CONTROL TECHNOLOGY ASSESSMENT FOR CHEMICAL PROCESS UNIT OPERATIONS

PRELIMINARY SURVEY REPORT

OF

FMC CORPORATION
PHOSPHORUS CHEMICALS DIVISION
POCATELLO, IDAHO

SURVEY CONDUCTED BY:
Harold D. Van Wagenen
Phillip A. Froehlich

DATE OF SURVEY
November 4, 1982

REPORT WRITTEN BY:
Harold D. Van Wagenen

DATE OF REPORT:
April 1983

NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
Division of Physical Sciences and Engineering
Engineering Control Technology Branch
4676 Columbia Parkway
Cincinnati, Ohio 45226

PURPOSE OF SURVEY:	Preliminary site survey to obtain information on control technology used to minimize or eliminate occupational exposure to elemental phosphorus and other hazardous compound in this outdoor processing facility.
EMPLOYER REPRESENTATIVES CONTACTED:	F. Harvey Herbert, Resident Manager J. Thomas Bernasek, General Operations Superintendent Lee Larson, Technical Superintendent John L. Sanderson, Operating Superintendent Elton R. Hewitt, Project Industrial Hygienist
EMPLOYEE REPRESENTATIVES CONTACTED:	None
STANDARD INDUSTRIAL CLASSIFICATION OF PLANT:	Industry No. 3338, Group 333
ANALYTICAL WORK PERFORMED BY:	None performed.

INTRODUCTION

The National Institute for Occupational Safety and Health (NIOSH) is conducting a study titled "Occupational Hazard Control Options for Chemical Process Unit Operations." The object is to obtain information on principles, equipment, and techniques employed by chemical processing industries to minimize or eliminate workplace exposures to hazardous compounds. Initially, the project was carried out under federal government contract by the Enviro Control Division of the Dynamac Corporation. When contract funding was exhausted in late FY 82, the project was continued by NIOSH personnel on an in-house basis.

Preliminary site visits are made to a number of chemical processing facilities to obtain information on effective control technology. In-depth studies, which include area and personal monitoring, and monitoring of emission sources will be conducted in a minority of these facilities, selected on the basis of the effectiveness of the controls observed during the preliminary site visits. This is the preliminary site visit report covering the November 4, 1982 visit to the FMC Corporation facility at Pocatello, Idaho.

The facility produces elemental phosphorus from the reaction of phosphate shale, coke, and silica in huge electric arc furnaces. Liquid phosphorus is stored in underground tanks (excluding air access) until pumped into dedicated rail tank cars for shipment to the five FMC phosphorus chemical product production facilities located throughout the U. S., and other customers. The furnaces operate continuously on a 24-hour, 7-day-week, 52-week-year basis. On a staggered schedule, the individual furnaces are shutdown for planned periodic major overhaul. Unlike most chemical plants previously visited, this FMC facility has a strong local staff of about 15 design and development engineers to plan and install major processing and environmental improvements.

Of approximately 600 employees, about two-thirds belong to the International Association of Machinists and Aerospace Workers Union. Maintenance is performed by FMC employees, while industrial hygiene is handled by a full-time professional. Medical service is by a contract M. D., who spends parts of three days per week at the site, plus a full-time day-shift nurse.

GENERAL FACILITY

DESCRIPTION

The facility, located about 5 miles west of Pocatello, Idaho, occupies 900 acres of land abutting the Fort Hall Indian Reservation. Figure 1 is an aerial photograph of the facility, while Figure 2 is a schematic flow sheet of the entire site's operation sequence. Yearly, four 65 MW electric arc furnaces produce approximately 250 million pounds (about 1,500 tank car loads) of elemental phosphorus from 2 million tons of the basic raw materials. The FMC phosphorus chemical division operates a highly integrated mining, transporting, and processing complex in the general Pocatello area. The phosphate shale is open-pit-mine at their Gay mine, located about 35 miles further inside the reservation. Twice daily, two trains of 100 gondola cars each (100 tons per gondola car) travel from the mine to the plant. The shale is unloaded, using a rail car rotodumper, onto a high speed conveyor belt and up to the top of a

