

MEMORANDUM

TO: A.W. Fleming

CC: J.S. McAlpine, K. Morton, G. Greenhill

FROM: K. Blower

SUBJECT: SINTERED METAL FILTERS FOR HIGH TEMPERATURE APPLICATIONS

DATE: January 23, 1989

On Friday, 20 January 1989, I visited Pall Corporation Laboratories on Long Island, New York with K. Morton and N. Figus (Fenco) to discuss the technical application of Pall products to the Warox plant proposed for construction at Yellowknife.

We met with six staff over a period of several hours to discuss in detail our application. Their most senior representative was Paul Johnson, Associate Director of Pall. Others of note were: Brian Donovan, General Sales Manager and Barry McLeod, Canadian Manager of Process Filtration Applications.

Most of the industrial applications are at classified facilities such as nuclear power plants and it was necessary to demonstrate our legitimate application for their product prior to having an in-plant visit.

Having completed this step, Pall are actively arranging a visit for Friday, this week or Monday, next week. I have given them my position that before any further discussion or action occurs I must see a production application and discuss maintenance and operating problems with the user.

We did obtain a list of Industrial installations similar to the Warox plant application (copy attached). The nearest facility is in Montreal, P.Q. where Chemetics (a division of C.I.L.) are using a classified system. This was confirmed by Doug Rostron, a consulting Engineer who has worked for Giant Yellowknife on process applications. He reports that the Chemetics installation is absolutely maintenance free for their period of operation to date (1 to 2 years).

The Pall filters are obviously the Cadillacs of filters. They spend big bucks on process development to ensure that the hardware is appropriate to the application.

A plant visit is required before I can feel confident that this sintered metal filter is the answer. In the meantime I am impressed with the technical strength of Pall Corporation, their attention to technical detail and their confidentiality.

We have agreed to the following action list:

1. Industrial Site Visit; if O.K. then
2. Visit by Pall technical Representative to R.P.C. to look at pilot application
3. Board decision to proceed with project
4. Retrofit of filter in pilot plant.
5. Test run in pilot plant to demonstrate suitability
6. Full scale design of production unit
7. Manufacture (16 weeks from approved drawings).

One important point that evolved from our discussions in New York was that it is not possible to collect a separate antimony product by filtration alone. If the filter works as designed, it should remove 99.9% (minimum) of all solids. Antimony would have to be extracted from Hot Baghouse dust by chemical means.

I will keep you advised of progress on this.

If you wish to send the attached bulletin to Gordon, please do so.



Ken Blower

KB/ja

Att.: 7

1000+°F TEMPERATURE APPLICATIONS FOR
PALL SELF CLEANING BLOWBACK FILTER SYSTEMS

SHALE OIL RECOVERY - Retort off-gas clean up at Gulf R&D Pittsburgh. Gulf is using Hastelloy X filter elements at 1400°F. Exxon, Baytown, Texas is using Inconel filters for their 1100°F off-gas temperature.

CATALYST ACTIVATOR FILTERS for licensees of the Unipol and Phillips Polyethylene Process use Hastelloy X elements at 1600 - 1750°F. Pall has more than twenty installations worldwide.

BIO-MASS GASIFICATION - HIGH PRESSURE - 310S porous stainless steel filters for the Bio-Syn Project in Quebec, Canada. Pall supplied not only the filter and ceramic housing, but also the heating system and the fail-safe instrumentation to prevent the build up of tars on the filter elements. The design temperature is 1400°F at 265 PSIG.

In addition, Pall has Hastelloy X filters operating at 800°C on the pressurized gas system for Studsvik Engineering Teknik in Nvskoting, Sweden. These filters have more than 1000 hours' service.

BIO-MASS GASIFICATION - LOW PRESSURE - Pall is working with Gasification Systems Limited in New Hampshire for low pressure gasifier systems suitable for lumber mills. The typical temperature is 1000°F. The filters consist of our 304 stainless steel sintered wire mesh.

OEM's - Pall is working with the several OEM's who manufacture fluid bed processing equipment. We have sold SST, Inconel 600, and Hastelloy X filters for applications up to 1650°F.

GOLD ROASTING - Amax is using our 310 stainless steel filters at 1100°F to capture fines from their fluidized roasting bed. The process involves oxidizing gold ore by driving off the sulfur. 310 SST was chosen for its resistance to sulfidation.

