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PESTICIDE DISPOSAL IN A CEMENT KILN IN PAKISTAN
Report of a Pilot Project

presented by

Gudrun Hartig Huden
AID/OFDA

and a report on

TEST RESULTS FROM A PILOT BURN
OF OVERAGED PESTICIDES
D.G. Khan, Punjab, Pakistan

by

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Sponsored by

The Office of U. S. Foreign Disaster Assistance
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PREFACE

This report presents the results of the pilot pesticide burn undertaken in a remote corner of the Punjab in Pakistan in November-December of 1989.

The demonstration burn was sponsored by A.I.D.'s Office of U. S. Foreign Disaster Assistance (OFDA) and supported by USAID/Islamabad with the full cooperation of the Government of Pakistan and the Government of the Punjab. Why was this done and what can be learned from it? Events leading up to the burn are briefly described below.

Background

In 1987, under the auspices of the World Environment Center (WEC), A.I.D. and the U.S. Environmental Protection Agency (USEPA) sent a technical evaluation team to Pakistan to study how overaged pesticides stored throughout the country should be handled. Their report, The condition of old pesticides in Pakistan and approaches to their effective management, relates their findings of visits to 28 representative storage sites belonging to the government of Punjab (and the Karachi port area). Stores surveyed represented less than 2 percent of the approximately 1900 sites within the country. The team estimated that they found 5000 metric tons (MT) of pesticide products and 3000 MT of contaminated materials in various storage sites, often in areas where people live and work. Most of these pesticides were acquired during the 1970's under the government's program of free or subsidized distribution. The anticipated demands never materialized and year after year greater quantities accumulated in storage. The government's policy of not allowing use of pesticides which had been shelved for more than two years further contributed to the growth of obsolete stockpiles.

Shelf-life of pesticides varies considerably, but is always related to conditions of storage. Unprotected from the elements, products lose their effectiveness and containers corrode more quickly, begin to leak, threaten groundwater or invade the aquifer and become a serious and insidious danger to human and environmental health. That was the situation found by the team in stores scattered throughout Pakistan's major farming area.

In 1980, the government's "New Agricultural Policy" began to withdraw subsidies for pesticides and transfer procurement and distribution to the private sector. The policy resulted in wiser acquisitioning and less build-up of obsolete stocks.

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The chief recommendation of the team was to consolidate the waste pesticides and dispose of them in one of three ways: using lined landfill in an isolated area, a transportable incinerator, or cement kilns. The first two options were thoroughly researched and costed, the cement kiln option was not. Projected costs ranged from $8.3 - 8.4 Million for the lined landfill to $17.5 - 17.6 Million for the transportable incinerator. Given the reality of needs and available resources, it is perhaps not surprising that neither the Government of Pakistan nor a donor came forth with funding. It is safe to say that the situation has only deteriorated since the study was done.

Enter OFDA in 1989

It has long been apparent that lined landfills have inherent problems and need to be monitored ad infinitum (not very likely under developing country conditions). "Transportable incinerators" are not particularly portable; cost-prohibitive and can introduce harmful emissions if not carefully controlled and operated. These commercial incinerators operate at temperatures of 800 to 900 degrees Celsius. The advantages of a rotary cement kiln which operates at a much higher temperature (1400 - 2000 degrees C), and provides a much longer residence time, become obvious. The idea of demonstrating the ease and elegance of a technique which seemed particularly appropriate for a developing country intrigued OFDA. The search began for an interested country where certain criteria would be met.

OFDA was pleased when early discussions with USAID/Islamabad revealed that the GOP was receptive to the idea of a demonstration, and a team to study feasibility was fielded in April 1989. The team was made up of Tony Marcil, President of the World Environment Center and John Chehaske, Vice President of the Air Monitoring Division of Pacific Environmental Services (PES).

Within the short time available to the team (about ten days) -- facilitated by the Office of Engineering of USAID/Islamabad -- the team was able to meet with officials in Islamabad, Lahore, Karachi and D. G. Khan, note the general interest and enthusiasm for the proposed project, and obtain informal agreements in principle for a liquid pesticide burn from the following: Ministry of Food and Agriculture (MFA), Ministry of Housing and Works, Environment and Urban Affairs Division, and the Ministry of Production (owners and operators of the state owned cement kilns). The Chairman of the State Cement Corporation gave permission to contact the Managing Director of the D. G. Khan Cement Company and the team visited the site 100 km west of Multan, bordering the foothills of the Suliman Range.

The D. G. Khan Cement Company (DGKCC) appeared to meet most of the criteria for a successful pilot burn, in fact seemed ideal. Most importantly, the Managing Director, Mr. Nasseer-ud-din Siddiqui, clearly understood the goals of the project and promised his full cooperation.

The MFA appointed the Director of the Department of Plant Protection as Project Manager who designated his deputy to run the project. The MFA further promised to request the release of 6 MT of each pesticide type (organo phosphates and organo chlorides) by the Punjab Department of Agriculture.

Upon their return to the U.S., the team provided their report, Cement kiln disposal: Overaged agricultural chemicals demonstration burn feasibility study, May 1, 1989. This document became the basis for discussion in Pakistan and Washington since it laid out technical considerations and caveats, duties and responsibilities of parties involved, and projected a draft schedule for implementation of the pilot burn. Optimistically it implied that actions would start on April 20 and that the burn could be completed by August 30. This schedule took into consideration the planned maintenance shut-down of the kiln during July, at which time sampling platforms could be constructed and port holes drilled. Within a few weeks USAID/Islamabad indicated the go-ahead, and preparations for the burn started in both countries. OFDA consulted with various officials at USEPA regarding identification of qualified contractors for the emissions testing. In consultation with USEPA, it was determined that PES had a unique capability and was, therefore, awarded the contract to do the emissions testing.

Personnel in Pakistan

- Colonel (R) M. I. Sarfraz, a Pakistani national, was hired by OFDA as Preparations Manager working out of USAID/Lahore to verify correctness, readiness, availability, etc. of all in-country measures necessary; including customs clearances and waivers for import and re-exportation of scientific testing gear. He was to confer weekly with the Project Support Manager in Washington and to work closely with the Scientific Advisor. He prepared a logistic plan for the safe collection and transport of the pesticides to the plant.

- Scientific Advisor, Patty Cleary, was engaged by USAID/Islamabad but stationed in Lahore to survey Pakistani laboratory ability to analyze samples and to obtain analysis for determining the pesticide of choice for the burn. The selection was to be made by sampling candidate products and having them analyzed for percent of active ingredient, viscosity and other physical characteristics. An environmental assessment for the

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proposed project was to be prepared, and a list provided of appropriate personal protective gear and monitoring devices. She would also be responsible for overseeing site safety and training of personnel. Her background as an USEPA employee matched the demands of the scope of work.

- USAID/Islamabad provided essential back-stop services via the Office of Engineering (Chief, John Morgan at first, then Gene George), the Mission's Environmental Coordinator, Dr. Wally Albertin, and Laiq Ali, Mission Environmental Engineer. Dr. Rifaq, the Mission's public health physician, took on the task of health and safety training of pesticide handlers.

- USAID/Karachi and Lahore also played significant roles as port of entry and transfer of scientific and protective gear.

- The Plant Protection Department in Karachi transported the sensitive gear imported from the U.S. to D. G. Khan.

A fuller understanding of the chain of command and information flow of the project can be gleaned from the organization chart in the Appendix to this report.

Personnel in the U.S.

- PES had primary responsibility for operation and analysis of the demonstration, with John Chehaske leading overall planning and design of the injection system, and Helen Yoest selecting test methodologies to be used, preparing the scientific gear, arranging for lab analysis, ordering reagent chemicals, packaging and insuring safe shipment. For personnel used in Pakistan, see Chapter I of their report.

- Bob Mournighan, USEPA Chemical Engineer with the Thermal Destruction Branch, Waste Minimization, Destruction and Disposal Research Division, Risk Reduction Laboratory of USEPA in Cincinnati reviewed the sampling and testing methodology plan and participated in the work at DGKCC at the time scheduled for the test burn. He also supervised analysis of process samples.

- Ray Krueger, consultant and formerly with USEPA's Office of Pesticides, was sent to Pakistan by OFDA during September to November 1989 to trouble-shoot, collect final pesticide candidate samples for analysis in the U.S., approve selection of protective gear, assist Colonel Sarfraz in the collection of pesticides from 7 stores in the Punjab, and consolidate OP and OC products into two batches of burnable cocktail.

- Gudrun Huden, OFDA Environmental Officer, served as Project Support Manager to keep all preparations moving if not at the same speed, then in the same direction, towards a timely burn with usable test results.

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Objective

Together, our objective was to demonstrate that a cement kiln destroys pesticides efficiently and completely, that the cement product is in no way affected by the process, and that stack gas emissions are within the range of established standards.

This technology had been applied in European countries, Canada and the U.S. for a number of years. Of the 275 cement companies in the U.S. alone, 25 burn hazardous waste on a daily basis at a rate of 30% fuel substitution. Destruction efficiency has been amply documented in the literature (see especially the World Bank's The safe disposal of hazardous wastes: the special needs and problems of developing countries, Vol. III, edited by Roger Batstone et al, 1989).

Discussion of problems and lessons learned

Problems encountered were numerous, but in no way implicate the process. As a matter of fact, large-scale destruction should be much easier than this pilot burn. Some of the obstacles and delays were beyond our control and peculiar to the setting; other problems could have been predicted and avoided with better communication. In the end it was the goodwill of many, and the tenacity and hard work of a handful, that brought the project to a successful conclusion.

It would be a disservice to those who want to learn from this pilot project to brush the difficulties aside, as results achieved are likely to have been colored by them.

- Candidate pesticide availability: The testing methodology was predicated on the assumption that OP and OC pesticides, (preferably only one of each class) would be made available in sufficiently large quantities with a percentage of active ingredient (A.I.) close to the original formulation (or not much less than 25%). These obsolete pesticides were to have been free-flowing liquids of a viscosity close to water. Low viscosity was necessary so that the atomizing nozzle at the end of the injection gun could measurably introduce the pesticide directly into the fuel stream and into the hottest part of the kiln flame. We thus were keenly interested in candidate pesticides which would yield the appropriate specifications. As knowledge of what goes into the kiln is related to understanding what comes out of the stack, we became concerned when sample analysis of candidates would often indicate complete decomposition, active ingredients in the 0-10% range, and very high viscosity. We were assured, however, that better candidates would be found and the order was placed for the injection system to be manufactured in the U.S. We knew there were other insecticide products in sufficient quantity, but we learned only shortly before the burn that a court order held

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these for litigation proceedings. Our most promising candidate became inaccessible. We also soon learned that inventories on paper do not necessarily represent stocks that can be located.

- Mixture heterogeneity: What was finally burned was not a homogenous batch, but a cocktail (the OP batch had 8 different pesticides) that was anything but free-flowing. This affected the performance of the delivery system at every step. Gears were stripped, flow meters stopped functioning and pumps broke. The system simply was not designed (by intention) for what could be regarded as "real world" waste batches. Still, all of the pesticides that were brought to DGKCC were burned. Ingenuity brought to bear and problem-solving are described in Chapter 3, Facility Description and Operation, of the PES report.

- Sampling site: Other problems that could not have been foreseen and to which there was no solution but other compromises: In baseline emissions testing, establishing normal velocity data at the stack sampling locations, it was discovered that the chimney produced cyclonic flow which would have made measurements meaningless. Several days were devoted to unsuccessful attempts to straighten the escaping gas flow. It was then decided to test the velocity conditions in the breach between Electrostatic Precipitator (ESP) and stack which gave a reliable alternative sampling site (although not ideal) from which all sampling was taken for the actual test runs. NB! The incidence of cyclonic flow in a stack was about 1 in 1000 and highly unusual for a modern facility such as DGKCC.

- Communications: Communications was a problem over these long distances from AID/Washington to the plant site at D. G. Khan, Islamabad, Lahore, Karachi, complicated by a 10-hour difference in time zones, an erratic phone system, a lack of Fax service, and a working week that effectively narrows communication to 3.5 days. Under these circumstances it is easy for erroneous assumptions to grow to which wishful thinking will not bring about resolution.

- Management: Discontinuity of management, particularly within important ministries of the GOP and the provincial government of Punjab; together with strikes of employees at the Ministry of Agriculture, threatened the final acceptance and progress of the project. Agreements in principle, but not yet on paper, tend to disappear like the smile of a Cheshire cat and a new regime may not be interested in honoring promises of someone who has departed. Permission to proceed with the burn (from the State Cement Corporation) and an official release of pesticides were finally granted October 8 and November 6, respectively.

- Public relations: Absence of a plan to involve the press, and to facilitate public relations in general, was a serious omission. Invitations had been issued to host country

officials, chemical industry representatives and foreign observers -- through the Director of Plant Protection -- to witness the pilot burn on November 19, 1989. This date coincided with a power outage which shut the kiln down and the 75 visitors had to content themselves with a viewing of the facility, the empty pesticide containers (the liquid pesticides having been transferred to a tank truck and holding container) and a description of the principle. The following day each of the four newspapers ran various versions of the story to the effect that an American project was burning American toxic chemicals. That information added to worker unrest at the plant which had been brewing under the surface but very ably controlled by the M. D. in meetings with his senior staff. That same night representatives of the press were invited to the plant and were given a thorough briefing by senior AID/Islamabad staff and the emissions testing team. To stop a threatened protest meeting of the opposition party, the M. D. invited community leaders and tribal chiefs the following night to give them a clear understanding of what was going on so that they could carry the message to their people.

PES and Joe Kitts, USAID Environmental Officer visiting DGKCC from Morocco, participated in that meeting. In the meantime, OFDA had written a press release for use by the State Cement Corporation as they saw fit.