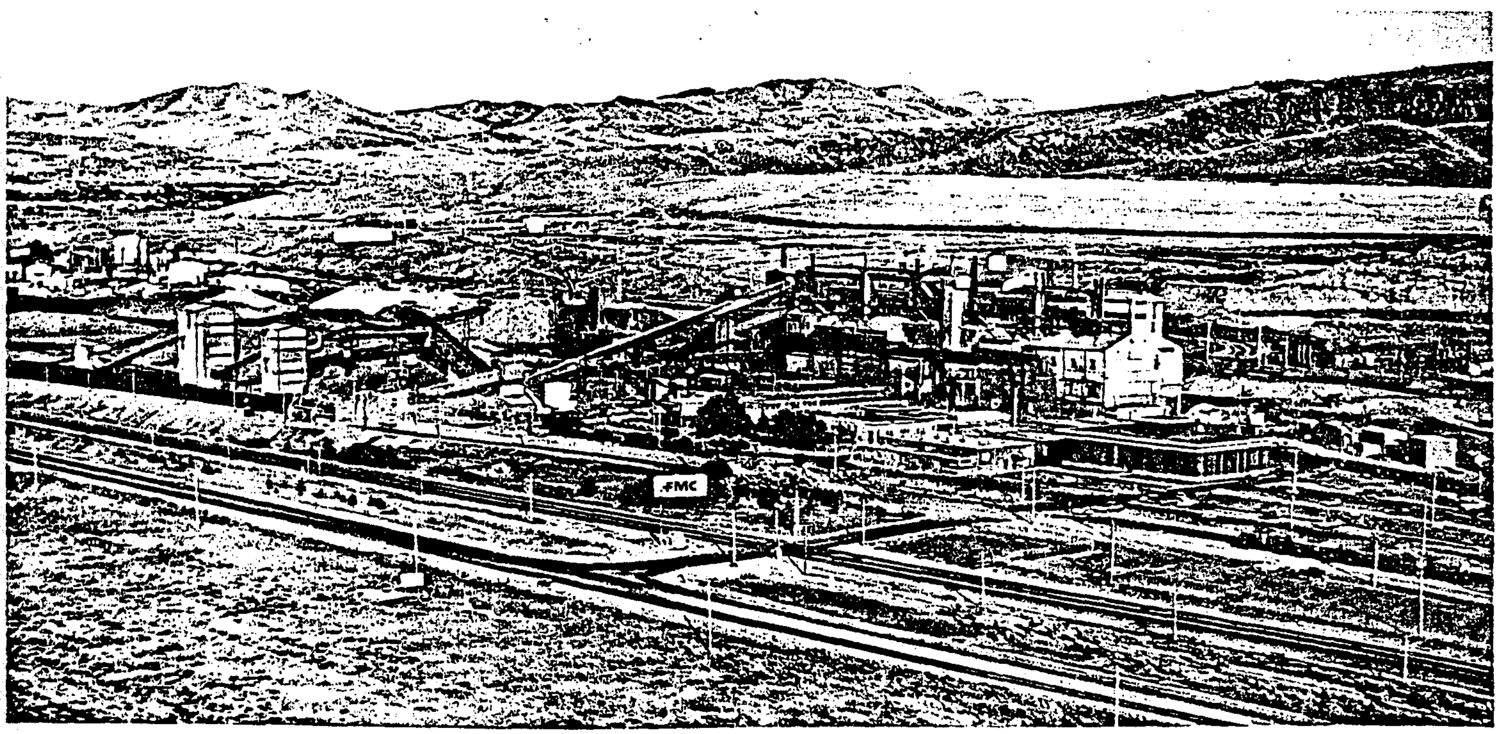


Figure 1. Aerial photograph of the FMC facility.

mountainous pile. The freezing winter weather confines shipping operations to an April through October season. The division also mines low sulfur coal at their Kemmerer, Wyoming open pit mines. Coking is conducted on an adjacent unit, using an exclusive FMC process with emission controls claimed to be superior to steel company counterparts. The silica (SiO_2), a flux for the calcium present in the phosphate shale, is also obtained locally and handled in bulk.

To maintain satisfactory continuous electric arc furnace operation, the "burden" (the carefully proportioned mix of phosphate shale, coke, and silica) must be sufficiently porous to permit the tremendous volume of gaseous products (carbon monoxide and phosphorus vapor), to easily and uniformly escape from the reaction zone near the bottom of the furnace. To obtain the desired porosity, all three components are preprocessed to provide small discrete particles. Because the phosphate shale is normally finely divided, an agglomeration process is employed. The FMC process comprises initial crushing and screening, followed by briquetting, and lastly calcining. During the calcining treatment, both moisture and organic impurities burn off and the briquettes harden; thereby, minimizing later breakage. By-product carbon monoxide gas is recycled and burned to provide the necessary heat for calcining.

The first of the furnaces was constructed and production started in 1949. Since then, expansion and major plant modifications have been frequent. We inspect only the upper portion of the huge open air building housing the equipment which distributes and feeds the burden to the furnaces below. Dotted lines in Figure 2 identify this processing area. Hence, other important operating areas of marked interest were neither seen nor described. These include: (1) Unloading, briquetting, and calcining of the phosphate shale; (2) burden blending; (3) electric furnace operation and equipment; and (4) liquid phosphorus tank storage, pumping, transfer, and rail tank car loading.

PROCESS

To provide background, this section covering the general reaction mechanism and electric furnace description, has been extracted from the 3rd Edition (Vol. 17) of Kirk and Othmers' Encyclopedia of Chemical Technology.