FLUID CAT CRACKING - Amoco has successfully used Pall Inconel 600 to filter the 1100°F regenerator flue gas (CO and CO₂) in a pilot plant study for several years. These elements held up well, even in the presence of some SO₂ and SO₃.

NUCLEAR FUEL PROCESSING - General Atomics is using our Hastelloy X elements at approximately 1800°F in a proprietary process.

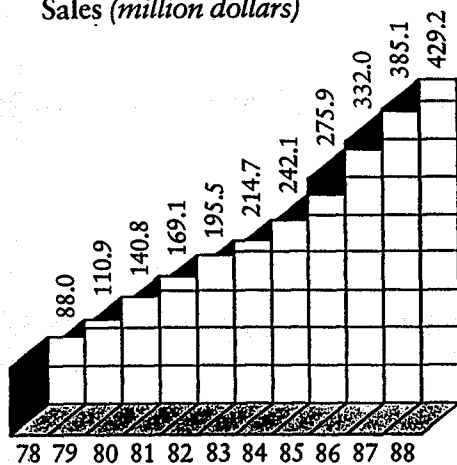
W

e are advancing filtration
technology and, at the same time, enhancing our multi-regional
capability to realize opportunities in an increasingly global market.

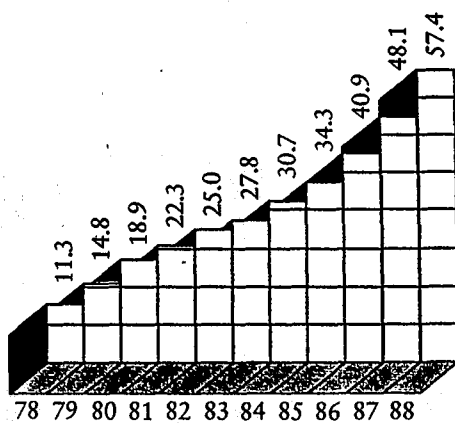


	<i>For the Years Ended</i>		% Increase
	July 30, 1988	August 1, 1987	
Net Sales	\$429,228,000	\$385,142,000	11%
Earnings Before Income Taxes	\$ 84,862,000	\$ 67,774,000	25%
Income Taxes	\$ 27,458,000	\$ 19,688,000	39%
Net Earnings	\$ 57,404,000	\$ 48,086,000	19%
Earnings Per Share	\$1.55	\$1.31	18%
Depreciation Deducted From Earnings	\$ 20,912,000	\$ 17,735,000	18%
Total Assets at End of Year	\$570,444,000	\$521,524,000	9%
Gross Investment in Plant and Equipment	\$306,732,000	\$273,616,000	12%
Working Capital	\$153,720,000	\$129,879,000	18%
Stockholders' Equity	\$321,353,000	\$267,182,000	20%
Average Shares Outstanding	37,041,000	36,796,000	
Equity Per Share Outstanding At Year End	\$8.65	\$7.23	20%

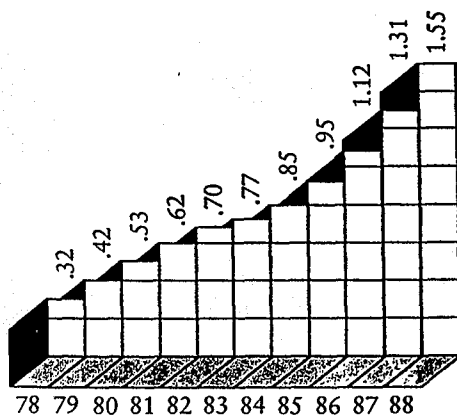
Sales (million dollars)



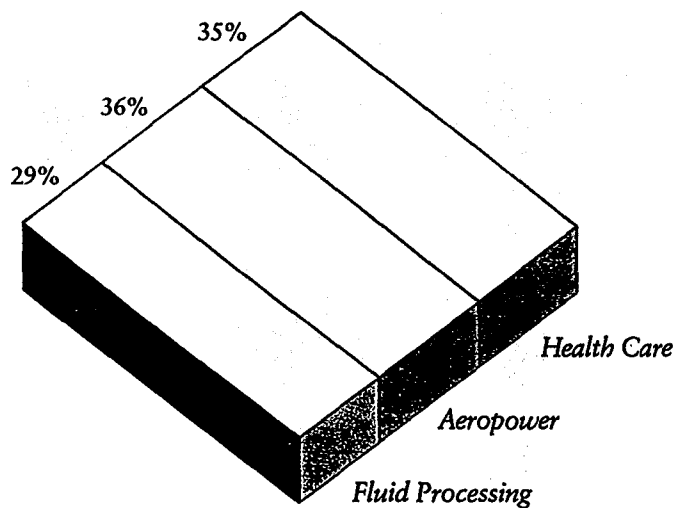
Earnings (million dollars)