- "Grass-roots" activity: The next day, newspaper reports more accurately reflected the work by the American team in cooperation with the Government of Punjab. By that time, the intent of the project was so well understood that unsolicited trucks with full pesticide drums showed up at the gates of the cement plant. These had to be turned back since we neither had the authority to accept untested pesticides, nor had we even started with the burn and we had to guard to limit rather than enlarge the pilot task. The trucks refused to leave. Another confrontation occurred between those inside the fence who thought enough was enough and those on the outside who wanted to get rid of materials that created daily stench and hazard in their community. One could say a golden opportunity for popular implementation was wasted; the grass-roots level of local store operators having understood our aims at last, were turned away.

In summary, 16,711 liters of pesticides were collected over the course of 3 days (using donkey carts for ease of access to some stores, trucks and a tank truck) from seven stores in the Punjab and transported to DGKCC. These were burned intermittently over the course of four days. Analysis showed that emissions of pollutants regulated by the Environmental Protection Agency of the Punjab did not exceed that agency's standards. Destruction Removal Efficiency (DRE) results were very close to US incinerator standards. We conjecture that had it been possible

to feed the pesticides at higher concentrations (and somewhat higher flow rates) into the kiln, instrument readings would very likely have shown that a DRE of 99.99% was not only achieved, but also demonstrated. Analysis of the process samples (dust and clinker) was excellent; the cement product was, as we expected, free of detectable contaminants.

Incineration in a cement kiln is very likely superior to destroying hazardous waste by conventional incineration. The combination of existing capital investment (assuming a modern facility with air pollution control devices), fuel value of the waste product, and consideration of some incentives to cement makers could be the winning formula for realistic, economic, lasting and least harmful way of risk reduction. Risks are relative and should always be weighed against those of not doing anything at all.

It is hoped that others will be encouraged by this pilot test in Pakistan and adapt it to their needs.

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ACKNOWLEDGMENTS

This project, initiated from afar, would have failed had it not been for the goodwill, commitment and hard work of many who, not unlike a secret society or community of spirits, invisibly subscribed to the aims and supported us to the end. As in all such endeavors, some key individuals stand out who encouraged and kept the faith at one or another critical stage. To these people goes our special gratitude:

Mr. Naseer-ud-din Siddiqui, Managing Director of the D. G. Khan Cement Company, bore the risks and the brunt of this undertaking by making available his plant, laboratory space, staff and support services without restrictions. He suffered the inconvenience of our prolonged stay graciously and with good humor. Despite the aggravation we presented to the smooth running of DGKCC, his word once given held good untill the end. This took courage and character and we will not forget. Naturally, we are indebted to the State Cement Corporation for supporting this innovative activity and for their foresight in choosing DGKCC. The plant's engineer, Ahamad Sohail, entered into our daily problem-solving with extraordinary care and knowledge. He shouldered what seemed at times impossible burdens and helped us see the light. He became a friend. He interceded for us to fulfill the unusual demands on the plant's machine shop, whose creativity and workmanship astonished us.

Colonel (R) M. I. Sarfraz, as Preparations Manager, had the unenviable role of shepherding this joint US-Pakistan project past innumerable obstacles, faithfully keeping the books and negotiating minor and major clearances, permits and releases without which the project might forever have remained feasible but unimplementable. We are indebted to him also for a sound logistics plan which reduced risks of transport significantly. Rarely do planners have to suffer the consequences of their paper actions, but he and Ray Krueger personally collected every liter of pesticide. They lived and slept with the transport from one rural store to the next until delivery of the material to the plant without mishap.

Dr. M. A. Haleemi, Director of the Plant Protection Institute at Faisalabad, made the services of the government laboratory available for analysis of a very large number of obsolete pesticide samples. We are grateful for his personal interest and the resources provided in the face of other pressing priorities.

//

Mr. M. D. Mohsin, Deputy Director of the Department of Plant Protection, Government of Pakistan, Project Manager of the "Demonstration Burn of Overage Pesticides" (DBOP) receives our thanks for facilitating in earnest the aims of the project out of his office in Karachi. His successful interventions were vital to our progress.

At USAID/Islamabad we are foremost indebted to John Morgan (then Chief of the Office of Engineering), who gave his blessing to our initial proposal; but sad fate removed him from this setting in June of 1989. Subsequently we worked with Gene George who took John Morgan's place and who backed us up firmly when the need was great. Wally Albertin, USAID's Environmental Coordinator, provided liaison with Patty Clary, who, among other things, produced the Environmental Assessment and site safety plan for this project. Laiq Ali, the Mission's Environmental Engineer, ably coordinated with the Preparations Manager in Lahore, and helped negotiate essential agreements between USAID and the GOP. Dr. Rifaq, USAID's public health specialist, provided intensive health and safety training of workers. He also came to DGKCC to discuss contingency emergency health care procedures with the plant's hospital physician and nurse. In addition, USAID/Islamabad put at our disposal over the stay of these 5 weeks excellent transport and drivers who carried us over treacherous roads like precious cargo. Their friendly attitude helped to relieve some of the tension.

On the U. S. side, I thank Steve Lintner (formerly the Environmental Officer of AID's Bureau for Asia and Near East, AID/ANE) and now with the World Bank (WB), as well as Anders Halldin both with the Environmental Division, Europe, Middle East and North Africa Region (WB) for their steadfast encouragement and sharing of this vision. Molly Kux, current Environmental Officer for AID/ANE, supported the project. USEPA provided the services of Bob Mournighan who looked over our shoulder throughout the process and helped us on the scene in Karachi and at D. G. Khan. Joe Kitts, USAID/Rabat Environmental Officer proved a keen observer of the DGKCC setting; I regret that his visit with two Moroccan experts did not coincide with the actual burn.

I owe much to the skills and enthusiasm of Tony Marcil (WEC), whose intimate acquaintance with Pakistan smoothed the way over the hurdles of the feasibility study, and finally to the PES team of John Chehaske, Helen Yoest, Tim Miller and Joey Fuller who gave all they could to adjust to field conditions and to keep the integrity of the testing program in balance. A hard act indeed.

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TEST RESULTS FROM A PILOT BURN OF OVERAGED PESTICIDES D.G. KHAN, PUNJAB, PAKISTAN

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LIST OF ABBREVIATIONS

AID/OFDA	Agency for International Development, Office of U.S. Foreign Disaster Assistance
AI	Active Ingredients
Al_2O_3	Aluminum Trioxide
Btu	British Thermal Units
CaO	Calcium Oxide
CEM	Continuous Emission Monitor
Cl^-	Chloride
Cl_2	Chlorine
cm	Centimeter
CO	Carbon Monoxide
CO_2	Carbon Dioxide
DGKCC	Dera Ghazi Khan Cement Company
DGM	Dry Gas Meter
DOT	Department of Transportation
DRE	Destruction and Removal Efficiency
dscf	Dry Standard Cubic Feet
dscfm	Dry Standard Cubic Feet Per Minute
dscm	Dry Standard Cubic Meter
EPA	Environmental Protection Agency
ESP	Electrostatic Precipitator
ft	Feet
g	Gram
GC/MS	Gas Chromatography/Mass Spectrophotometry
gr/dscf	Grains Per Dry Standard Cubic Foot
HCl	Hydrogen Chloride
hr	Hour

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H_2O_2	Hydrogen Peroxide
H_2SO_4	Sulfuric Acid
IC	Ion Chromatography
IPA	Isopropanol
kcal/kg	Kilocalories Per Kilogram
kg/hr	Kilogram Per Hour
K_2O	Potassium Oxide
lbs/hr	Pounds Per Hour
l/min	Liters Per Minute
m	Meter
M5	Method 5
M5/8	Method 5/Method 8 Combination
$MeCl_2$	Methylene Chloride
MeOH	Methanol
mg	Milligrams
mg/Nm^3	Milligrams Per Normal Cubic Meter
MgO	Magnesium Oxide
ml	Milliliter
ml/min	Milliliter Per Minute
MM5	Modified Method 5
NaOH	Sodium Hydroxide
Na_2O	Disodium Oxide
NDIR	Non-dispersive Infrared
Nm^3/min	Normal Cubic Meter Per Minute
OC	OrganoChloride
OP	OrganoPhosphate
O_2	Oxygen
PES	Pacific Environmental Services, Inc.
PIC	Products of Incomplete Combustion
psig	Pounds Per Square Inch-Gauge
QA/QC	Quality Assurance/Quality Control
QC	Quality Control
RCRA	Resource Conservation and Recovery Act
rpm	Revolutions Per Minute

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SiO_2	Silicon Dioxide
SO_x	Oxides of Sulfur
SO_2	Sulfur Dioxide
SO_3	Sulfur Trioxide
TLI	Triangle Laboratories, Incorporated
tpd	Tons Per Day
μg	Micrograms
USEPA	U.S. Environmental Protection Agency

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EXECUTIVE SUMMARY

The Agency for International Development, Office of U.S. Foreign Disaster Assistance (AID/OFDA), contracted Pacific Environmental Services, Inc. (PES) to conduct a pilot burn of overaged pesticides in a cement kiln to show developing countries that this is a safe and effective technique for destroying pesticides. The site selected to host the demonstration burn was the Dera Ghazi Khan Cement Company, a State-owned and operated dry process cement plant in D.G. Khan, Punjab, Pakistan.

Two types of pesticides were utilized for the pilot burn; organophosphates, and organochlorides. The pilot burn was designed to determine the efficiency of a cement kiln in destroying pesticides; to determine the emissions of particulate matter, chlorides (Cl^-), oxides of sulfur (SO_x), carbon monoxide (CO) and products of incomplete combustion (PICs) in the kiln exhaust gases; and to determine if any of the pesticides migrated to the clinker or the ESP dust.

Four pesticide burn tests were conducted, two with each pesticide type, to determine the pesticide emission rate. The pesticide destruction and removal efficiency (DRE) was calculated by comparing the feed rate of each pesticide with the kiln exhaust gas emission rate of each pesticide. Analysis by high resolution GC/MS indicated that the average DRE was 99.97 percent for the organophosphate (OP) pesticide group and 99.93 percent for the organochloride (OC) group.

The United States Environmental Protection Agency (USEPA) does not have specific standards for cement kilns that burn hazardous wastes. However, in many cases States have imposed the U.S. Resource Conservation and Recovery Act (RCRA) hazardous waste incinerator standards as part of a facility's operating permit. The RCRA standards have a unique method for determining compliance. Sources must demonstrate that 99.99% of selected organic compounds are destroyed/removed by the incineration system (including any air pollution control devices). Regulations in most countries are not based on the destruction/removal efficiency (DRE) concept; they are based on maximum allowable concentrations either of specific organic compounds or total organic compounds. The average pesticide concentration in the exhaust gases for the OP runs was 0.033 milligrams per normal cubic meter (mg/Nm^3). The OC runs averaged 0.011 mg/Nm^3. This compares very well to European standards which are usually in the 0.1 to 5.0 mg/Nm^3 range for toxic compounds. (A summary of air pollution regulations for several European countries is provided in the appendix to the overall report of which this report is a part.)

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A total of six particulate emission tests were performed to measure particulate emission rates and concentrations. The particulate concentrations for all tests were well below post 1990 standards of the Environmental Protection Agency of the Province of Punjab, Pakistan (EPA Punjab), as well as U.S. RCRA standards for hazardous waste incinerators.

Emissions of hydrogen chloride (HCl) and free chlorine (Cl_2) were measured using a procedure that analyzes for chlorides. The results were below the 1990 EPA Punjab standards and standards of some, but not all of the European countries. The emissions exceeded the RCRA standards. There is an inherent problem when measuring HCl emissions from cement plants because the emissions contain chloride salts which bias the results high. Unfortunately, there currently is no economical way to measure HCl and Cl_2 emissions more accurately in cement plant exhaust gases.

Oxides of sulfur (SO_x) were measured as an indicator of process upset. Burning the pesticides is not expected to affect SO_x emissions. SO_x emissions were analyzed as sulfur dioxide (SO_2) and sulfuric acid (H_2SO_4). SO_x emissions during the pilot burn were well within 1990 EPA Punjab standards and European standards. RCRA does not include standards for SO_x emissions. SO_2 emissions were very low and did not indicate there were any process upsets.

Carbon monoxide (CO) emissions were recorded continuously by the cement plant with a continuous emission monitor (CEM). CO emissions averaged over each test period were below the 1990 EPA Punjab standard, although there were times during the tests when the instantaneous CO concentration exceeded the standard. Four of the six runs exceeded European standards, including one of the baseline runs with no pesticides being burned. There is no RCRA standard for CO. Not unexpectedly, the runs with the highest CO emissions had the lowest DREs.

A GC/MS search for PICs was conducted by identifying the 20 most prevalent organic compounds in the exhaust gas samples. About one-third of the compounds were siloxanes which are laboratory contaminants. The compounds found during the pesticide burning runs were essentially the same ones that were found during the baseline runs when no pesticides were being burned.

Samples of kiln feed, ESP dust, and clinker were analyzed by the USEPA for traces of the organophosphate and organochloride pesticides. No pesticides were found in any of the samples.

The USEPA collaborated with PES at the test site in Pakistan. They also provided suggestions for the overall test plan, they analyzed the process samples, and they reviewed the test results. Independently, we arrived at similar conclusions; that the kiln proved effective in destroying the pesticides, that DRE values may have been adversely impacted by kiln process upsets, and that the DRE values very likely

would have been higher if the pesticide concentration and/or feed rate had been higher. The collected samples would then have contained a higher concentration of analyte which would have allowed more accurate analyses instead of being so close to the analytical minimum detection limits.