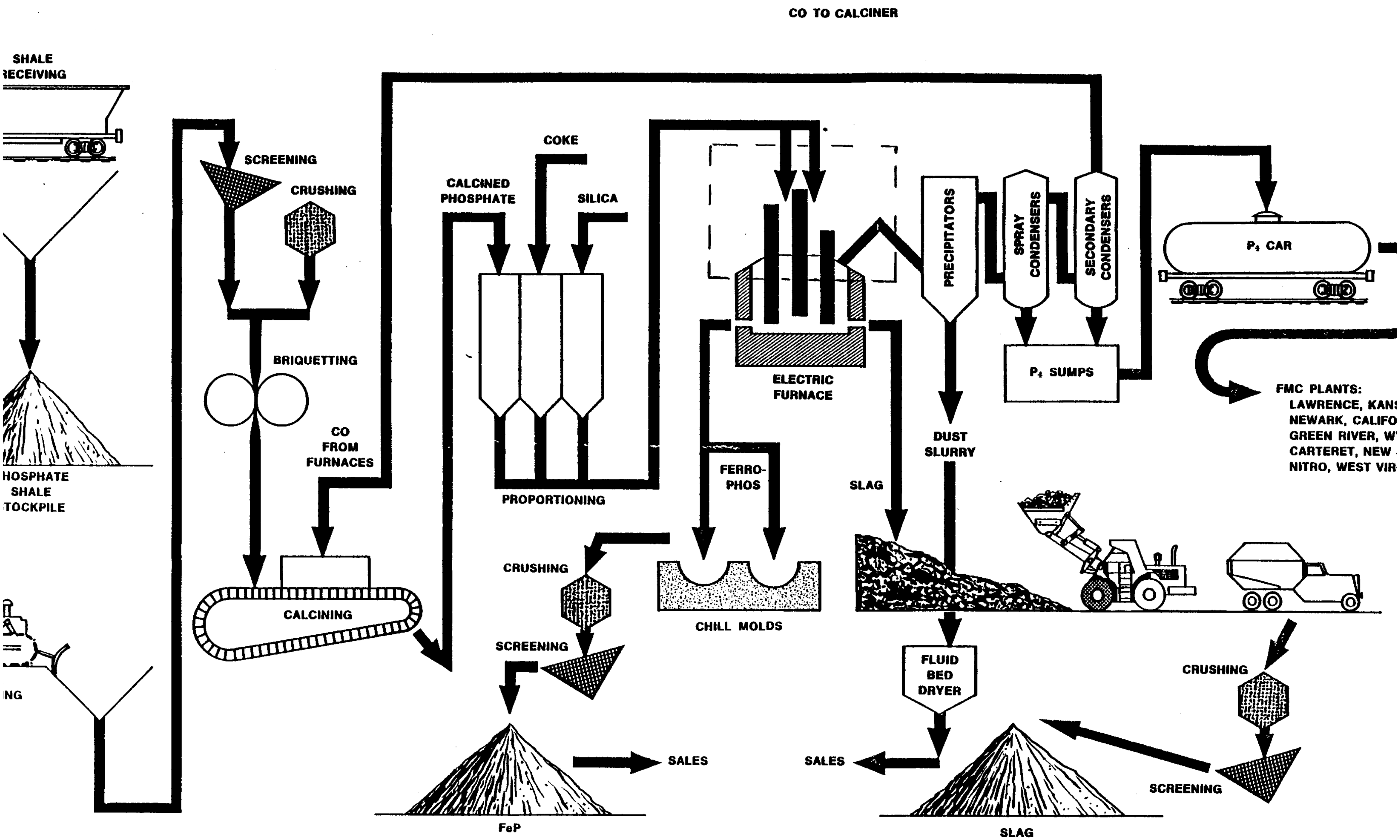


Figure 2. Schematic flow sheet of entire site operation.

An approximate chemical equation for the electric furnace process for manufacturing elemental white phosphorus is:

$$4\ Ca_5F(PO_4)_3 + 18\ SiO_2 + 30\ C \rightarrow 18\ CaO{\cdot}SiO_2{\cdot}1/9\ CaF_2 + 30\ CO + 3\ P_4$$

Fluorapatite	Silica	Coke	Slag	Carbon Monoxide	Elemental white-yellow phosphorus

The Idaho fluorapatite used by FMC has about 28 percent P_2O_5 content. On a weight basis, approximately 10 parts of shale and 1.5 each of silica and coke yield 1 part phosphorus, 4 of slag, 2.8 of carbon monoxide, and 0.3 ferrophosphorus (termed ferrophos).

The cut-away electric furnace drawing (Figure 3) shows the "burden" distributed throughout the electric arc furnace by means of multiple feed chutes. There are two tapholes at the bottom of the furnace - an upper one for the lighter slag and a lower one for by-product ferrophos. Ferrophos, formed by reduction of the iron compounds present in the burden, also contains chromium, titanimum, vanadium, etc. Other companies buy the ferrophos to recover these valuable metals. The size of the 25 MW electric furnace is emphasized by comparison of the operator and furnace.

OCCUPATIONAL EXPOSURE HAZARDS

Elemental phosphorus is a major occupational exposure hazard in its various forms. Exposure may occur by inhalation of the vapor, or if it comes in contact with the eyes or skin. It can also affect the body if it is swallowed.
Also, elemental white-yellow phosphorus is extremely hazardous when exposed to air; fires result via spontaneous ignition. Other hazardous materials at this facility are: (1) Crystalline quartz - a component of silica; (2) coke dust; (3) nuisance dusts - small particulates of slag and ferrophos formed as these electric furnace by-products are moved and processed; and (4) the by-product carbon monoxide (CO) gas.

