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Review Copy

INCINERATION OF POLYCHLORINATED BIPHENYLS

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Polychlorinated biphenyls (PCB's), manufactured by Monsanto Company, are presently sold as transformer fluids under the trade name Aroclor®. Sales as heat transfer fluids under the trade name Therminol® FR have been discontinued.

Used Aroclors and Therminols could not be discarded indiscriminately, and a method of destroying these waste PCB's would have to be developed. Incineration was, of course, the most obvious method to try, despite the fact that the Aroclors and Therminols do not support combustion under normal conditions of use. Laboratory tests showed that these materials could be burned in a bench scale refractory lined incinerator if the incinerator were preheated to a temperature of 1800 to 2000°F and some auxiliary fuel added.

In March, 1970, tests were run on Aroclor 1242 (42% chlorine) and Aroclor 1260 (60% chlorine) in the John Zink Company pilot plant thermal oxidizer at temperature of 1600, 1800, and 2000°F. Both Aroclors were burned successfully, although the 1260 required auxiliary fuel to maintain a stable flame.

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Samples of the flue gas were analyzed for HCl, chlorine, and PCB's. Although high levels of destruction of PCB's were achieved (99.99+%) even more complete destruction was deemed advisable.

Further tests on Aroclor 1260 were run in the John Zink pilot plant in May. The incinerator was operated at 2000, 2400, and 2800°F and at a residence time of 1.2 to 1.9 seconds. The results, shown in Figure 1, indicate that the unburned Aroclor decreases at the higher temperature. The levels of destruction were higher than those attained in the March test. The highest level of PCB measured in the flue gas (.089 mg per cu. meter) is equivalent to 99.9999% destruction of the Aroclor 1260.

Based on the pilot plant results, a system to burn 1250 pounds per hour of PCB's was designed and installed at Monsanto's Sauget, Illinois, plant. The full scale system consists of a Thermal oxidizer, a quench pot, a Venturi scrubber to remove particulate, and a packed scrubber to remove HCl as shown in Figure 2. Water is used as the quenching and scrubbing liquor. The scrubber system was designed to meet the following requirements on emissions to the atmosphere:

HCl	5 lb/hr. maximum
Cl_2	50 ppm maximum
Particulate	.05 gr/scf max.

The scrubber system has consistently operated well within these limits.

The design rate of 1250 pounds per hour has been attained for short periods of time. However, the average operating rate, for the reasons noted below, has been about 800 pounds per hour.

The incinerator system was designed to destroy wastes containing a high percentage of Aroclors, which have heats of combustion ranging from 9000 BTU per pound for Aroclor 1242 to 6000 BTU per pound for Aroclor 1260. However, much of the waste returned contains large percentages of hydrocarbon solvents used to flush out heat transfer systems. These solvents have heats of combustion of about 17,000 BTU per pound. Since the incinerator has a constant capacity for heat release, the capacity for solvents on a pound basis is correspondingly reduced. This reduction in capacity is reflected in the current charge of 3¢ per pound for burning straight PCB's to 5¢ per pound for solvent - PCB mixtures.

Early in the operation of the incinerator system, the scrubber liquor and the scrubber off gas were monitored for PCB's to determine the level of destruction. Fig. 3 shows the relationship between the temperature in the oxidation chamber and the total quantity of undestroyed PCB leaving the oxidizer. The data indicate that at temperatures below 2000°F the quantity of undestroyed PCB may rise sharply and that there is no significant increase in destruction at temperatures above 2200°F. Current practice is to operate the oxidizer at 2200 to 2400°F. It should be noted that at normal operating temperatures, 99.9998% of the PCB's are destroyed. Even the highest sample encountered in the test is equivalent to 99.998% destruction.

A number of mechanical problems were encountered in the startup and operation of the oxidizer-scrubber system, primarily with the refractory lining in the oxidizer and the polyester lining in the scrubber.

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The refractory originally installed in the burner plenum and the oxidizer chamber was a high chrome basic brick. A basic brick was selected to resist attack by the lime present in some of the waste materials as well as to resist the chlorine and HCl released in the combustion of straight chlorinated hydrocarbons.