CHAPTER 1

INTRODUCTION

Under contract to the Agency for International Development, Office of U.S. Foreign Disaster Assistance (AID/OFDA), Pacific Environmental Services, Inc. (PES) conducted a pilot burn of overaged pesticides in a cement kiln in Pakistan. The overall objective of this effort was to prove to developing countries that incineration in cement kilns is a safe and effective method for destroying pesticides.

In order to establish guidelines for measuring success, PES compared the results of the test burn with the U.S. Resource Conservation and Recovery Act (RCRA) standards and the Environmental Quality Standards for Industrial Gaseous Emissions of the Environmental Protection Agency of Punjab, Pakistan (EPA Punjab).

The RCRA standards are published in Title 40 of the Code of Federal Regulations, Part 264.343. They currently cover the combustion of hazardous wastes in incinerators, although regulations have been proposed to extend the coverage to boilers and industrial furnaces (Federal Register, Vol. 54, No. 206, Thursday, October 26, 1989). Cement kilns are included in the industrial furnace category. Even though the Federal RCRA standards do not cover cement kilns today, most State air pollution agencies incoporate the RCRA standards in the operating permits that they issue. The RCRA standards include the following specific requirements:

- 99.99 percent destruction and removal efficiency (DRE) of hazardous organic constituents,
- 99 percent removal of hydrochloric acid (HCl) or 1.81 kg/hr HCl, whichever is greater, and
- 183 mg/Nm^3 particulate emissions corrected to 7 percent oxygen (O_2).

In addition to the U.S. RCRA standards, PES also compared the results with the EPA Punjab standards for particulate emissions, HCl, Cl_2, SO_x, and CO. These standards are as follows:

Pollutant	Before 1990 (mg/Nm^3)	After 1990 (mg/Nm^3)
Particulates	600	300
HCl	500	400
Cl_2	200	150
SO_x	500	400
CO	1,000	800

The site selected to host the demonstration burn was the Dera Ghazi Khan Cement Company (DGKCC), a state owned and operated dry process cement plant in D.G. Khan, Punjab, Pakistan. This site was centrally located to a number of pesticide storehouses. Mixtures of organophosphate (OP) and organochloride (OC) pesticides used in the pilot burn were collected from eight storehouses in the Punjab area (see Figure 1.1). The type and quantity of each pesticide in the two mixtures was as follows:

Organophosphate Mixture

Pesticide	Liters
Nexion	6,187
Fenitrothion	1,641
Nuvacron	1,411
Nogos (DDVP)	1,128
Metasystox	600
Dimethoate	205
Gusathion	200
Total	11,372

Organochloride Mixture

Pesticide	Liters
Dieldrin	2,620
Zolone[1]	2,404
STAM F-34[1]	200
Thiodane	180
Kelthane	141
Total	5,545

The sampling program included three conditions. Condition 1 was a baseline condition in which Number 6 fuel oil was burned with no pesticides. Under Condition 2, the OP pesticide mixture was cofired with Number 6 fuel oil, and under Condition 3, the OC pesticide mixture was cofired with number 6 fuel oil. The pesticides were fed to the kiln through a separate burner gun that was positioned close to the main number 6 fuel oil burner gun. For each condition, a series of two test runs were conducted. Condition 1 sampling was conducted on November 24 and 25, 1989. Condition 2 sampling was conducted on November 29 and 30, 1989, and Condition 3 sampling was conducted on December 10, 1989. Figures 1.2 through 1.4 summarize the actual sampling times and show the relationship between different sampling activities.

The average feed rates of the pesticide mixtures were 4.16 liters per minute (l/min) for Run 1 and 5.36 l/min for Run 2 for the OPs and 0.48 l/min for Run 1 and 1.06 l/min for Run 2 for the OCs. Stack gas

[1]Although Zolone is an organophosphate pesticide, it was incorrectly identified as an organochloride during the pesticide collection, and was mixed with the organochlorides. Similarly, STAM F-34 is an amide.