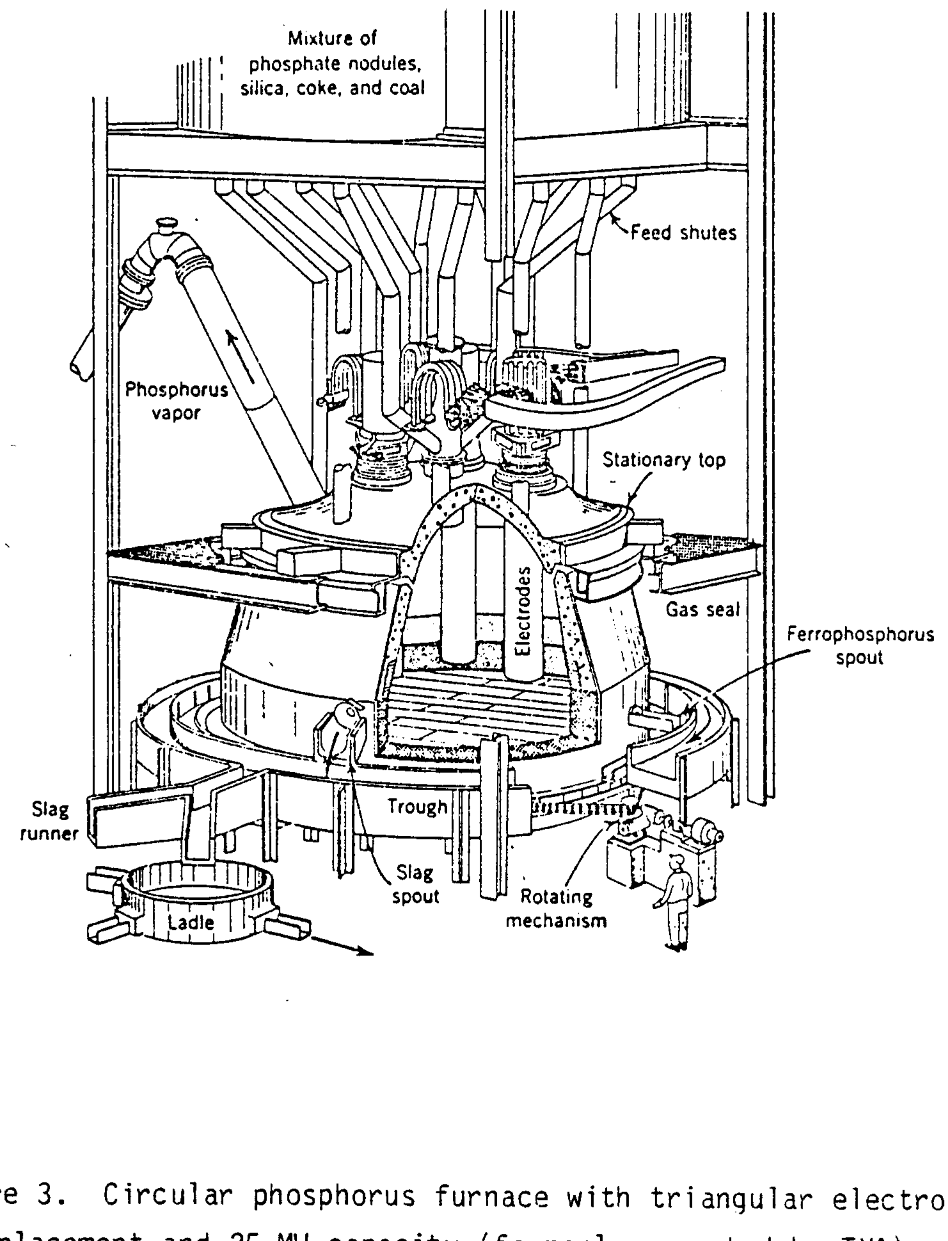


Figure 3. Circular phosphorus furnace with triangular electrode placement and 25-MW capacity (formerly operated by TVA).

(From Kirk-Othmer Encyclopeida of Chemical Technology, 3rd. Ed. Vo. 17, p 480.)

Table 1. Hazardous material exposure limits.

Hazardous Materials	Exposure Limits OSHA PEL	ACGIH TLV-TWA	ACGIH TLV-STEL
1. Silica (SiO_2) (as 100% crystalline quartz)			
Total Dust	0.3	0.3	--
Respirable dust	0.1	0.1	--
2. Coal Dust (<5% quartz)			
Respirable Dust	2.4	2	--
3. Nuisance Particulates (<1% quartz) (i.e. slag & ferrophos)			
Total Dust	15	10	--
Respirable Dust	5	5	--
4. Phosphorous (white-yellow)	0.1	0.1	0.3
5. Carbon Monoxide	55	55	440

NOTES: PEL - OSHA permissible exposure limit (mg/m^3-8 hrs.).
ACGIH - American Conference of Govermental Industrial Hygienists.
TLV - ACGIH threshold limit value (TLV); TWA - time-weighted average (mg/m^3-8-hrs.).
STEL - ACGIH short-term exposure limit (mg/m^3-15 mins.).

