalyst performance (Note: STPD = Short tons acid produced per day; MTPD = Metric tons of acid produced per day):

Case 1: Single Absorption Sulfur Burning Plant

Pre-Cs Data

(1) Aging, conventional catalyst in all beds
(2) Pass 4 operating at 427°C (800°F) inlet temperature
(3) Conversion at 97.5% with 8% SO_2 feed gas
(4) Stack SO_2 emissions at 33 lbs/STPD (16.5 kg/MTPD)

Post-Cs Information

(1) Screened all beds; full fourth pass of Cs-110
(2) Pass 4 operating at 395-405°C (743-760°F)
(3) Conversion measured at 98.4% with 8% SO_2 fed
(4) Stack SO_2 emissions at 21 lbs/STPD (10.5 kg./MTPD; ***36% reduction***)

Case 2: Double Absorption Spent Acid Plant

Pre-Cs Data:

(1) Standard catalyst in all beds; 12% SO_2 gas strength
(2) Pass 1 at 405°C (760°F); Pass 3 at 400°C (750°F)
(3) Heat exchanger pluggage limited Pass 3 inlet temperature
(4) Pre-heater required, especially after short shutdowns
(5) Rate reduced to stay with SO_2 stack requirements

Post-Cs Information

(1) Cs-120 cap in Pass 1; full 3rd bed of Cs-110 rings
(2) Pass 1 inlet at 360°C (680°F); outlet at 600°C (1110°F)
(3) Pass 3 operating well at 400°C (750°F)
(4) Need for pre-heater virtually eliminated
(5) Rate dramatically increased with low SO_2 emissions

Case3: Double Absorption Sulfur Burning Plant

A new sulfuric acid plant was designed and built by Monsanto Enviro-Chem for the purpose of operating at high gas strengths (>11.5% SO_2) with stack emissions approaching 100 ppm SO_2. This novel converter design incorporated Cs-120 rings as a cap in Bed 1 and a full bed of Cs-110 rings in the final pass, operating at 390-400°C (734-750°F) inlet temperature. Following normal start-up adjustments and fine tuning, the Monsanto cesium catalyst beds are operating at or above expected levels and the plant emissions are near ***100 ppm SO_2***.

Case 4: Double Absorption Metallurgical Plant

Pre-Cs Data

(1) Gas strengths between 12 - 14 % SO_2
(2) First bed outlet temperature > 660°C (1220°F)

Post-Cs Information

(1) 50% cap of Cs-120 rings installed in first pass; March 1992
(2) First bed inlet/outlet temperatures: 380°C (715°F) and 610°C (1130°F)
(3) Operated for two years without screening
(4) Screening losses < 10%

Several other applications for the cesium promoted catalyst are under consideration. Scenarios have been developed for increasing the acid production rates for double absorption plants and yet maintaining the same permitted hourly SO_2 emissions. Using Cs-110 rings in the bottom pass of double absorption plants, it is possible to reduce the lbs. SO_2 per ton of acid and hence allowing for greater production at the same SO_2 ppm level in the stack.

In order to take advantage of the benefits of the cesium-promoted Cs-120 and Cs-110 catalyst, there are some considerations that need to be evaluated prior to installation. Firstly, the heat exchange capacity in the plant must be evaluated in order to insure the feasibility of reaching the lower inlet temperatures required for the cesium catalyst beds. Secondly, the highly active cesium-promoted catalyst has a more mobile molten salt than that of the conventional catalyst, which has a slightly greater tendency for accumulating incoming converter dust. The larger Cs-120 rings (12.5 mm, 1/2 in.) were developed to minimize the potential pressure drop buildup and yet maintain the required performance. The low temperature benefits of the Cs-120 rings in the first pass must be weighed against the slight possibility of higher pressure drop. Cs-110 applications in all other passes must have been in operation for over two years without any indication of pressure drop buildup and/or loss of activity.

Overall, the use of the Monsanto cesium-promoted catalyst in sulfuric acid converters has contributed to the significant reduction in SO_2 emissions and improved operability of the acid plants.

PORTABLE GAS ANALYSIS SYSTEM (*PeGASyS*)

The Monsanto Enviro-Chem Portable Gas Analysis System was developed several years ago to provide sulfuric acid producers with the means to fully characterize their plant operations. The ***PeGASyS*** system consists of a highly specialized gas sampling system and the state-of-the-art gas analyzer. **Figure 9** shows a photograph of a portion of the gas analyzer system, including the specially designed gas syringe. The analyzer is generally set up near a control room or laboratory and occupies a desk-sized space. A gas sample is taken from a slip stream of gas at the converter, heat exchanger, or absorbing tower pressure tap (or any available sampling port). The gas sample is then injected into the analyzer (state-of-the-art gas chromatograph) which accurately determines the SO_2 and O_2 levels. The ***PeGASyS*** method for characterizing the sulfuric acid plant operations is much more reliable and accurate than the standard wet chemical Reich test method. A typical sulfur burning plant can be completely analyzed in only a few hours with the ***PeGASyS*** system.