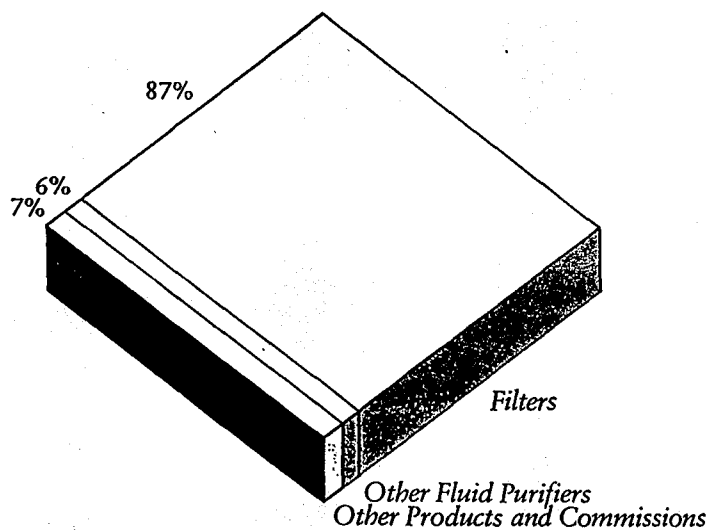
Earnings Per Share* (dollars)



Sales by Market



Sales by Product





GSS FILTER VESSELS JET PULSE DESIGN

GSS-V1
November 1987

Description

Pall jet pulse design vessels are fitted with the GS series of PSS® sintered metal powder elements. Jet pulse blowback is used in GSS systems to separate solids with a bulk density greater than 20 lb/ft³, which will settle easily after being dislodged from the filter elements. Blowback is accomplished by directing a short duration pulse of high pressure gas into the throat of each element, while maintaining full forward flow at all times.

The vessels are available in carbon steel, 304 stainless steel, or other alloys as required. Standard designs offer a maximum pressure of 600 psig at 400°F and a maximum temperature of 1400°F at 100 psig (see Table 1). Higher design limits are available. Other options include refractory linings for high temperature insulation, jacketed vessels for precise temperature control, and fluidizing cones to assist solids discharge. External mounting lugs are provided as standard. All vessels are designed for ASME Section VIII, Division 1 and "U" stamped. The system includes all instrumentation and solenoid valves to control blowback operation.

The vessel head is bolted to the vessel, capturing the tube sheet and elements between the vessel body flanges. This allows for easy access and removal of the elements should service be necessary. The elements are located between the tube sheet and a support grid, with the gas inlet below the grid. A cone angle of 30° is standard to facilitate solids discharge.