MEDICAL, TRAINING, AND MAINTENANCE PROGRAMS

The medical service is provided by a contract M. D. who spends part of three days per week at the facility plus a full-time day-shift nurse. A thorough initial medical examination is conducted on all newly hired employees. Current employees over 40-years-old have regular annual physical examinations, while those under 40 are re-examined on an 18-month cycle basis. The NIOSH/OSHA Occupational Health Guidelines for Chemical Hazards[1] recommended that employees, potentially exposed to white-yellow phosphorus, be given periodic medical examinations on a semi-annual basis with emphasis on blood testing.

Training and safety are a line management responsibility. Each plant area has its own trainer, and each foreman holds monthly crew meetings on training and safety subjects. Additionally, there are monthly IAM union-management safety meetings. Consultants have helped in setting up the training and safety programs. The technical department conducts frequent audits of both equipment functions and employee work practices in the various facility areas.

Maintenance is conducted by skilled FMC employees headquartered in a large shop on the facility grounds. A major maintenance operation is the replacement of the huge electrodes hanging down from the furnace domes. According to Kirk and Othmer, these electric arc furnaces normally operate with three electrodes. These are rather rapidly consumed, thereby requiring frequent replacement.

1. NIOSH/OSHA Occupational Health Guidelines for Chemical Hazards. January 1981. DHHS(NIOSH Publication No. 81-123.

BURDEN DISTRIBUTION AND FURNACE FEEDING

DESCRIPTION

Management personnel cooperated during discussion and inspection of the burden distribution and furnace feeding area (Figure 2). An article printed in the June 2, 1980 issue of Chemical Week (attached) discusses the recently completed $16,000,000 project for minimizing dust emissions from the open air building housing the four electric arc furnaces, and the overhead equipment distributing and feeding burden to the furnaces. A feature of the project was continuous operation of the electric arc furnace during the 18 months required for the building and equipment alterations and expansion.

The four huge electric furnaces are spaced in a line down the length of the building. With the new burden feeding addition, each furnace is fed via a total of seven separate chutes from five feed bins mounted above the furnace. For each furnace, the main chute discharges at the center of the furnace floor area. The other six chutes discharge in a circular pattern around the center. The new enclosed feed bins are each 12-feet-tall and 40-feet-square. A 216-foot reversible shuttle conveyor, feeding the bins by gravity, is enclosed, completely automated, and controlled by computer to provide seven separate burden additions to each cluster of five bins during a 90-minute period. Bin feeding is programmed to maintain as uniform a level of burden in each bin as possible. Theoretically, preprocessing the burden components to provide porous discrete particles should allow free and uniform passage of the gaseous products. However, prior operation demonstrated formation of recurrent mounds and cavities in the furnaces, sudden releases of large volumes of gas, and consequent pressure fluctuations. When temporary higher pressures developed, the charge backed-up within the feed bins and large clouds of dust were raised. Also, when CO gas and phosphorus vapor broke through bin burden layers, fires frequently occurred. With the previous operation, two operators wearing air-supplied respirators, manually directed burden into the bins through open gratings. Because of the dust, exact bin load levels were difficult to determine and/or control. In the new installation, gamma/nuclear gauges provide both level control and blockage detection. To protect equipment against pressure variations, the bin and feed conveyor enclosures are equipped with blow-out panels. These release about 1 psi above atmospheric pressure, a level which provides safety for operation and maintenance personnel. Two large local ventilation units move air through: (1) the enclosed conveyor system, and (2) the chamber above the feed bins (above the burden layer). Dust, carried by the combined airstreams, is removed in baghouses specially designed by the Swedish firm, Bahco Systems, Inc. Each of two new Bahco compact filter system baghouses, having 80,000 cfm capacity with 88 cells, are 60-foot-long, 30-foot-wide, and 4-foot tall. Each cell is 3 feet by 1-1/2 feet square and operates at an air-to-cloth ratio of 4:1 compared to a 6-8:1 normal ratio. The collected dust (about 10 to 15 tons per day) is pulsed-off the bags with compressed air and collects in hoppers. It is recycled back with the incoming shale prior to the briquetting operation. Choice of the Bahco equipment was made, following a world-wide search by FMC and the contractor, for the best and most efficient baghouse design. This is the first U. S. installation of the Bahco equipment.

EMISSION SOURCES AND EXPOSURE DATA

The marked change in quantity of emissions from the burden feeding area is graphically illustrated by before and after photographs (page 35 of the attached Chemical Week article). Mr. Elton Hewitt, facility industrial hygienist, provided the following comparative data, the averages for an unknown number of individual monitoring results. "Before modification" values are primarily area sampling results, while the "after modification" values are from personal samplers on shift operators.