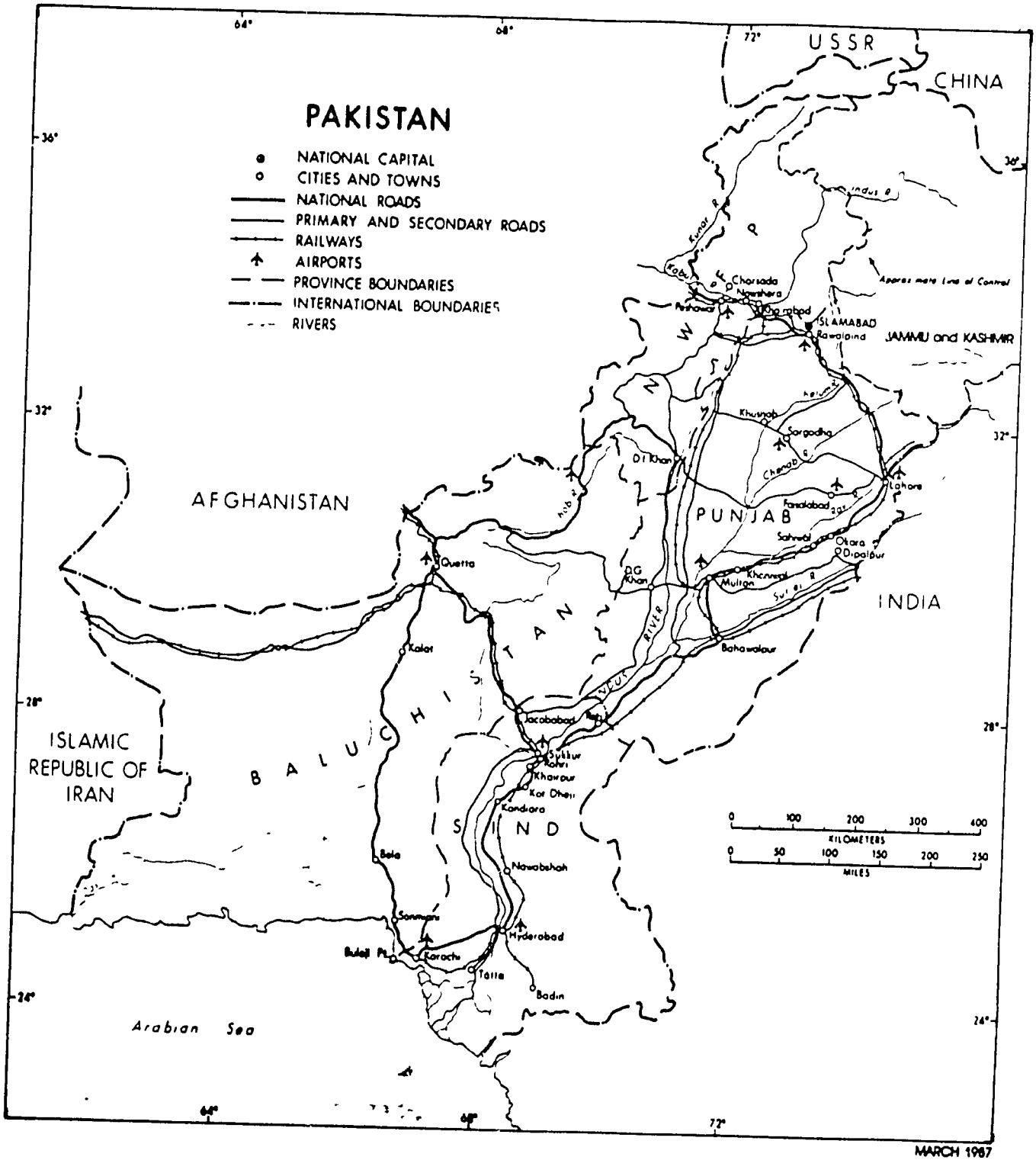

Figure 1.1 Map of Pakistan

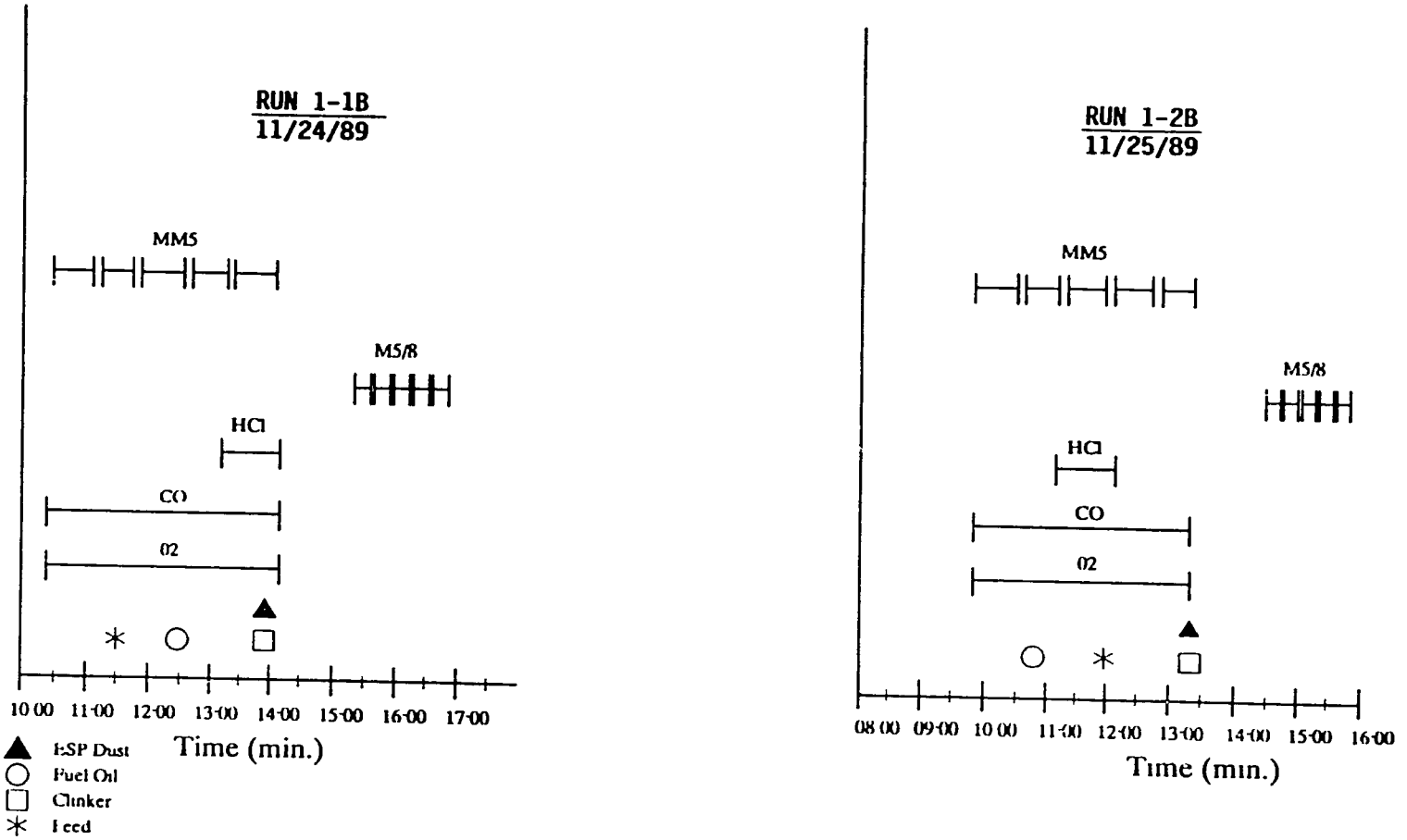

Figure 1.2 DGKCC Pilot Burn Test Chronology Condition 1

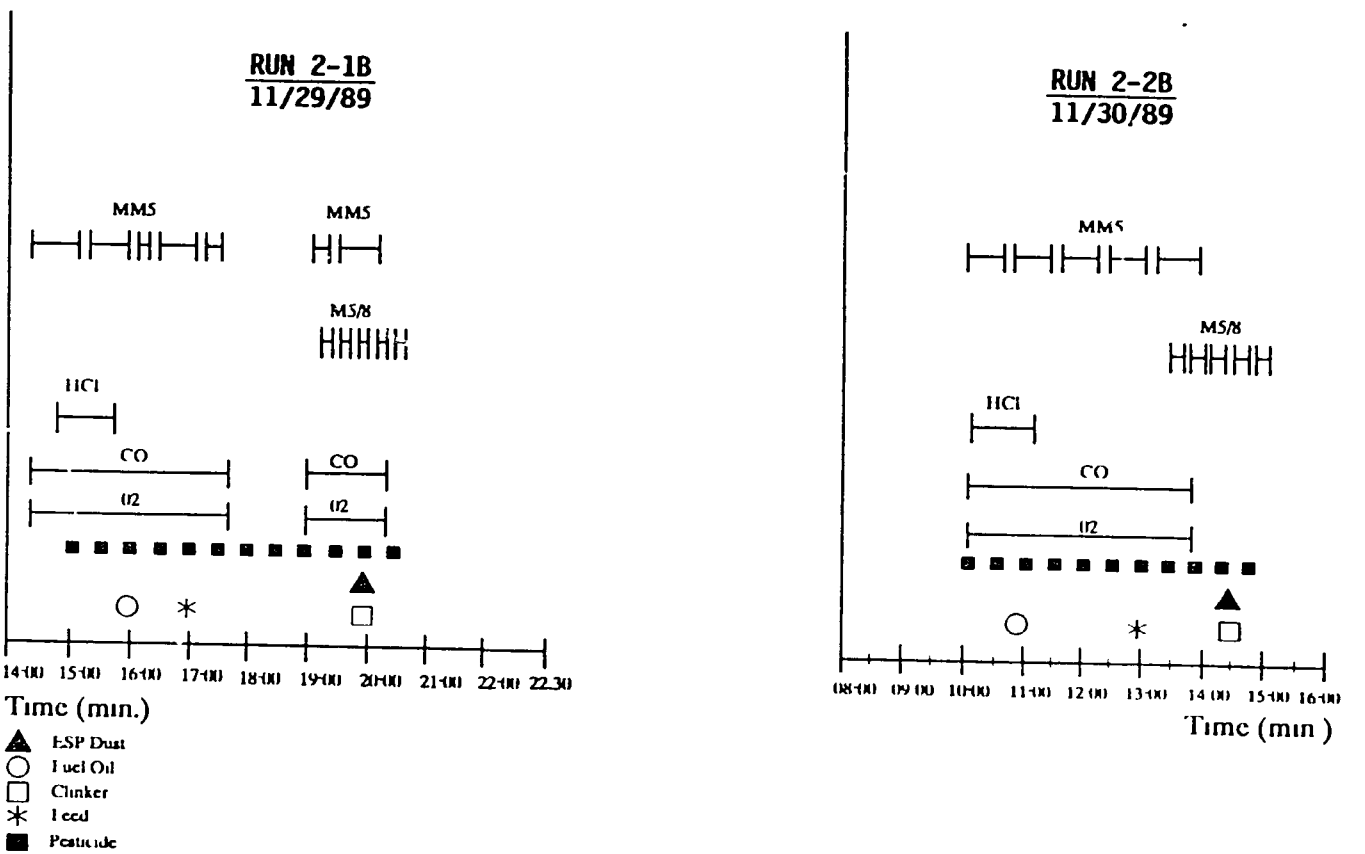

Figure 1.3 DGKCC Pilot Burn Test Chronology Condition 2

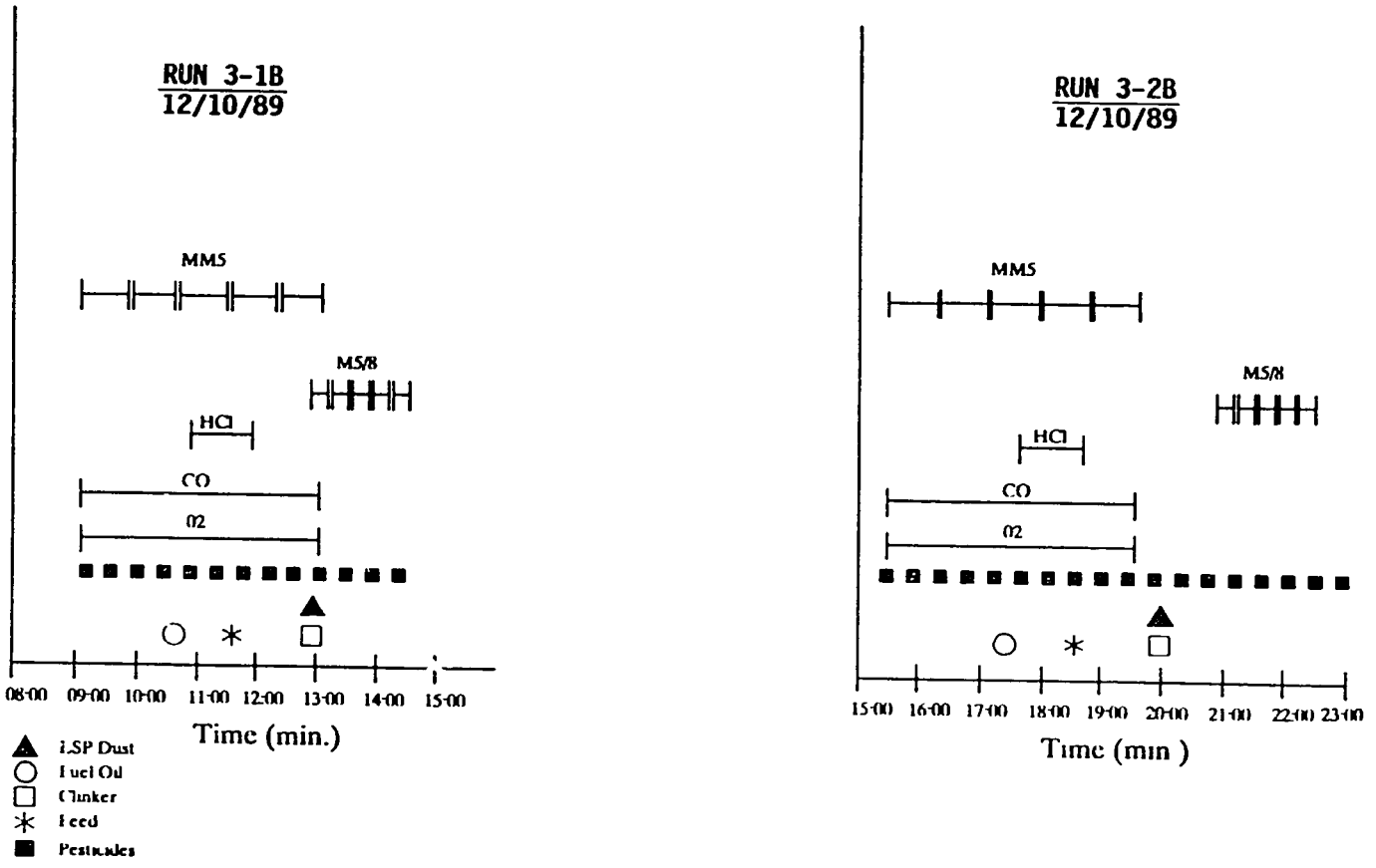

Figure 1.4 DGKCC Pilot Burn Test Chronology Condition 3

samples were collected and analyzed for total particulate emissions, O_2, CO_2, CO, SO_2, H_2SO_4, HCl and Cl_2, OP and OC pesticides, and products of incomplete combustion (PICs).

In addition to the emission testing, process samples were collected and analyzed. These samples included kiln feed, fuel oil, clinker, electrostatic precipitator (ESP) dust, and OP and OC pesticide mixtures. The kiln feed, clinker, and ESP dust process samples were analyzed for OP and OC pesticide content. The OP and OC pesticide samples were analyzed for percent active ingredient (AI), specific gravity, viscosity, heat content, chlorides, and degradation products. No analyses were performed on the fuel oil samples.

The PES test team consisted of John Chehaske, Joey Fuller, Tim Miller, and Helen Yoest. Mr. Chehaske oversaw the assembly and operation of the waste pesticide delivery system. Ms. Yoest was the Field Team Leader for the sampling and analysis portion of the test program. Mr. Bob Mournighan represented the U.S. Environmental Protection Agency and Ms. Gudrun Huden represented AID/OFDA.

The remainder of the document consists of the following chapters:

- Chapter 2 Summary of Results;
- Chapter 3 Facility Description and Operation;
- Chapter 4 Sampling Locations;
- Chapter 5 Sampling and Analytical Procedure; and
- Chapter 6 Quality Assurance and Quality Control.

CHAPTER 2

SUMMARY OF RESULTS

The results of the pilot burn testing program are summarized in this chapter. Based upon the results of this sampling program, the cement kiln safely and effectively destroyed the overaged pesticides. Table 2.1 is a comparison of the demonstration burn test results with current Environmental Protection Agency of Punjab, Pakistan (EPA Punjab) pollutant standards. As shown in the table, the emissions of those pollutants regulated by the EPA Punjab, Pakistan did not exceed that agency's standards.

In Table 2.2, the pilot burn test results are compared with current U.S. Resource Conservation and Recovery Act (RCRA) regulations for hazardous waste incinerators. This comparison indicates that the cement kiln did meet RCRA incinerator standards for particulate concentrations. RCRA limits for destruction and removal efficiency (DRE) and hydrochloric acid (HCl) emissions were not met. The DRE results were very close to the RCRA incinerator standard. Because the concentrations of some pesticides measured in the feed and the stack gases were near the detection limit for those compounds. PES believes that the pesticides in the feed to the kiln were too low to enable measurement of a DRE of 99.99 percent and had more pesticide been fed to the kiln, a DRE of 99.99 percent could have been demonstrated. Measured HCl emissions were substantially higher than the RCRA incinerator limits. Because chlorides in the gaseous emissions may have been measured as HCl by the test method used, actual HCl emissions are believed to have been less than those indicated.

In the remainder of this chapter, more detailed discussion of the sampling results is presented for the following:

- Destruction and Removal Efficiency (DRE) of the Pesticides
- Particulate Emissions
- Chloride (Cl^-) Emissions
- Sulfur Dioxide (SO_2) and Sulfuric Acid (H_2SO_4) Emissions
- Oxygen (O_2) and Carbon Monoxide (CO) Emissions
- Products of Incomplete Combustion (PICs)

TABLE 2.1

D.G. KHAN CEMENT COMPANY
COMPARISON OF PILOT BURN TEST RESULTS
WITH "ENVIRONMENTAL QUALITY STANDARDS FOR INDUSTRIAL
GASEOUS EMISSION, EPA, PUNJAB, PAKISTAN"

Test Run Number	Particulate Concentration (mg/Nm^3)	HCl (mg/Nm^3)	CL_2 (mg/Nm^3)	SO_x		CO (mg/Nm^3)
				SO_2 (mg/Nm^3)	H_2SO_4 (mg/Nm^3)	
1-1B	88.5	24	15	2.4	0.25	208
1-2B	89.7	40	12	1.4	0.15	037
2-1B	93.6	37	6.6	0.65	170.0	358
2-2B	121	77	8.8	0.34	34	233
3-1B	92.7	61	8.7	3.1	7.3	*
3-2B	88.8	59	2.3	10	2.5	680
EPA Punjab Standard after 1990	300	400	150	400		800

* Analyzer malfunction, no data

TABLE 2.2

D.G. KHAN CEMENT COMPANY
COMPARISON OF PILOT BURN TEST RESULTS
WITH RCRA STANDARDS

Test Run Number	Overall DRE[1] (%)	Particulate Concentration (mg/Nm^3)	HCl (kg/hr)
1-1B	NA	88.5	5.8
1-2B	NA	89.7	9.6
2-1B	99.96	93.6	9.0
2-2B	99.86	121	19
3-1B	99.98	92.7	16
3-2B	99.91	88.8	14
RCRA Standard	99.99	183	1.8

[1] Analysis by high resolution GC/MS (SIR)

- Process Data
  - Kiln Feed
  - ESP Dust
  - Clinker

Testing was first performed in the stack but was stopped when the gas flow in the stack was found to be cyclonic. The test site was moved to the breaching duct that connects the stack to the induced draft fan (see Chapter 4 for a more detailed discussion). Because the stack sampling location was not considered to be an acceptable site, only the results from the tests made in the breaching are presented below in this report.

DESTRUCTION AND REMOVAL EFFICIENCY (DRE) OF THE PESTICIDES

The measured DRE is the fundamental indicator of the effectiveness of the cement kiln in destroying the OP and OC pesticides. Data used in calculation and resultant DREs are presented in Tables 2.3 through 2.6. A brief description of the data in these tables is presented below.

•	Total Feed Rate (l/min)	Rate at which the pesticide mixture (feed) was pumped from the tank truck to the burner gun. A detailed description of how this rate was calculated is presented in Chapter 3.
•	Active Ingredient in the Feed (μg/ml)	Concentration of each pesticide in the feed. Determined by laboratory analysis of actual field collected samples of the pesticide mixtures fed to the kiln.
•	Pesticide Feed Rate (kg/hr)	A calculated value representing the actual quantity of pesticide introduced into the kiln for destruction. This quantity is the product of "Total Feed Rate" of the pesticide mixture and "Active Ingredient in the Feed". Example calculations are provided in Appendix E.
•	Sample Volume (Nm^3)	Volume of exhaust gas, measured at dry standard conditions, that was passed through the Modified Method 5 (MM5) sampling train. (Standard conditions are 20°C and 1 atmosphere.)
•	Exhaust Gas Flow Rate (Nm^3/min)	Volumetric flow rate of the exhaust gas corrected to dry standard conditions.

TABLE 2.3

D.G. KHAN CEMENT COMPANY

ORGANOPHOSPHATE DESTRUCTION AND REMOVAL EFFICIENCY
INITIAL ANALYSIS BY LOW RESOLUTION GC/MS

CONDITION 2

Run	Pesticide	Total Feed Rate (l/min)	Active Ingredient in the Feed (µg/ml)	Pesticide Feed Rate (W_{in}) (kg/hr)	Sample Volume (Nm^3)	Exhaust Gas Flow Rate (Nm^3/min)	Active Ingredient in the Sample (µg/sample)	Pesticide Emission Rate (W_{out}) (g/hr)	DRE (%)
1	Nexion (bromophos-methyl)	4.16	66,956.37	16.71	3.2462	4,102.5	586.4	44.5641	99.7
1	Nogos	4.16	87,608.57	21.87	3.2462	4,102.5	(0.14)	<0.0106	>99.99995
						Overall DRE			>99.8
2	Nexion (bromophos-methyl)	5.63	19,823.77	6.70	3.2276	4,044.6	8.49	0.6383	99.990
2	Fenitrothion	5.63	12,192.33	4.12	3.2276	4,044.6	(1.47)	<0.1105	>99.997
2	Nuvacron	5.63	(2,349.25)	0.79	3.2276	4,044.6	(0.82)	<0.0617	>99.992
2	Nogos	5.63	(3,614.73)	1.22	3.2276	4,044.6	(0.16)	<0.0120	>99.9990
						Overall DRE			>99.994

( ) - Not Detected; value shown is the analytical limit of detection.
( ) - Estimated; value shown is above minimum detection limit but below the quantitation limit.

NOTE: Overall DRE is calculated from sum of W_{in} and W_{out}. Only pesticides with active ingredients in excess of the minimum detection limit in the feed were included in the overall DRE.