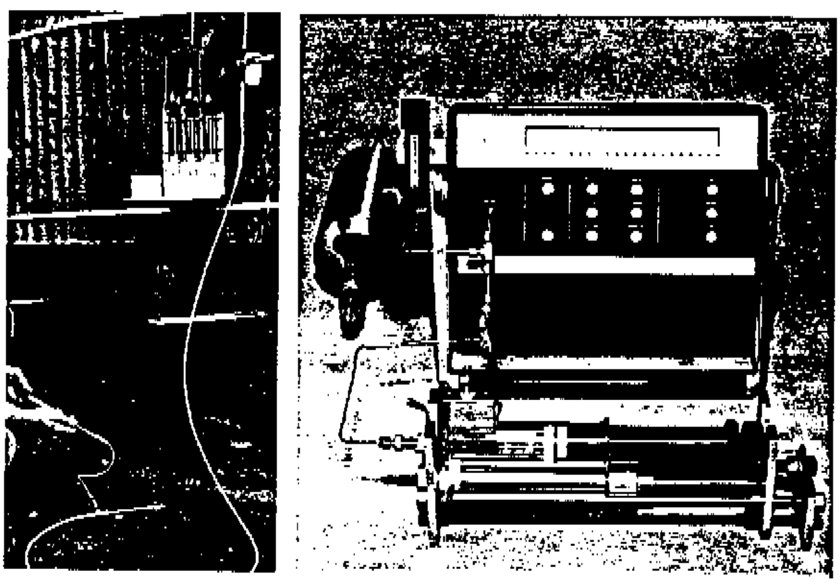


FIGURE 9: Gas Sampling and *PeGASyS* Analyzer

The results obtained with the ***PeGASyS*** system consist of an analysis report of the SO_2 and O_2 levels in each sample and a conversion calculation for each specific converter sample based on the inlet gas to the first bed. **Figure 10** shows a typical Converter Performance Summary for a sulfur burning double absorption plant. The custom ***PeGASyS*** software also calculates gas flow rates based on the given production rates. Utilizing the ***PeGASyS*** data, the converter performance can be effectively simulated using Monsanto Enviro-Chem proprietary modeling software. This information can then be used to optimize the plants operations, adjusting bed inlet temperatures, upgrading catalyst charges to maximize conversion and minimize SO_2 emissions.

CUSTOMER NAME: EXAMPLE DATA FILE: XXX001.SAM

PLANT LOCATION: U. S. A.

PLANT NUMBER: 3

PLANT TYPE: SULFUR BURNER DOUBLE ABSORPTION

SAMPLE NO.	SAMPLE IDENTIFICATION	DATE / TIME OF SAMPLE		% SO_2	% O_2	% CONV.
5	SULFUR BURNER OUTLET	4-1-91	1600	11.209	9.506	1.563
4	FIRST PASS OUTLET	4-1-91	1600	5.135	6.998	59.394
3	SECOND PASS OUTLET	4-1-91	1600	2.088	5.638	84.269
2	THIRD PASS OUTLET	4-1-91	1600	0.911	5.144	93.257
1	FOURTH PASS OUTLET	4-1-91	1600	0.035	4.771	99.744
		SULFUR BURNER GAS		11.366	9.580	

SAMPLE NO.	SAMPLING POINT
1	OUTLET OF FINAL TOWER ABOVE MIST ELIM.
2	PASS 4 INLET AT CONVERTER TAP
3	PASS 3 INLET AT CONVERTER TAP
4	PASS 2 INLET AT CONVERTER TAP
5	PASS 1 INLET AT CONVERTER TAP

	KG/HR.	LBS./HR.
SULFUR FEED RATE	26054.80	57441.31
SO_2 EMISSIONS	133.04	293.30

LBS.SO_2/TON = 3.35 KG SO_2/TON = 1.67

	NM^3/HR	SCFM
AIR TO SULFUR BURNER	160139.22	94243.89
CONVERTER INLET GAS	160139.22	94243.89
CONVERTER OUTLET GAS	132907.50	78217.69
DILUTION AIR	0.00	0.00
TOTAL GAS TO PLANT	160139.22	94243.89

PRODUCTION RATE = 2100.00 SHORT TONS PER DAY

NOTE: ALL GAS VOLUMES ARE BASED ON DRY, SO_3-FREE GAS.

CATALYST BED TEMPERATURES

L/STPD	BED	°F	°C
	1 IN	779	415
31.5	1 OUT	1130	610
	RISE	351	195
	2 IN	824	440
33.0	2 OUT	988	531
	RISE	164	91
	3 IN	831	444
38.5	3 OUT	891	477
	RISE	60	33
	4 IN	795	424
50.5	4 OUT	844	451
	RISE	49	27
	5 IN		
	5 OUT		
	RISE		
TOTAL RISE		624	346

FIGURE 10: Converter Performance Summary

Another important application of the *PeGASyS* system is in gas-gas heat exchanger leak detection. The exchanger must have shell side and tube side gas streams which contain different SO_2 levels in order for the analysis to be effective. Figure 11 shows the typical output for a heat exchanger analysis. Often, leaking heat exchangers contribute to high SO_2 emissions by bleeding high SO_2 gas directly to the stack or flooding lower pass catalyst beds with SO_2-rich gas. Once the leaking exchanger is identified, it can be repaired, leading to a direct reduction in the stack emissions.