Material	Before Modification (area)	After Modification (personal)
Total dust (mg/m^3-8 hrs)	8-100	0.25
Respirable dust (mg/m^3-8 hrs)	--	0.17
Carbon monoxide (ppm-8 hrs)	100-1000	5

The after modification personal sampler values are below OSHA PEL's for nuisance particulates and carbon monoxide. Inspection of the conveyor disclosed small piles of dust outside the blow-out panels, occasioned by seepage of fine dust past panel seal surfaces. To remove this dust, a permanent built-in building-wide vacuum cleaning system will be installed. Numerous outlets, strategically located on all floors, will permit thorough cleaning of all floor and equipment surfaces. Currently, the burden feeding area has a single operator on each of three 8-hour shifts and a single day-shift clean-up man.

CONTROL TECHNOLOGY

Impetus for the burden area emission control project meeting rigorous state EPA air quality standards for this nonattainment area. Both Pocatello air quality needs and facility worker occupational exposure have been minimized by successful completion and operation of this engineering project and equipment.

ENGINEERING CONTROLS

Automated and computer-controlled burden feeding of the electric arc furnaces has been a major advance over prior practice. More uniform furnace operation has diminished pressure upsets within the furnace reaction mass and thereby drastically reduced fires in the burden feeding area. Also, it has permitted successful operation of local ventilation equipment and air cleaners to remove the dust generated in the burden handling and feeding equipment. Some years previously, the manually operated burden feeding equipment had been enclosed. Simple enclosure actually led to an increase in fires and explosions. The engineering control methods exemplified by this engineering project are:

1. Process modification or substitution.
2. Equipment selection or modification.
3. Ventilation (successful local ventilation).

On the specialized subject of dust removal from air streams, two items are of interest:

1. The Swedish Bahco compact filter system baghouses are particularly effective and compact.

2. During winter cold weather conditions, the application of electrical heating to air ducts (leading to the baghouses) prevents moisture in the captured dust from condensing on the filter cloth surfaces. This, in turn, prevents muddying these surfaces with resultant reduction in filter efficiency.

MONITORING

As part of the burden feeding improvement project, a remote control multipoint Wilkes carbon monoxide monitoring system was installed. Approximately 20 sampling points throughout the burden feeding area are monitored from a control unit wall-mounted in the area office. Initially, the system functioned satisfactorily and CO content in air levels were determined to be well below the OSHA limit at all the sampling points. Operational problems have been encountered with this unit and at the time of inspection it was inoperative.

WORK PRACTICES AND PERSONAL PROTECTIVE EQUIPMENT

While no specific information on facility work practices was volunteered, management personnel emphasized that job procedure, and work practices were carefully worked out, implemented, and audited regularly.

Personal protective equipment is employed wherever and whenever necessary in the absence of effective engineering controls. All the protective equipment employed meets OSHA regulations and is approved by NIOSH. Specialized protective clothing is employed by skilled operators when loading rail tanks cars with liquid white-yellow phosphorus, since various plastics, rubber, and coatings are attacked by liquid phosphorus. Currently, permanent or disposable dust masks are employed in the burden feeding area only when high winds blow residual dust around.

CONCLUSIONS AND RECOMMENDATIONS

This FMC elemental phosphorus facility operates on a massive scale employing highly automated bulk handling equipment. A relatively limited number of skilled operators man this high output facility, the largest elemental phosphorus production facility in the United States. The FMC phosphorus chemicals division operates it as a component of a highly integrated mining, transporting, and processing complex in the general Pocatello area; mining and processing its own phosphate shale and coal as feed stocks. Based on judgement of the quality of the management staff and the information gathered during inspection of the burden feeding area, the conclusion is that FMC operates this facility in an efficient, conscientious manner, and provides good state-of-the-art protection to minimize occupational exposure of the workers to a group of very hazardous materials.

Controls in the burden area are well designed and appear to function well. Of particular interest are the Bacho compact filter system baghouses (designed and supplied by the Swedish firm, Bacho Systems, Inc.) which efficiently removed burden dust from the local ventilation air streams.

An in-depth survey of this FMC facility is not recommended because of FMC limitation of NIOSH inspection and discussion to the modified and expanded burden feeding area, and our conclusion that the time and expense of an in-depth survey is not warranted for this single processing area. This is unfortunate as it was apparent that a good health and safety program was in effect and a substantial amount of effective nonproprietary control technology was being employed in other processing areas, particularly in liquid phosphorus storage, handling, and loading.

FMC bags a big one in Pocatello

Emission control system's bag collectors capture 15 tons/day of dust

Controlling dust emissions at an elemental phosphorus plant is no mean feat. But FMC is now doing just that. Since November, it has been collecting 15 tons/day of dust at its 124,000-metric-tons/year Pocatello, Ida., plant, the largest in the U.S. Moreover, the plant's four 65-mw. electric-arc furnaces remained in operation throughout the 18 months of construction work on a $16-million dust-control project and there was not one lost-time accident in over 300,000 man-hours.

"It was the wildest job I've ever been on," says Art Henrickson, FMC's assistant plant manager and project manager for the control system. And it is proving to be a successful one. "We are meeting tough state standards," he adds.