The unit was started up on waste PCB's containing no lime. After one month of operation, the brick lining showed general deterioration, sanding, and loss of strength, with spalling in localized areas. Analysis of the brick (Fig. 4) showed severe losses of MgO and SiO_2. It was concluded that the brick was being attacked by chlorine or phosphorous in the oxidizer atmosphere. Phosphorous is not a normal component of Aroclors, but is believed to have been present in some of the waste received.

Since the predicted life of the original refractory was low, a search was started for a brick that would give better service. Samples of alumina brick containing from 70 to 90% Al_2O_3 were tested in the furnace. The samples were exposed to chlorine and HCl gases during the test, but were not exposed to any lime. Under these conditions, the alumina brick was much more resistant to attack than the basic brick, and the resistance increased at the higher alumina levels.

On January 28, 1972, the shell at the top of the burner plenum burned through, scattering pieces of hot metal and insulating refractory over a radius of 30 ft. Fortunately, no one was injured and the damage was confined to the oxidizer. The failure appears to have occurred when the refractory brick had deteriorated to a point where the arch collapsed. Failure of the insulating refractory and the steel shell followed.

The plenum chamber was repaired and relined with 80% alumina brick, which was immediately available, and the unit was returned to operation. At present the unit is down to replace the original basic refractory lining with 90% alumina brick.

The packed scrubber column is constructed of polyester lined steel. After a month and a half of operation there were a number of failures in the polyester lining. Inspection disclosed that there was no chemical attack on the liner, but large areas had disbonded from the steel shell. Visual and microscopic examination of the shell revealed that the surface had not been properly sandblasted prior to application of the lining. The original lining was removed, the interior surface were sandblasted, and a new polyester lining applied. The new lining has maintained its bond to the shell, and only minor repairs have been required.

The original lining was also eroded at the flue gas inlet nozzle. It was concluded that the erosion was caused by small particles spalled from the brick in the oxidizer and trapped in the water in the quench pot. In the original installation, water from the quench pot was used as make-up for the Venturi scrubber as shown in Fig. 5. Water containing the brick dust was accelerated to a high velocity in the Venturi scrubber and impinged on the wall of the packed scrubber column. The problem was solved quite simply by using water only from the bottom of the scrubber column to supply the Venturi.

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In conclusion, the thermal oxidizer scrubber system has performed well in achieving high levels of destruction of PCB's and in controlling losses of particulate, chlorine, and HCl to the atmosphere. Mechanically, performance has been less satisfactory. Maintenance costs have been high, and on-stream time low.

A great deal of progress has been in solving mechanical, refractory, and corrosion problems. However, it is doubtful that this will ever be a low maintenance operation.

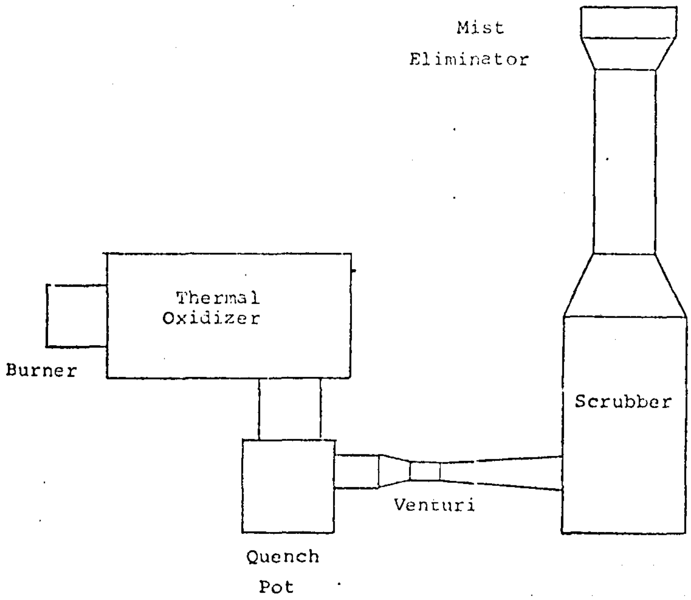

Fig. 2 - Oxidizer - Scrubber System

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Fig. 1 and 3 - These data are based upon samples tested in the laboratory and are not guaranteed for all samples.