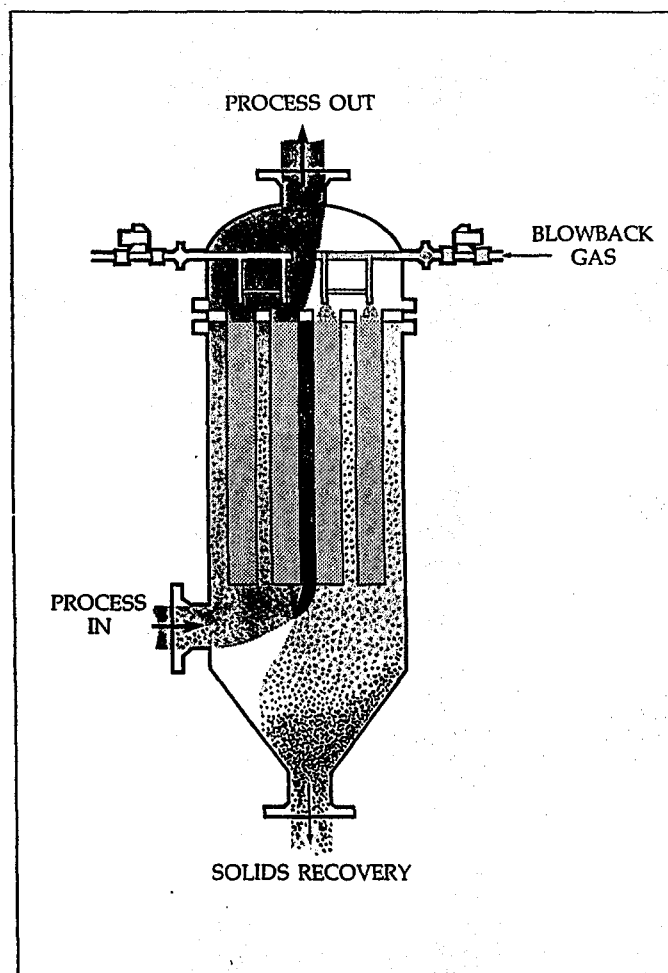


Figure 1. Jet Pulse Blowback Schematic

Table 1. Vessel Specification

Carbon Steel				Stainless Steel			
Type	Flanges	Pressure (PSIG)	Temp (°F)	Type	Flanges	Pressure (PSIG)	Temp (°F)
Low Pressure	150 lb.	50	750	Low Pressure	300 lb.	10	1400
		60	650		150 lb.	50 60	900 400
High Pressure	600 lb.	500	750	High Pressure	600 lb.	100	1400
		600	650			500 600	900 400

Table 2. Filter Characteristics

* Number of GS Elements	Area Ft. ²	Vessel Diameter (Inches)	Vessel Length (Inches)	Inlet/Outlet Nozzles (Inches)	Drain Nozzles (Inches)	Dimension A (Inches)	Dimension B (Inches)	Differential Pressure Loss Factor K_v
5	20	10	100	3	3	92	10	1.9×10^{-4}
10	40	14	110	4	4	98	14	5.1×10^{-5}
19	76	18	120	6	6	105	19	1.3×10^{-5}
31	124	22	128	8	6	108	20	4.6×10^{-6}
42	168	26	132	10	8	112	22	2.4×10^{-6}
68	272	32	140	12	8	116	24	9.5×10^{-7}
96	384	38	152	14	10	126	28	5.0×10^{-7}
130	520	44	164	18	10	138	36	2.5×10^{-7}
170	680	50	176	20	12	148	42	1.5×10^{-7}

Table 3. Approximate Vessel Weights (lbs.)

Vessel Diameter (Inches)	Carbon Steel (Weight)		304 SST (Weight)	
	Low Pressure	High Pressure	Low Pressure	High Pressure
10	500	1050	450	1000
14	750	1550	700	1550
18	1150	2550	1000	2550
22	1750	3650	1550	3900
26	1850	5100	1850	5400
32	2600	7400	2600	7400
38	3750	9800	3750	9800
44	5200	13600	5200	13600
50	6550	19650	6500	19650

Pressure Drop Calculations

Clean Pressure Drop:

Clean $\Delta P = \Delta P_{\text{Vessel}} + \Delta P_{\text{Filter Elements}}$

$$= K_v \rho Q^2 + K_m \mu Q / A$$

where K_v and K_m are loss coefficients for the vessel and filter medium respectively, ρ is the gas density in lb/ft^3 , μ is the viscosity of the gas at operating conditions in centipoise, Q is the gas flow rate in ACFM and A is the filter area in ft^2 . The terminal pressure drop at which the filter is blown back is determined by the customer to fit within the pressure drop available in the system. K_v values are given in Table 2.

K_m values are:

PSS Grade	K_m (for 3/32" medium thickness)
PH	2.0
PF	0.45

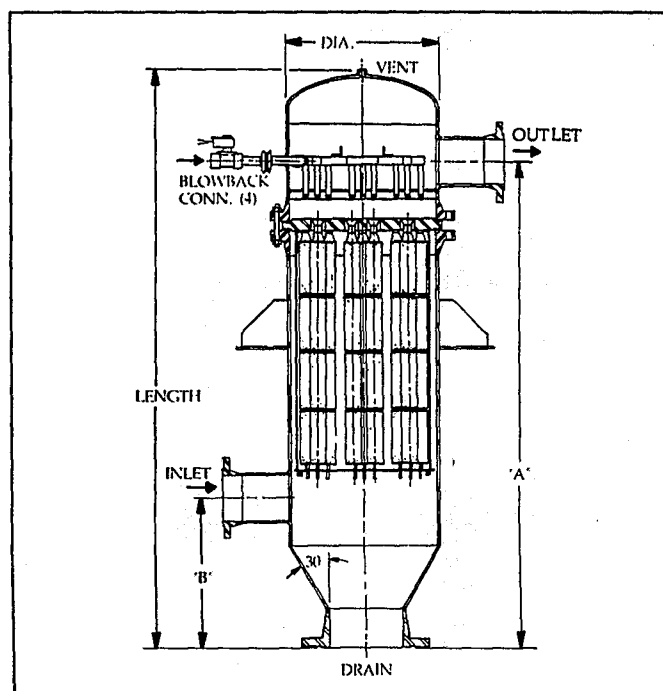


Figure 2. Dimensional Drawing of a Standard Jet-Pulse Design Vessel



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Serves the Refinery, Natural Gas, Petrochemical, Polymer, Chemical Process, Minerals, Electric Power, Pharmaceutical, Electronics, and Food and Beverage Industries.



Porous metal filters prevent fluid bed catalyst loss

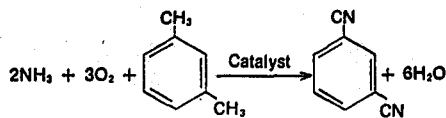
Expensive vanadium catalyst retained in fluid bed; no other particulate collection required

MICHAEL N. SCHWENDEMAN, Plant Manager
ROGER McBRIDE, Technical Manager
DAN REUTER, Process Engineer
Diamond Shamrock Corporation
Greens Bayou Plant
Houston, Texas

MARX ISAACS, Houston Regional Editor

Porous metal filters are the only devices required to provide high retention of catalyst solids in two high temperature fluidized beds at Diamond Shamrock's Greens Bayou site. Operating at over 750°F, the reactor and re-oxidizer fluid beds contain a vanadium catalyst that is too costly to lose by elutriation. The porous metal filters not only retain the catalyst within the fluid beds, but, since optimization of the filter metallurgy, do so with a minimum of downtime for cleaning and maintenance.

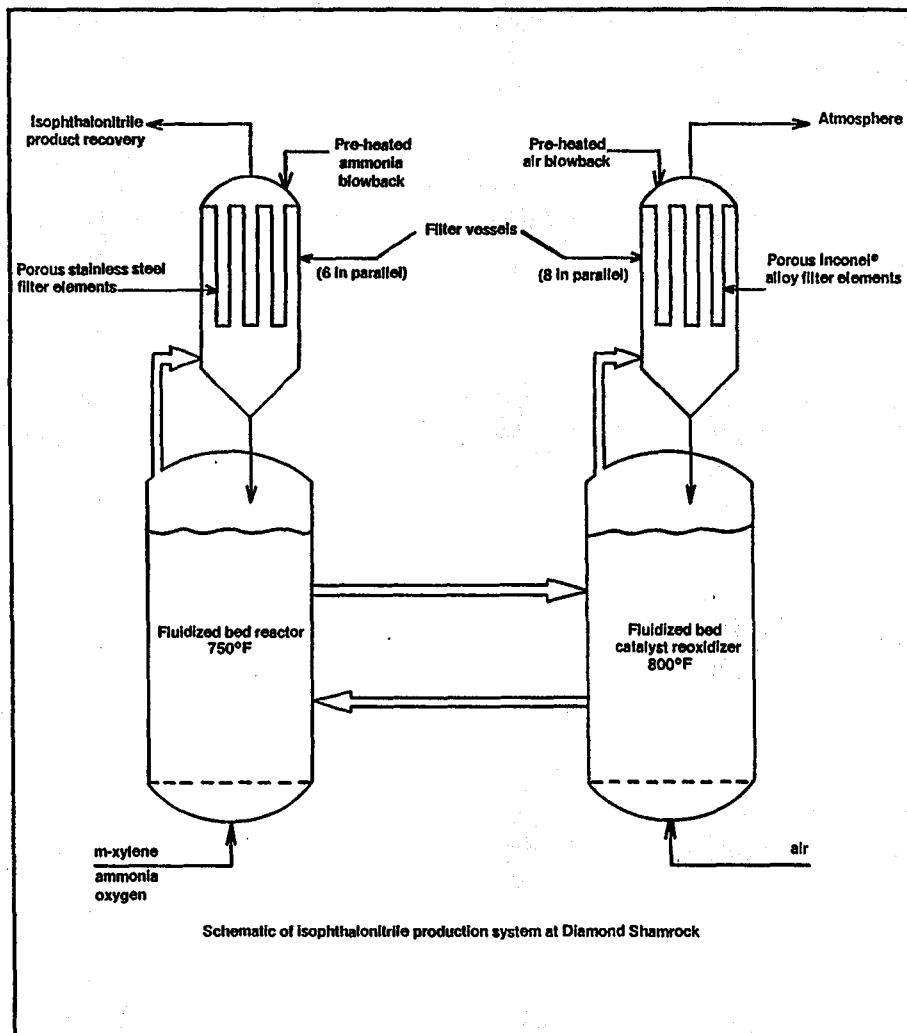
In 1976, Diamond Shamrock began operation of a unit to produce isophthalonitrile, an intermediate in the production of herbicides and fungicides. Using the basic chemical reaction