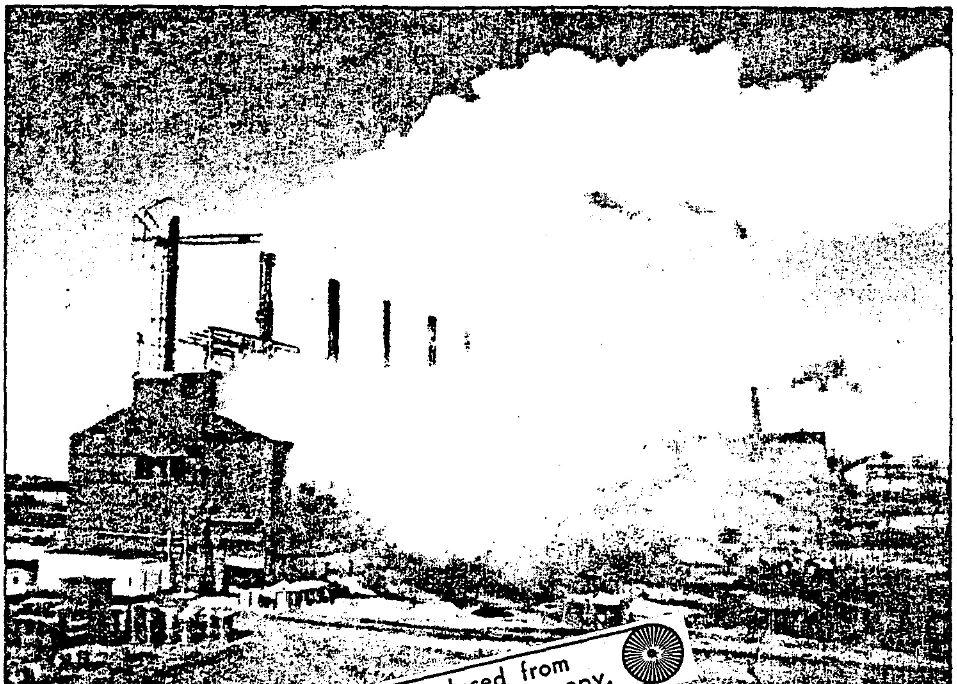
Although there are no federal emission standards on elemental phosphorus operations *per se*, Idaho is a nonattainment area and has imposed strict local regulations that the plant must meet.

The pollution-control system involves innovations that have led to two patent applications, and in the case of one, may result in what Henrickson sees as a major market for FMC. And it marks the first U.S. use of dust-collection baghouses designed by Sweden's Bahco Systems Inc., which recently opened offices in Atlanta.

Full of Complexities: The production of elemental phosphorus generates large quantities of hot (3,000 F) slag, dust and carbon monoxide. Clouds of smoke, fires and explosions are not uncommon. In fact, a fire last May destroyed about $700,000 worth of equipment. Still, the solution to the dust problem seemed simple enough: enclose the burden level above the furnaces. Phosphate nodules, coke and silica are conveyed to this level to supply the furnace feed bins.

"It may have sounded simple, but it was full of complexities," says Klaus Thiel, project manager for Davey McKee. (The pollution-control system was built by Western Knapp Engineering, which is now a part of Davey McKee.) FMC had tried enclosing the burden level five years earlier, but a series of fires and explosions convinced the company that it didn't have the answers. Actually, says Thiel, "enclosing the burden level made things worse."

He explains that blowers maintain 1-in. (water) pressure in the furnaces. But cavities of up to 15-ft. diameter can form in the furnaces and dust can collapse these cavities, causing the pressure to zoom to 40 in. within 2-3 seconds. "No relief valve ever made can handle that kind of change," he says. As a result, the charge backs up into the feed



Dust cloud from burden level of FMC's Pocatello phosphorus plant (top photo) was eliminated by raising roof, enclosing the level and adding bag collectors.

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National Assn. of Corrosion Engineers. Continuing-education seminars: A. Basic corrosion course; B. Corrosion prevention by cathodic protection; C. Corrosion prevention by coatings; D. Corrosion prevention in oil and gas production. Seminars A, B and D, Holiday Inn North, Charlotte, N.C., Jan. 6-11. A, B, C and D, Four Seasons hotel, Toronto, Can., Jan. 13-18. A, B and D, Holiday Inn, Amarillo, Tex., Jan. 20-25. A and B, Holiday Inn, Memphis, Tenn., Jan. 27-Feb. 1. (Education Dept., NACE Headquarters, P. O. Box 218340, Houston, Tex. 77218)

The Conference Board and The U.S. Office of Consumer Affairs. Conference: International consumer protection. Plaza hotel, New York City, Jan. 8, 9. (The Conference Board Inc., 845 Third Ave., New York, N.Y. 10022)

Society of Cosmetic Chemists. New York Chapter. Scientific meeting. Subject: Electrostatic charge on aerosol cans. Robin Hood Inn, Clifton, N.J., Jan. 9. (Neil Blackmore, c/o The Mennen Co., Hanover Ave., Morristown, N.J. 07960; 201 538-7100, ext. 473)

Technology Futures Inc. and Industrial Management Center Inc. Technology forecasting workshop, The Cloister, Sea Island, Ga., Jan. 13-18. (TFI/IMC, 2200 Guadalupe, Austin, Tex. 78705)