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TABLE 2.4

D.G. KHAN CEMENT COMPANY

ORGANOCHLORIDE DESTRUCTION AND REMOVAL EFFICIENCY
INITIAL ANALYSIS BY LOW RESOLUTION GC/MS

CONDITION 3

Run	Pesticide	Total Feed Rate (l/min)	Active Ingredient in the Feed (µg/ml)	Pesticide Feed Rate (W_{in}) (kg/hr)	Sample Volume (Nm^3)	Exhaust Gas Flow Rate (Nm^3/min)	Active Ingredient in the Sample (µg/sample)	Pesticide Emission Rate (W_{out}) (g/hr)	η_{RE} (%)
1	Dieldrin	0.48	50,035.63	1.441	3.4367	4,287.4	(0.98)	<0.0734	>99.995
1	Zolone	0.48	37,709.27	1.086	3.4367	4,287.4	(3 91)	<0 2927	>99.97
							Overall DRE		>99.986
2	Dieldrin	1.06	48,608.68	3.092	3.3151	4,115 9	8.21	0.6116	99.98
2	Zolone	1.06	35,355.04	2.249	3.3151	4,115.9	(3.26)	0.2428	>99.989
							Overall DRE		>99.98

( ) - Not Detected; value shown is the analytical limit of detection.
( ) - Estimated; value shown is above minimum detection limit but below the quantitation limit.

NOTE: Overall DRE is calculated from sum of W_{in} and W_{out}. Only pesticides with active ingredients in excess of the minimum detection limit in the feed were included in the overall DRE.

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TABLE 2.5

D.G. KHAN CEMENT COMPANY

ORGANOPHOSPHATE DESTRUCTION AND REMOVAL EFFICIENCY
REANALYSIS BY SIR

CONDITION 2

Run	Pesticide	Total Feed Rate (l/min)	Active Ingredient in the Feed (µg/ml)	Pesticide Feed Rate (W_{in}) (kg/hr)	Sample Volume (Nm^3)	Exhaust Gas Flow Rate (Nm^3/min)	Active Ingredient in the Sample (µg/sample)	Pesticide Emission Rate (W_{out}) (g/hr)	DRE (%)
1	Nexion (bromophos-methyl)	4.16	66,956.37	16.71	3.2462	4,102 5	182.15	13 812	99.92
1	Nogos	4.16	87,608.57	21.87	3.2462	4,102.5	(5.39)	<0 409	>99.998
							Overall DRE		>99.96
2	Nexion (bromophos-methyl)	5.63	19,823.77	6.70	3 2276	4,044 6	23.09	1.736	99.97
2	Fenitrothion	5.63	12,192.33	4.12	3.2276	4,044.6	(0.09)	<0.007	>99.9998
2	Nuvacron	5.63	(2,349.25)	0.79	3.2276	4,044.6	(0.048)	<0.004	>99.9995
2	Nogos	5.63	(3,614.73)	1.22	3.2276	4,044 6	(0.018)	<0.001	>99.99992
							Overall DRE		>99.986

( ) - Not Detected; value shown is the analytical limit of detection.
( ) - Estimated; value shown is above minimum detection limit but below the quantitation limit.

NOTE: Overall DRE is calculated from sum of W_{in} and W_{out}. Only pesticides with active ingredients in excess of the minimum detection limit in the feed were included in the overall DRE.

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TABLE 2.6

D.G. KHAN CEMENT COMPANY

ORGANOCHLORIDE DESTRUCTION AND REMOVAL EFFICIENCY
REANALYSIS BY SIR

CONDITION 3

Run	Pesticide	Total Feed Rate (l/min)	Active Ingredient in the Feed (µg/ml)	Pesticide Feed Rate (W_{in}) (kg/hr)	Sample Volume (Nm^3)	Exhaust Gas Flow Rate (Nm^3/min)	Active Ingredient in the Sample (µg/sample)	Pesticide Emission Rate (W_{out}) (g/hr)	DRE (%)
1	Dieldrin	0.48	50,035.63	1.441	3.4367	4,287.4	2.55	0.1909	99.987
1	Zolone	0.48	37,709.27	1.086	3.4367	4,287.4	3.01	0.2253	99.98
							Overall DRE		99.98
2	Dieldrin	1.06	48,608.68	3.092	3.3151	4,115.9	52.74	3.929	99.8
2	Zolone	1.06	35,355.04	2.249	3.3151	4,115.9	13.82	1.030	99.95
							Overall DRE		99.91

( ) - Not Detected; value shown is the analytical limit of detection.
( ) - Estimated; value shown is above minimum detection limit but below the quantitation limit.

NOTE: Overall DRE is calculated from sum of W_{in} and W_{out}. Only pesticides with active ingredients in excess of the minimum detection limit in the feed were included in the overall DRE.

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- **Active Ingredient in the Sample (μg/sample)** — Total pesticide mass collected per sample determined from laboratory analysis of the pesticide collection media from the MM5 sampling train.

- **Pesticide Emission Rate (g/hr)** — A calculated value representing the the rate of pesticide emission from the cement kiln. This emission rate is calculated using the "Sample Volume", "Flow Rate", and "Analytical Results". Example calculations are provided in Appendix E.

- **DRE (%)** — The destruction and removal efficiency of the cement kiln. This value is calculated as follows:

$$DRE = \frac{W_{in} - W_{out}}{W_{in}} \times 100 \text{ percent}$$

where: W_{in} = Pesticide feed rate to the kiln, (kg/hr)

W_{out} = Pesticide emission rate (g/hr) from the kiln in the exhaust gases.

Results for the OP and OC low resolution gas chromatography/mass spectrometry (GC/MS) analyses are shown in Tables 2.3 and 2.4. The OP feed mixture was analyzed for seven different pesticides that were expected to be present. As shown in Table 2.3, only two pesticides were detected in each OP feed sample. The other pesticides were not present in sufficient quantity to be detected, and DREs could not be calculated. For the Nuvacron and Nogos in Run 2, the estimated concentration reported by the laboratory was used to calculate an estimated pesticide feed rate which was used to estimate the DRE. The MM5 Stack gas samples were analyzed for the same seven OP pesticides as the feed samples. As shown in Table 2.3, only Nexion (Bromophos-Methyl) was present in sufficient quantity to be detected. For those compounds that were detected in the feed but not in the exhaust gases, DREs were calculated using the analytical detection limit for the exhaust gas MM5 samples. This is a conservative approach: because the actual quantity of pesticides in the exhaust gas was less than the value used in the DRE calculation, the calculated DRE is lower than the actual DRE. For those situations, the DRE values in Table 2.3 are reported as greater than (>) values. The OC pesticides feed mixture was analyzed by low resolution GC/MS for the five pesticides that were expected to be present. Only Dieldrin and Zolone were detected. These results are presented in Table

2.4, and show uniformity between the two feed samples. For the first run, neither pesticide was detected in the exhaust gas. In the second run, Dieldrin was detected but Zolone was not. Thus, three of the four calculated DREs are reported as greater than values.

PES was concerned that low resolution GC/MS technique failed to detect most of the pesticides in the MM5 sampling train media. In an effort to improve the results, methods allowing lower analytical limits of detectability were used to reanalyze the samples. Samples were reanalyzed using high resolution GC/MS with Selected Ion Response (SIR). The OP samples were analyzed for Nexion (Bromophos-Methyl), Fenitrothion, Nuvacron, and Nogos. The OC samples were analyzed for Dieldrin and Zolone. Results of these reanalyses are presented in Tables 2.5 and 2.6.

The high resolution GC/MS (SIR) analysis did increase the calculated DREs for those pesticides that were not previously detected. However, DREs calculated for Fenitrothion and Nogos for Run 1 and Nexion (Bromophos-Methyl) for Run 2 using the results of the high resolution GC/MS method were lower than those calculated with the low resolution GC/MS values. Use of the high resolution GC/MS method also resulted in the determination of lower DREs for the OC pesticides.

Examination of the "Active Ingredient in the Feed" data determined by GC/MS low resolution for the OP pesticides suggested that the pesticide mixture fed to the kiln was not homogenous. This fact is illustrated by comparing the reported concentration of Nexion (Bromophos-Methyl) for Condition 2, Run 1 (66,956 μg/ml) and Run 2 (19,824 μg/ml), in Table 2.3. This nonhomogeneity was expected because the tank truck contained two compartments into which the waste pesticides had been dumped at random, resulting in different pesticide concentrations in each compartment. PES tried to ensure the homogeneity of the feed by drawing simultaneously from both compartments, but that procedure did not work well because the compartment outlet lines periodically became plugged with sludge. PES asked the laboratory to verify the reported concentrations. The reanalysis confirmed the reported concentrations were correct. Because examination of the "Active Ingredient in the Feed" data for the OC pesticides indicated that this mixture was homogeneous, no reanalysis of the OC pesticides was necessary. PES had anticipated that the OC pesticides would be homogeneous because the OC pesticides were blended in a holding tank before being loaded into the tank truck.

OP DRE

The OP pesticide burn was designated as Condition 2. Although the original test protocol called for the injection of a single OP pesticide, availability on site made this impossible. Therefore, the actual pesticide burned was a mixture of seven different OPs in varying amounts. The respective quantities of each of the seven pesticides fed to the kiln are summarized below.

OP Pesticide	Quantity (liters)
Nexion	6,187
Fenitrothion	1,641
Nuvacron	1,411
Nogos (DDVP)	1,218
Metasystox	600
Dimethoate	205
Gusathion	200
	11,372

Tables 2.3 and 2.5 present the DRE for Condition 2, OP pesticides, using low resolution and high resolution GC/MS analysis respectively. These data are summarized below.

Run	Analytical Technique	Overall DRE (%)
1	Low Resolution	>99.8
2	Low Resolution	>99.994
1	High Resolution	>99.96
2	High Resolution	>99.98

The results for the low resolution and high resolution GC/MS averaged >99.897 and >99.97 percent DRE respectively.

These values do not satisfy RCRA standards of ≥ 99.99 percent DRE. It is PES' opinion that the quantities of pesticides in the MM5 samples were too low to measure accurately, a fact which may have produced the inconsistencies in the low versus high resolution GC/MS results. Had there been only one pesticide, or had the feed rate been higher, more pesticide would have been collected in the MM5 samples and the analytical accuracy would have been improved. It is likely that the higher DREs could have been determined and that the 99.99 percent DRE RCRA standard can be achieved.

OC DRE

The OC pesticide burn was designated as Condition 3. As with the OP pesticide, the original protocol called for the injection of a single OC. Because of availability constraints, the actual pesticide burned was a mixture of three OCs, one OP, and one amide. The quantities of each of the five pesticides fed to the kiln are summarized below.

OC Pesticide	Quantity (liters)
Dieldrin	2,620
Zolone	2,404
STAM F-34	200
Thiodane	180
Kelthane	141
	5,545

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Because STAM F-34, Thiodane, and Kelthane were present in such low quantities in the mixture, the laboratory was not able to detect them in the feed samples.

The DREs calculated for the OC pesticide mixture are summarized below.

Run	Analytical Technique	Overall DRE (%)
1	Low Resolution	>99.986
2	Low Resolution	>99.98
1	High Resolution	99.98
2	High Resolution	99.91

Results for low resolution and high resolution GC/MS analyses averaged >99.98 and 99.95 percent respectively. The low resolution OC DREs are closer to the RCRA standard than the low resolution OP DREs, while the high resolution OC results are not quite as high as the corresponding OP DREs. The OC DREs are very close to the RCRA standard. PES believes that the feed rate of pesticide was too low to enable a sufficiently accurate determination of DRE.

PARTICULATE EMISSIONS

A total of six particulate emission tests were performed to measure particulate mass emission rates and concentrations during three different firing conditions. Two tests were performed for each condition. Condition 1 was a baseline condition in which only Number 6 fuel oil was burned with no pesticides fed into the kiln. During Condition 2, a mixture of OP pesticides was fed into the kiln through a separate burner in addition to the Number 6 fuel oil. Condition 3 consisted of burning a mixture of OC pesticides in addition to the Number 6 fuel oil. Particulate emission data are presented below for each condition. Although sampling was performed at a location in the stack as well as the breaching, only the results for the samples collected in the breaching are presented below. The location of the sampling ports in the stack was later judged not be representative.

Condition 1, Baseline

The results of the Condition 1 particulate tests are presented in Table 2.7. The exhaust gas velocities were 23.7 and 23.5 meters per second (m/sec) for Runs 1 and 2 respectively. The volumetric flow rates were 6,416 and 6,366 actual cubic meters per minute (acm/min) and 4,133 and 4,192 dry normal cubic meters per minute (dncm/min) for Runs 1 and 2 respectively.

The particulate concentrations corrected to 7 percent O_2 were 0.1281 and 0.1247 grams per dry normal cubic meter (g/dncm) for Runs 1 and 2 respectively. The particulate emission rates were 21.98 and 22.54 kilograms per hour (kg/hr)for Runs 1 and 2 respectively. The results for Run 1 and Run 2 for Condition 1 were consistent. The particulate

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TABLE 2.7

D.G. KHAN CEMENT COMPANY

METHOD 5 PARTICULATE RESULTS FOR CONDITION 1, BASELINE

Parameter	Units	Run 1	Run 2
Sample Time	mins.	75	75
Sample Volume	m^3	1.061	1.048
ExhaustGas Velocity	m/sec.	23.7	23.5
Exhaust Gas Volumetric Flowrate	acm/min.	6416	6366
Exhaust Gas Volumetric Flowrate	dncm/min.	4133	4192
Exhaust Gas Temperature	°C	116	116
Exhaust Gas Moisture	% vol.	11.8	9.8
Oxygen Conc.	% vol.	11.3	10.9
Carbon Dioxide Conc.	%	15.4	16.8
Percent Isokinetic	%	99.8	95.6
Particulate Collected	mg	89.0	87.4
Particulate Conc.	g/dncm	0.0885	0.0897
Particulate Conc. Corrected to 7% O_2	g/dncm	0.1281	0.1247
Particulate Emission Rate	kg/hr.	21.98	22.54

concentrations corrected to 7 percent O_2 were less than the RCRA limit of 0.183 g/dncm during both runs.