DATE / TIME: 4-1-91 / 1500 FILE: INTHEX.HEX

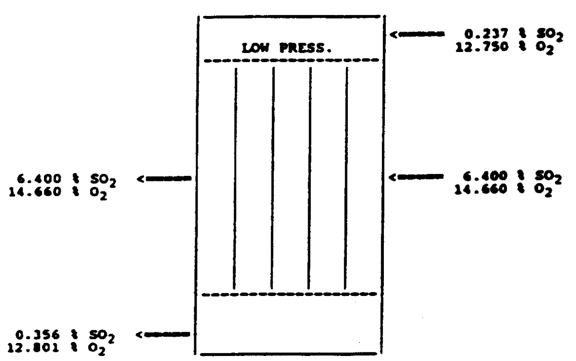
CUSTOMER: EXAMPLE

PLANT LOCATION: U. S. A.

PLANT NUMBER: 1

PLANT TYPE: METALLURGICAL; SINGLE ABSORPTION

HEAT EXCHANGER: INTERMEDIATE HEX



2.0 % OF SHELL SIDE GAS IS LEAKING INTO TUBE SIDE

TUBE SIDE INLET GAS WAS SAMPLED AT:

INLET TO INTERMEDIATE HEX

TUBE SIDE OUTLET GAS WAS SAMPLED AT:

PASS 4 INLET AT CONVERTER

SHELL SIDE GAS WAS SAMPLED AT:

PASS 1 INLET AT CONVERTER

FIGURE 11: Heat Exchanger Evaluation Summary

There are a number of examples of the application of the ***PeGASyS*** technology to improving sulfuric acid plant operations. We present the following discussions of several case histories of typical applications of the ***PeGASyS*** service to reducing stack emissions and improve plant operations:

Case 1: Spent Acid Double Absorption Plant

Issue: SO_2 emissions higher than expected

Result: ***PeGASyS*** analysis indicated that the aging first pass was operating at a reduced efficiency. Replacement of the first pass resulted in significant reduction in stack emissions.

Case 2: Sulfur Burning Double Absorption Plant

Issue: SO_2 emissions were approaching permitted limit

Result: ***PeGASyS*** analysis indicated a severe leak in the cold heat exchanger. Following exchanger repair, SO_2 emissions decreased from 3.9 lbs/STPD to 2.0 lbs/STPD (2 kg/MTPD to 1 kg/MTPD).

Case 3: Metallurgical Double Absorption Plant

Issue: Emissions extremely high (1500 ppm SO_2)

Result: ***PeGASyS*** analysis showed a small but significant leak in the Cold Heat Exchanger which was directly channeling 1st pass inlet gas to the plant stack.

This leak resulted in raising the stack emissions from 300 ppm SO_2 to the observed 1500 ppm SO_2. The leak was eventually repaired and the plant returned to acceptable operating conditions.

Case 4: Sulfur Burning Double Absorption Plant

Issue: SO_2 emissions approaching allowed limit

Result: ***PeGASyS*** analysis of the Hot Interpass Heat Exchanger identified significant leak which was allowing some 2nd pass outlet gas to channel directly to the 4th pass inlet, resulting in the observed poor conversion performance in the plant. All of the catalyst beds were found to have excellent conversion efficiency.

As you can see from these examples, the Portable Gas Analysis System is an extremely effective tool for optimizing sulfuric plant operations and reducing stack SO_2 emissions. In a number of cases, the ***PeGASyS*** results have led to the installation of Monsanto cesium-promoted catalyst which resulted in the best overall conversion and the lowest level of sulfur dioxide escaping to the atmosphere.

CONCLUSIONS

Monsanto Enviro-Chem has long been acknowledged as a world leader in sulfuric acid technology. Our commitment is to provide the most effective solutions to all challenges facing this sulfuric acid industry. All engineered products offered by MEC are backed by the years of experience, knowledge and understanding of your specific needs. The introduction of SX several years ago has been a resounding success with substantive benefits realized by many acid plant operators. We are confident that SX will be the standard material of choice by the industry well into the next decade.

The effectiveness of the Monsanto Enviro-Chem cesium-promoted catalyst (Cs-120 and Cs-110 rings) in improving sulfur dioxide conversion and reducing stack emissions has been demonstrated in a number of applications. We discussed specific examples of case studies for both single and double absorption plants. Monsanto cesium-promoted catalysts can be used in a variety of situations, resulting in reduced emissions as well as enhancement of the versatility of the plant operations. In many situations, the Cs catalyst can be used to reduce the impact of heat exchanger limitations. Cesium catalyst effectiveness in both single absorption and double absorption plants has been demonstrated and novel applications are still under development.

The Monsanto Enviro-Chem Portable Gas Analysis System (***PeGASyS***) has effectively been used in a variety of plant to optimize converter performance and identify problem areas. We showed you that the ***PeGASyS*** results can be instrumental in assisting the plant personnel in reducing their SO_2 emissions.

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