Diamond Shamrock chose a proprietary aromatic nitrile process technology that had not previously been applied commercially. The process uses a vanadium catalyst in a fluid bed reactor operating at 750°F, with catalyst being continuously reoxidized in an adjacent re-oxidizer fluid bed.

Minimizing loss of the expensive vanadium catalyst was essential to the economic viability of the project. Catalyst loss could also cause other difficulties. Elutriation from the reactor could enter the downstream product recovery system, causing operating problems, and losses from the re-oxidizer could be emitted to the atmosphere, causing environmental problems.

Conventional cyclones normally used to retain solids in high temperature fluid-



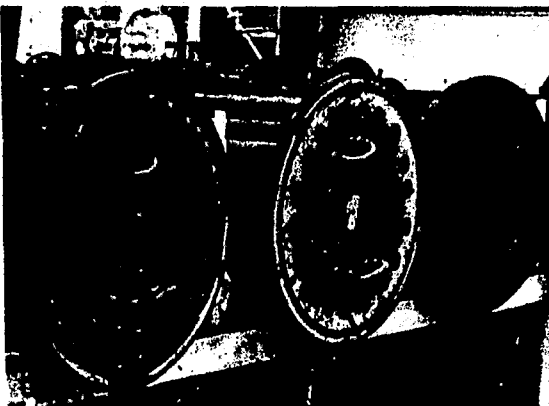
Schematic of isophthalonitrile production system at Diamond Shamrock

Filter modules removed for inspection and cleaning

ized beds were not considered efficient enough for this process. Therefore, Diamond Shamrock installed a porous metal blowback filter system on the exit gas stream from each fluid bed to provide positive particle retention.

The overall system (see flow chart) provides parallel banks of filter vessels on each fluid bed to allow sequential blow-back of each vessel. To accommodate the different flow conditions in the two fluid beds, the reactor was equipped with 6 vessels while the re-oxidizer was equipped with 8.

Initially, each vessel was equipped with 57 1/4" diam filter elements fabricated from sintered stainless steel powder to provide removal of particles 3 microns and larger. Since this was the first operating system of any size for this process, the startup was not uneventful. Operating conditions of the re-oxidizer were slightly different than anticipated. The stainless tubes experienced embrittlement, cracking, and buildup of catalyst between tubes. Thus, a change in the filter element configuration and metallurgy for the eight reoxidizer filters was



Heavy insulation covers porous metal filters on top of high temperature fluidized bed

required. Each vessel on the re-oxidizer still provides about 150 sq ft of filter area, but now contains 2 $\frac{3}{8}$ " diam elements constructed of a sintered Inconel® high nickel alloy. Designed to retain particles

greater than 1 micron, the filter tubes have successfully withstood the service requirement.

Filter vessels are blown back sequentially on a timed cycle, using approximately two vessel volumes of gas for each 5–7 sec blow-back. Every 15 seconds a filter is blown back. This periodic fluctuation of gas flow through the system does not cause any noticeable disruption of the fluidization or elutriation characteristics of the units.

Since modification of the re-oxidizer filter vessels, maintenance on the filter has been minimal. High retention of costly vanadium catalyst within the beds and infrequent cleanout required of the filters have resulted in an economically sound entrainment separator system. Discharge of catalyst to the atmosphere is within acceptable limits and catalyst loss to the product stream is so low that only a

minor amount is collected in the recovery system feed tank—too little to justify recovery—and discarded by an infrequent purge. ■

PSS® porous metal filter supplied by Pall Process Filtration Corporation, Cortland, NY 13045.

Inconel® alloy is a product of Huntington Alloys, Inc., Huntington, WV 25720.

Aromatic nitrile process technology, engineering design and construction provided by C-E Lummus Co., Division of Combustion Engineering Inc., 1515 Broad St., Bloomfield, NJ 07003.