Condition 2, Organophosphate Mixture

The particulate sampling results for Condition 2 are presented in Table 2.8. The exhaust gas velocities were 23.2 and 24.2 m/sec for Runs 1 and 2 respectively. The volumetric flow rates were 6,269 and 6,552 acm/min and 4,230 and 3,952 dncm/min for Runs 1 and 2 respectively.

The particulate concentrations corrected to 7 percent O_2 were 0.1413 and 0.2335 g/dncm for Runs 1 and 2 respectively. The particulate emission rates were 23.74 and 28.72 kg/hr for Runs 1 and 2 respectively.

Results from Run 2 were slightly higher than Run 1. Particulate emissions during Run 2 exceeded the RCRA standard of 0.183 g/dncm.

Condition 3, Organochloride, Mixture

The Condition 3 particulate results are presented in Table 2.9. The exhaust gas velocities were 23.0 and 22.8 m/sec for Runs 1 and 2 respectively. Volumetric flow rates were 6,215 and 6,154 acm/min and 4,131 and 3,981 dncm/min for Runs 1 and 2 respectively.

Particulate emission concentrations corrected to 7 percent O_2 were 0.3226 and 0.1225 g/dncm. Particulate emission rates were 22.95 and 21.23 kg/hr for Runs 1 and 2 respectively.

The particulate concentration corrected to 7 percent O_2 for Run 1 was higher than the RCRA standard of 0.183 g/dncm.

Particulate Emission Data Comments

The particulate emissions data were relatively consistent. The mass emission rates ranged from 21.33 kg/hr to 28.72 kg/hr. Particulate concentrations ranged from 0.0885 to 0.1210 g/dncm. There was some variation in the Orsat measured oxygen values and this caused the normalized particulate concentrations (corrected to 7% oxygen) to vary more than the uncorrected values. Two of the six runs resulted in particulate concentrations corrected to 7 percent oxygen that were higher than the RCRA standard. One of these runs, Condition 3, Run 1, the oxygen concentration appears to have been unusually high. There may have been a problem with this oxygen sample. All of the particulate concentrations were well below the Punjab standard of 0.300 g/dncm. It should be remembered that the RCRA standards are for incinerators, not cement kilns.

CHLORIDE (Cl^-) EMISSIONS

Chloride emissions were analyzed as hydrochloric acid (HCl) and free chlorine (Cl_2) and the results are summarized in Tables 2.10 and 2.11. Results from the demonstration burn are within EPA Punjab

TABLE 2.8

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METHOD 5 PARTICULATE RESULTS FOR CONDITION 2, ORGANOPHOSPHATE MIXTURE

Parameter	Units	Run 1	Run 2
Sample Time	mins.	75	75
Sample Volume	m^3	1.062	1.050
Exhaust Gas Velocity	m/sec.	23.2	24.2
Exhaust Gas Volumetric Flowrate	acm/min.	6269	6552
Exhaust Gas Volumetric Flowrate	dncm/min.	4230	3952
Exhaust Gas Temp.	°C	114	142
Exhaust Gas Moisture	% vol.	8.2	11.7
Oxygen Conc.	% vol.	11.7	13.7
Carbon Dioxide Conc.	% vol.		14.1
10.8			
Percent Isokinetic	%	97.2	100.3
Particulate Collected	mg	93.6	116.8
Particulate Conc.	g/dncm	0.0936	0.1210
Particulate Conc. Corrected to 7% O_2	g/dncm	0.1413	0.2335
Particulate Emission Rate	kg/hr.	23.74	28.72

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TABLE 2.9

D.G. KHAN CEMENT COMPANY

METHOD 5 PARTICULATE RESULTS FOR CONDITION 3, ORGANOCHLORINE MIXTURE

Parameter	Units	Run 1	Run 2
Sample Time	mins.	75	75
Sample Volume	m^3	1.023	1.038
Exhaust Gas Velocity	m/sec.	23.0	22.8
Exhaust Gas Volumetric Flowrate	acm/min.	6215	6164
Exhaust Gas Volumetric Flowrate	dncm/min.	4131	3981
Exhaust Gas Temp.	°C	104	108
Exhaust Gas Moisture	% vol.	11.7	13.2
Oxygen Conc.	% vol.	16.9	10.8
Carbon Dioxide Conc.	% vol.	6.0	16.8
Percent Isokinetic	%	95.4	101.8
Particulate Collected	mg	88.8	87.6
Particulate Conc.	g/dncm	0.0927	0.0888
Particulate Conc. Corrected to 7% O_2	g/dncm	0.3226	0.1225
Particulate Emission Rate	kg/hr.	22.95	21.23

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TABLE 2.10

D.G. KHAN CEMENT COMPANY
SUMMARY OF CHLORIDE EMISSIONS AS HCl

ANALYSIS BY SPECIFIC ION ELECTRODE

Run Number	Sample Duration (min)	Sample Volume (dscf)	Stack Gas Flow Rate (dscf/min)	Chloride Collected (mg)	Concentration as Cl		Concentration as HCl		HCl Rate (g/min)
					(mg/dscf)	(mg/dncm)	(mg/dscf)	(mg/dncm)	
HCl-1-1B	60	3.884	140,029	2.6	0.67	24	0.69	24	96
HCl-1-2B	60	3.675	142,409	4.0	1.1	38	1.1	39	160
HCl-2-1B	60	4.579	144,881	4.7	1.0	36	1.1	37	150
HCl-2-2B	60	3.621	142,838	7.7	2.1	75	2.2	77	310
HCl-3-1B	60	4.483	151,413	7.5	1.7	59	1.7	61	260
HCl-3-2B	60	5.035	145,356	8.2	1.6	58	1.7	59	240

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TABLE 2.11

D.G. KHAN CEMENT COMPANY
SUMMARY OF CHLORIDE EMISSIONS AS FREE Cl_2

ANALYSIS BY ION CHROMATOGRAPHY

Run Number	Sample Duration (min)	Sample Volume (dscf)	Stack Gas Flow Rate (dscf/min)	Chloride Collected (mg)	Concentration as Cl		Concentration as Cl_2		Cl_2 Rate (g/min)
					(mg/dscf)	(mg/dncm)	(mg/dscf)	(mg/dncm)	
Cl_2-1-1B	60	3.884	140,029	1.6	0.41	15	0.41	15	58
Cl_2-1-2B	60	3.675	142,409	1.2	0.34	12	0.34	11.8	48
Cl_2-2-1B	60	4.579	144,881	0.86	0.19	6.6	0.19	6.6	27
Cl_2-2-2B	60	3.621	142,838	0.90	0.25	8.8	0.25	8.8	36
Cl_2-3-1B	60	4.483	151,413	1.1	0.25	8.7	0.25	8.7	37
Cl_2-3-2B	60	5.035	145,356	0.33	0.066	2.3	0.066	2.3	9.5

BEST AVAILABLE DOCUMENT

standards but do not meet RCRA standards (standards for HCl are 30.24 g/min or 99 percent destruction removal, whichever is greater). The sampling method selected for measuring HCl and Cl_2 was a Draft USEPA method. Subsequent to selecting and using the method, PES learned that there were potential problems associated with using the method on cement kiln exhaust gases. In a paper presented in March 1990 at an Air and Waste Management Association specialty conference on hazardous waste combustion in boilers and kilns,[1] it is proported that the Draft USEPA Method 26 is not appropriate for cement kilns because the method collects ammonium chloride and other chloride salts and reports them as HCl. Therefore, the high HCl values should probably be discounted.

SO_x EMISSIONS

SO_x emissions are measured as a vehicle for identifying process upsets. SO_x emissions were analyzed as sulfur dioxide (SO_2) and sulfuric acid (H_2SO_4). Measured concentrations and emission rates are reported in Table 2.12.

Runs 2-1B and 2-2B showed the highest H_2SO_4 levels, with concentrations of 166.8 mg/dncm and 33.7 mg/dncm and an emission rate of 42,450 g/hr and 8,001 gr/hr respectively. Average for the remaining runs was 8.2 mg/dncm and the average emission rate was 1,982.85 g/hr.

SO_2 levels were consistent between runs and in compliance with EPA, Punjab, Pakistan emission limits. SO_2 concentrations were all very low, ranging from 0.65 to 10 mg/dncm.

CONTINUOUS EMISSION MONITORS (CEMS)

The plant operated two CEMs; one for oxygen and one for carbon monoxide (CO). The range for the oxygen analyzer was 0-5 percent. The range for the CO analyzer was 0-2 percent.

In Figures 2.1 through 2.6, the oxygen and carbon monoxide concentrations measured by the CEMs for each of the six runs are depicted graphically. The graphs were prepared from 15 minute averages taken from the CEM strip charts. There was one run, Run 2-1B (Breaching), where the O_2 level exceeded the range of the analyzer. These readings are identified with a dashed line at the 5.0 percent level.

CO was measured in the 0-2.0 percent range. Most of the time, the CO concentration was essentially zero, but there were spikes that occurred when kiln operations were upset. The highest spike during a Modified Method 5 sampling run occurred during Run 2-1B when the CO concentration reached 0.6 percent (6,990 mg/Nm³). The run with the most spikes was 3-2B. The highest spike during run 3-2B was 0.44 percent

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[1]"Cement Kilns, Sources of Chlorides Not HCl Emissions", Dr. Michael von Seebach and David Gossman.

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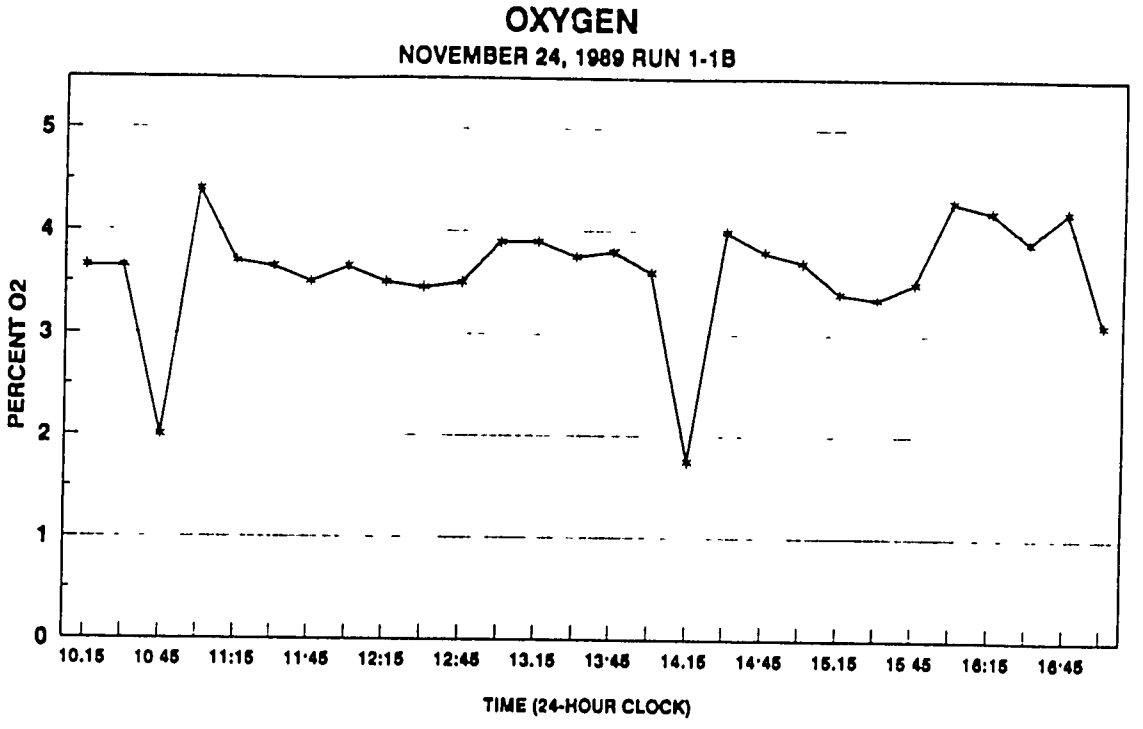