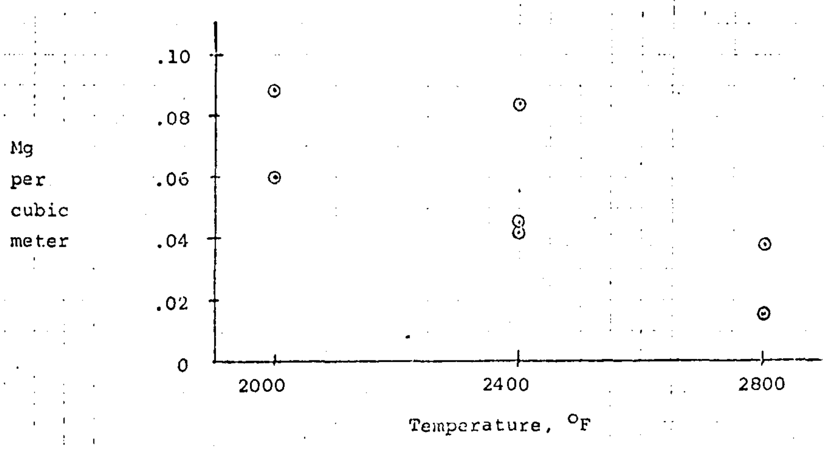

Fig. 1 - PCB in Flue Gas - Pilot Plant

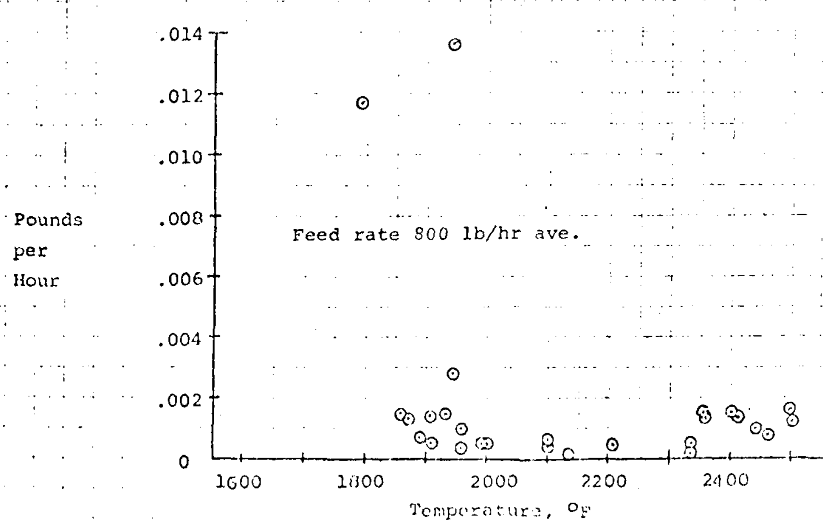

Fig. 3 - PCB in Flue Gas - Sauget Plant

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Component	Original Analysis wt. %	Hot Face Analysis wt.%
MgO	39-42	20.5
Fe_2O_3	9.5-11	7.6
Cr_2O_3	21-23	27.4
CaO	0.5-1	.12
SiO_2	4.5-5.5	.20
Al_2O_3	20-22	40.6
P_2O_5	0	3.5

Fig. 4 - Analysis of Initial Brick Lining

Fig. 4 - These data are based upon samples tested in the laboratory and are not guaranteed for all samples.

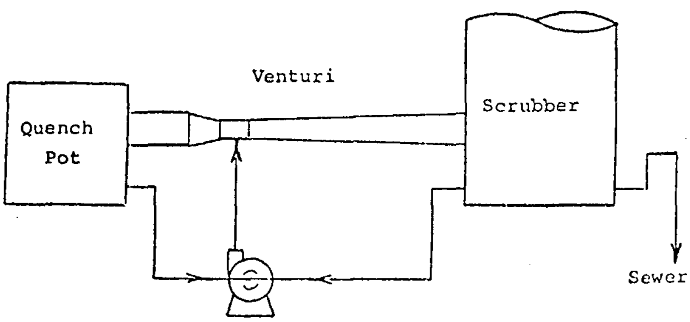

Fig. 5 - Scrubber Water System

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