Texas A&M University. Annual symposium. Theme: Instrumentation for the process industries. Rudder Conference Center, Texas A&M Campus, College Station, Tex., Jan. 15-18. (M. Jones, P. O. Box 6151, Pasadena, Tex. 77506)

American Society of Mechanical Engineers. Solid Waste Division. Meeting. Topic: Hazardous wastes. United Engineering Center, New York City, Jan. 16, 17. (Don Belanger, Administrator 911-4, ASME, 345 E. 47th St., New York, N.Y. 10017; 212 644-7740)

Commerce Clearing House Inc. Conference. Theme: Energy and crude oil. Houston Oaks hotel, Houston, Tex., Jan. 21-23. (Conference Dept., Commerce Clearing House Inc., Quail Hill, San Rafael, Calif. 94903; 415 472-3100)

Cooling Tower Institute Inc. Annual technical meeting. Shamrock Hilton hotel, Houston, Tex., Jan. 21-23. (John Walko, Betz Laboratories, Somerton Rd., Trevose, Pa. 19047; 215 355-3300)

Plastics Institute of America Inc. Conference. Topic: Plastics in packaging. Mexico City, Mexico, Jan. 24-26. (PIA at Stevens Institute of Technology, Hoboken, N. J. 07030; 201 420-5552) □

bin, raising clouds of dust, and bringing the possibility of fire and explosion. "There is no way to prevent that backing up into the feed bin," Thiel adds.

Making It Work: But this time around, the company came up with some design innovations. It has installed blowout panels, for which patents have been applied, on the equipment. They release at pressures that are safe for operating and maintenance personnel. "Our tests indicate that pressure is 1 psi.," Thiel says.

Based on past experience, Henrickson expects blowouts about twice a year. But so far there have been none.

In addition, a new raw-material feed system has been installed that is expected to prevent conditions that caused fires. "The whole feed system had to be changed," Thiel says.

A huge cloud of some 10-30 tons/day of dust previously surrounded the burden level and occassionally would blow into the surrounding area. The new automated feed system can't eliminate the dust, but the cloud has been cut down and controlled.

A 216-ft.-long reversible shuttle conveyor feeds each of the four furnaces through seven chutes. During a 90-minute cycle, it carries out 28 separate feeding operations. The cycle is controlled by a computer that is programed to handle problems common to phosphorus production. For example, phosphorus burning in air can form fused globules that prevent feeding of raw materials. In the event this takes place, the feed mode is upset and an emergency mode is put into operation to relieve blockages.

Because it is impossible to see into the bins, nuclear gauges are used to "sight" problems. Gamma rays are beamed across the bins to measure resistance and detect blockages.

In the Bag: The job of capturing the dust from the operation is being handled by Bahco's new Compact Filter System. Each of the two baghouses has a 80,000-cfm. capacity. Each is 60 ft. long, 30 ft. wide and 4 ft. high, and consists of 88 cells: Each cell is 3 ft. x 1½ ft. square and does the work of 10-15 conventional bags, according to Thiel.

The dust is pulsed off the bags by compressed air and collected in hoppers. As much as 80% is recycled to the burden level.

FMC picked the system, Henrickson says, after a world-wide search for the most efficient one.

But the efficiency of the baghouse system didn't completely solve the dust-collection problems. Moisture in the captured dust condensed in the cold air and muddied the baghouse. The solution worked out by FMC and Western Knapp was a heating system for the primary ductwork.

Several approaches, including indirect heaters, were examined, says Thiel. But corrosion and erosion problems ruled out most.

"The answer had to be external," says Thiel, and was narrowed down to either a steam jacket or electric heating. Electric heating finally won out. "We came up with some tricks, including the use of aluminum foil," he says. The solution to the problem of getting the heat from the cable into the ductwork involved some innovations that have led to patent applications. "We've had to deal with outside temperatures of −10 F without experiencing any muddying," says Thiel. Henrickson, who sees a major market for FMC with the heating patent, says it has been successful "beyond our expectations."

Ductwork heating system solved problem of moisture in the dust

Raising the Roof: In the course of enclosing the 20 new 40-ft.-square, 12-ft.-high feed bins (five for each furnace), FMC had to raise roof of the 30-year-old plant from 72 ft. to 120 ft. This required over 1,500 tons of steel and new foundations. In some cases, piles for new footings had to be placed within a few feet of slag heaps, where temperatures were about 3,000 F.

FMC built walls around these areas and used forced air conditioning. Even so, temperatures were about 130 F and the holes for the footings had to be hand-excavated. Under those conditions, workers took breaks after work periods of 5-15 minutes.

In addition, FMC spent $700,000 for temporary stacks to discharge toxic fumes from the furnaces well above ground level. Four radio-equipped inspectors were stationed at the burden level to clear the area at any sign of carbon monoxide in large amounts. Despite the safety precautions the 27-day schedule for bin replacement was cut to 16 days.

And wet scrubbing was added to reduce emissions from furnace tap-holes from over 500 tons/year to less than 40 tons/year.

All-in-all the company and its contractors and suppliers seem to have come up with some big solutions to big problems. □