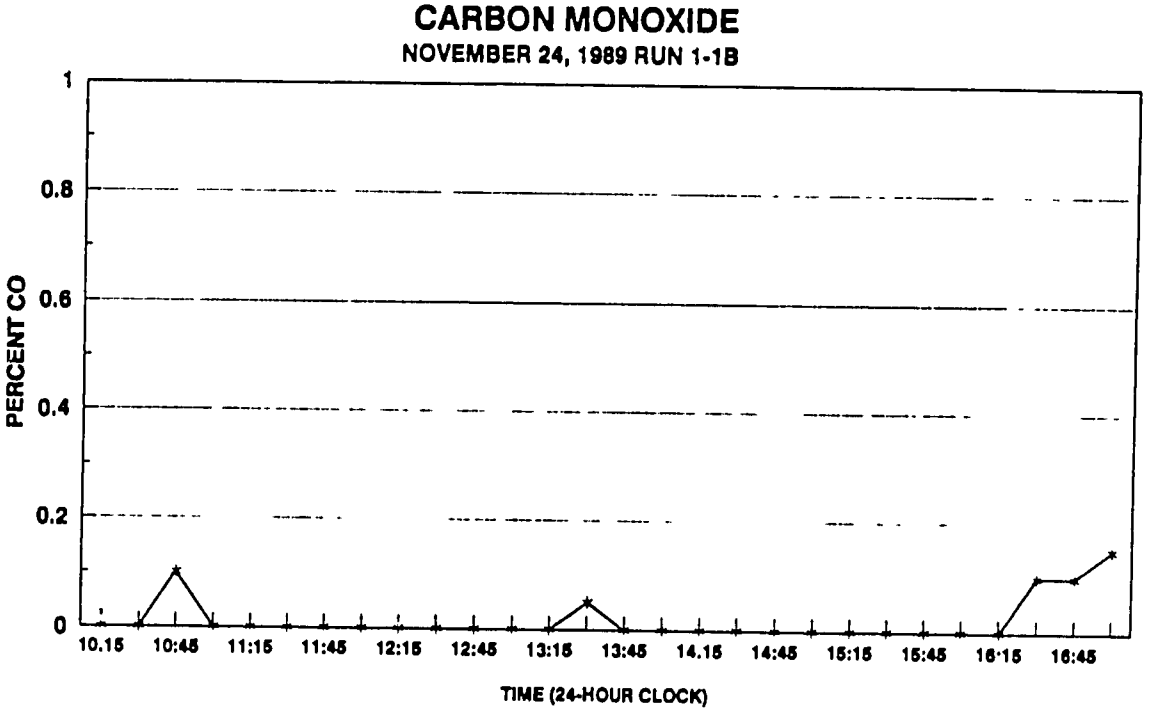
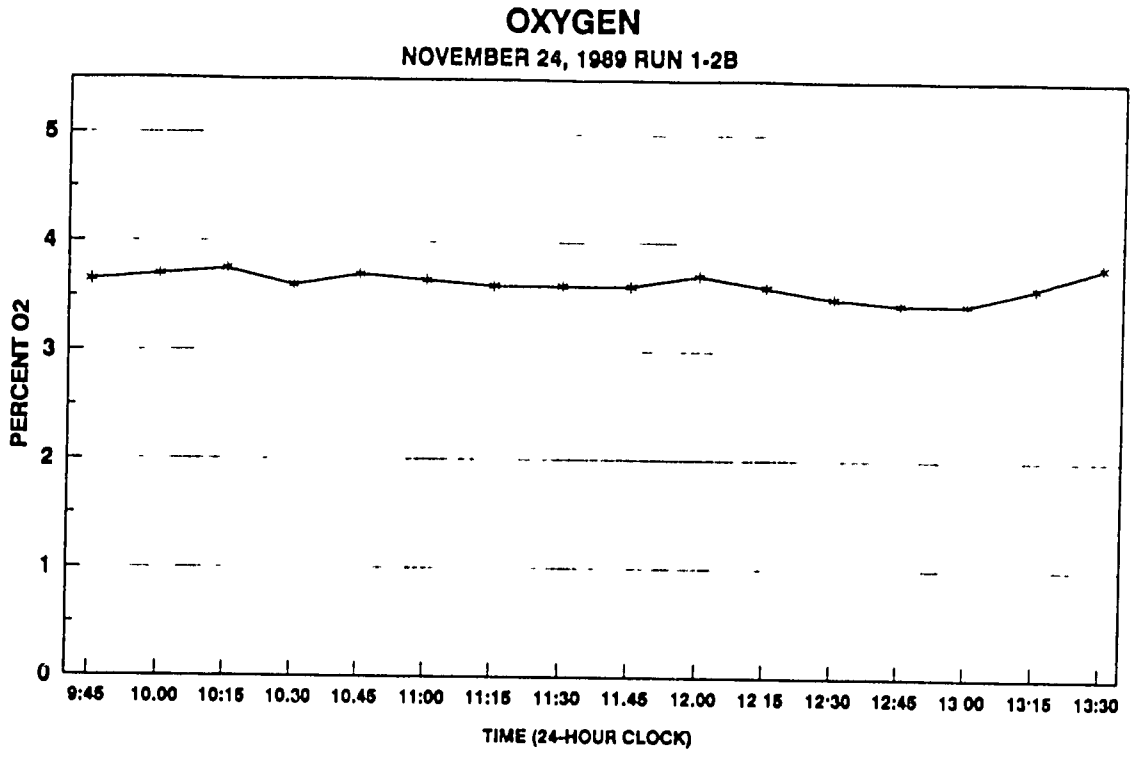


FIGURE 2.1 O_2 AND CO CEM FOR RUN 1-1B



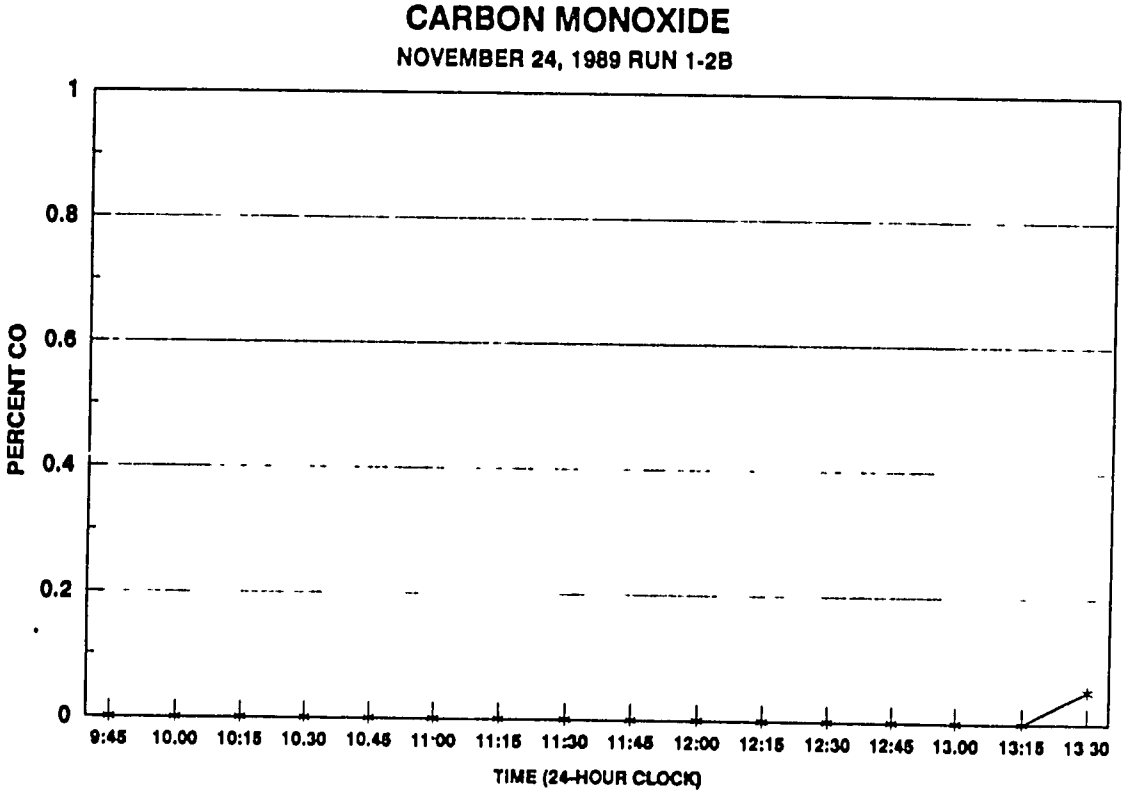


FIGURE 2.2 O_2 AND CO CEM FOR RUN 1-2B

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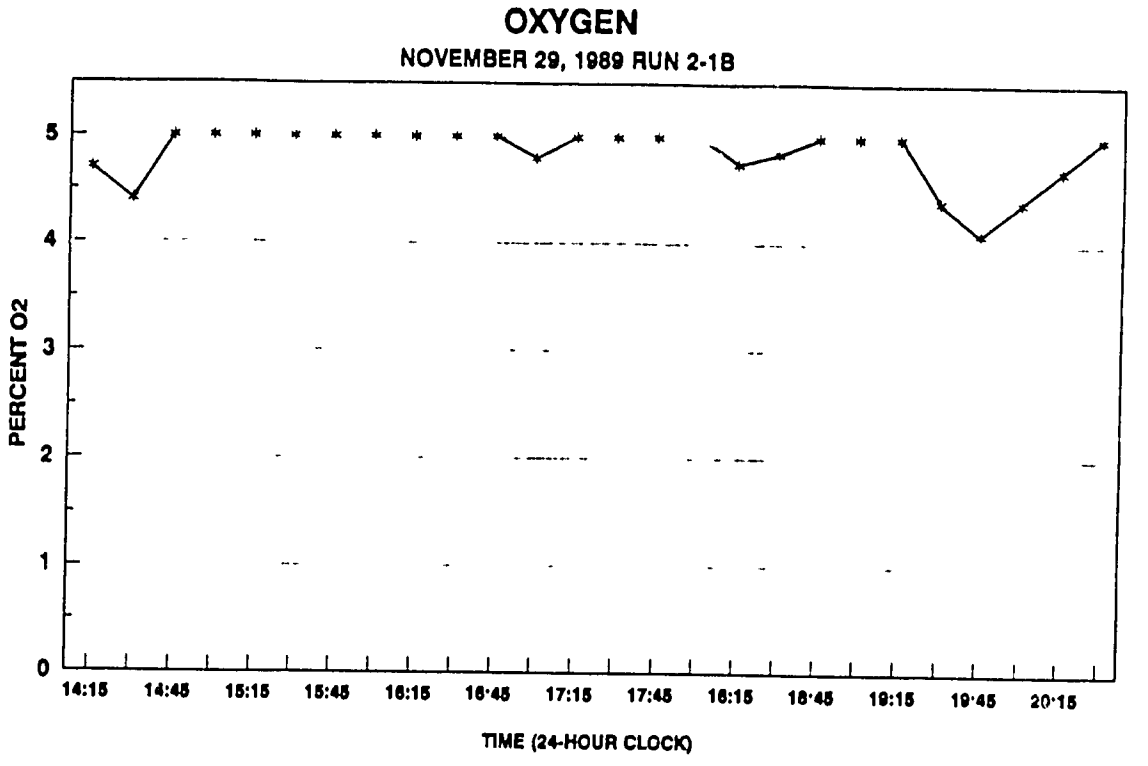


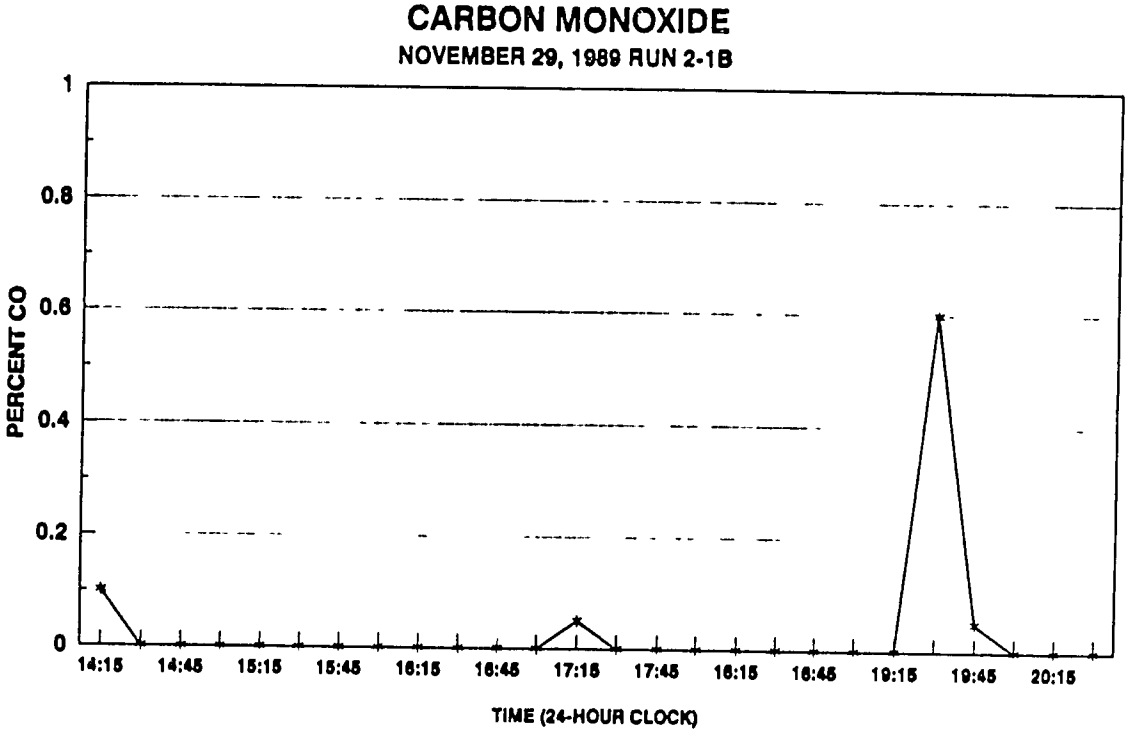
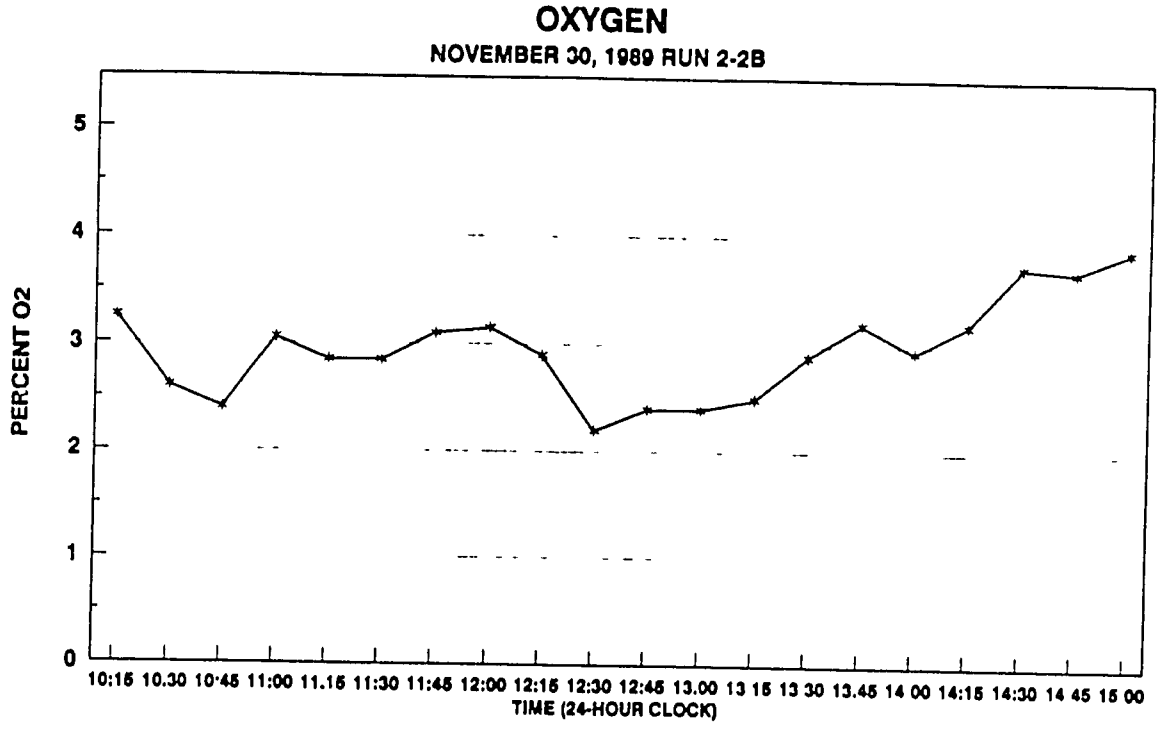


FIGURE 2.3 O_2 AND CO CEM FOR RUN 2-1B



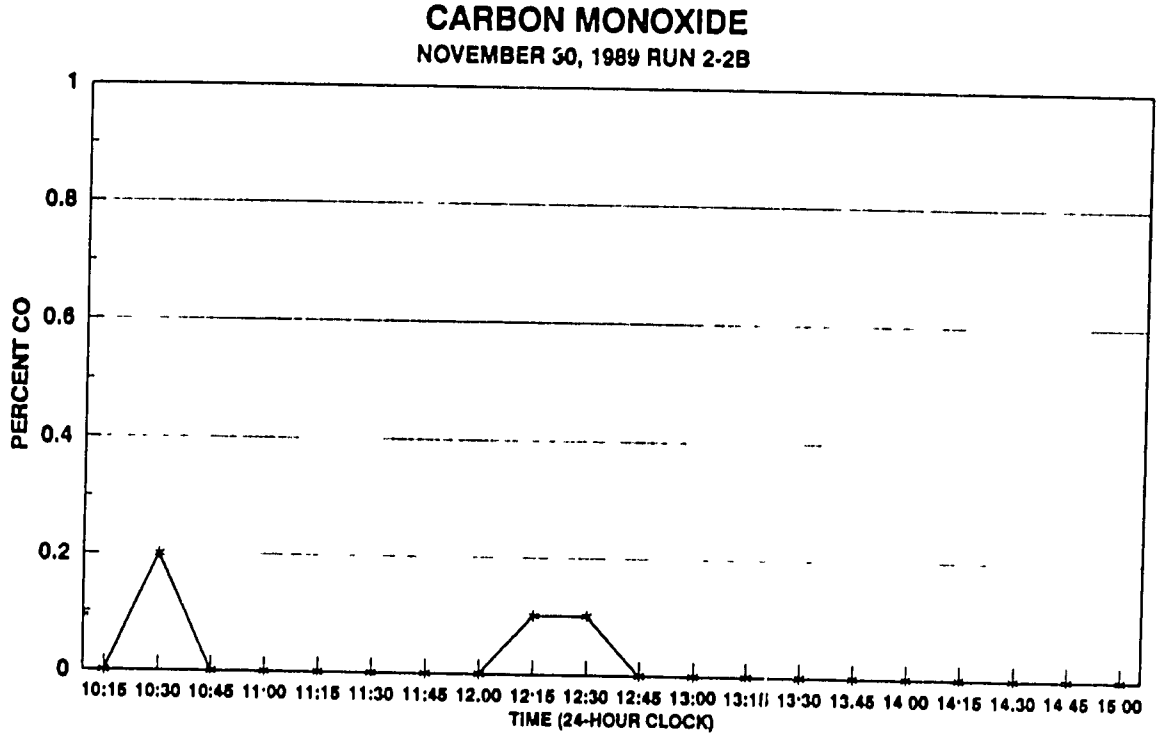


FIGURE 2.4 O_2 AND CO CEM FOR RUN 2-2B

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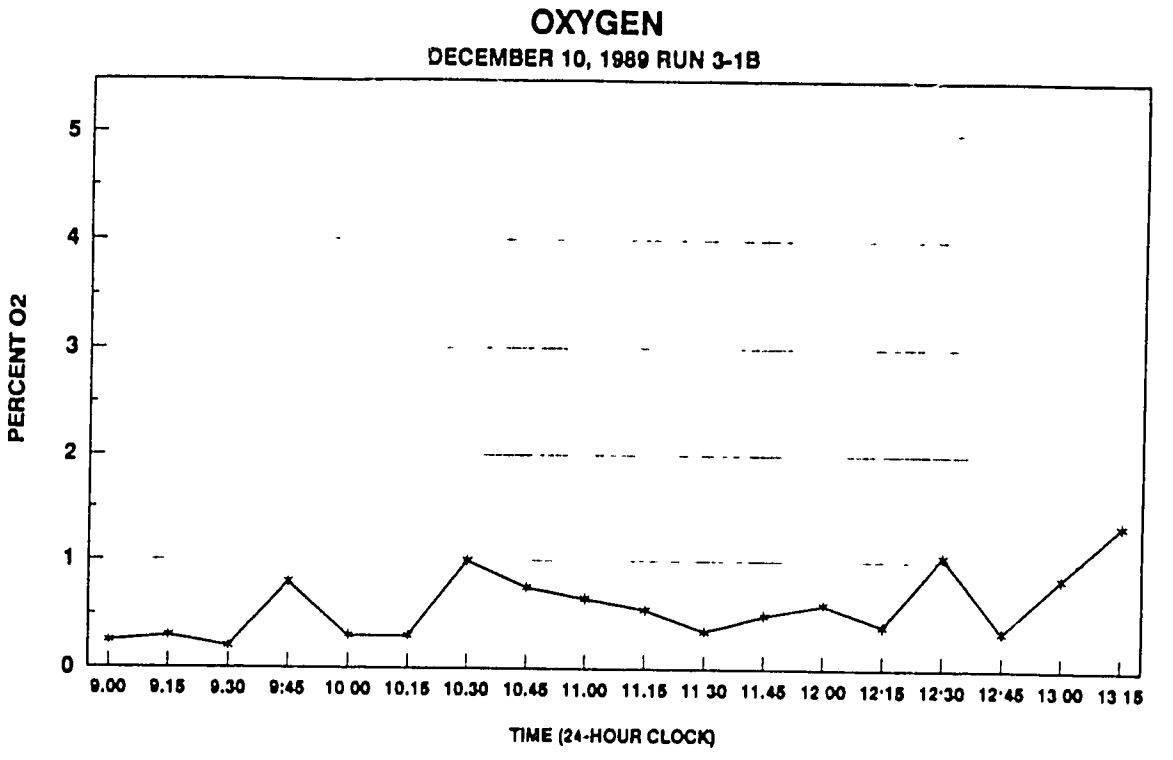


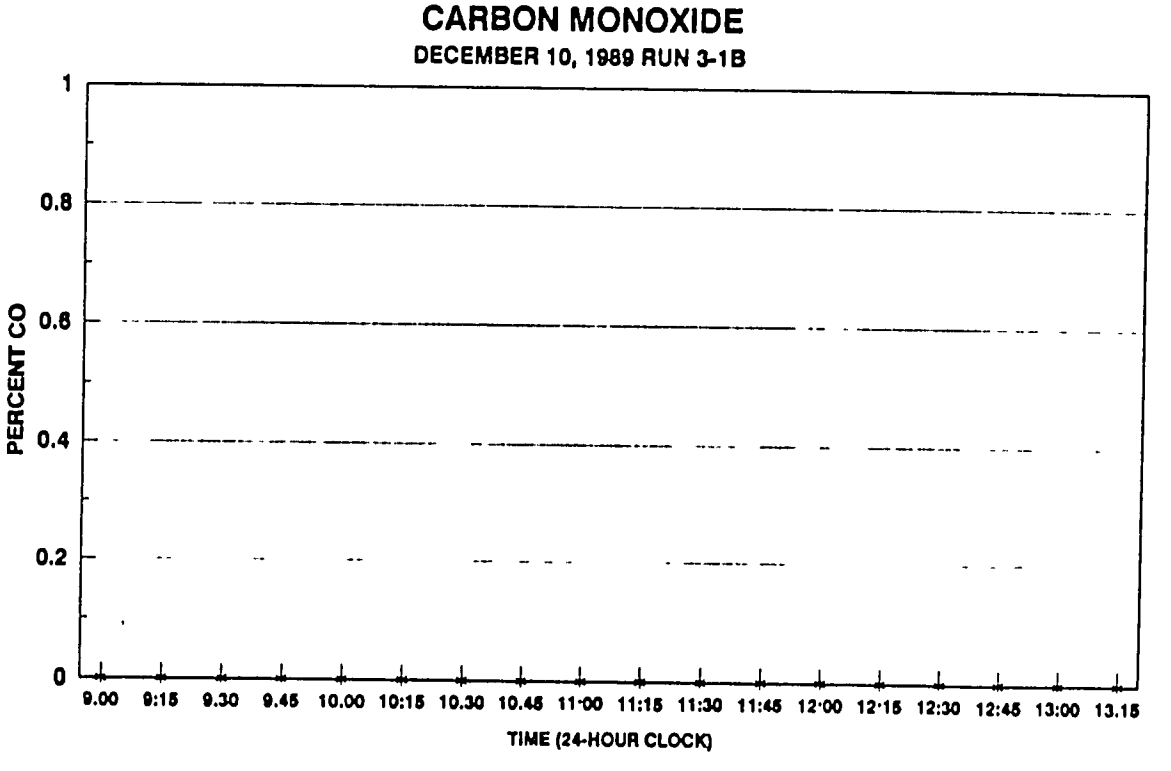
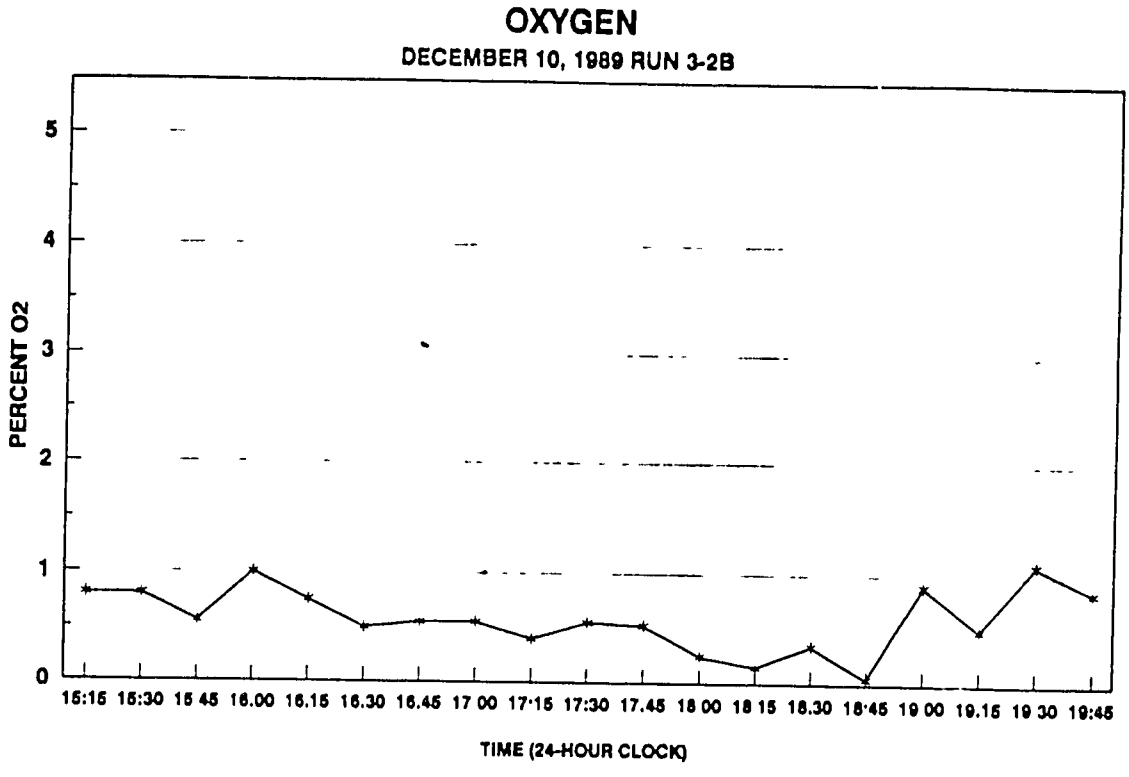


FIGURE 2.5 O_2 AND CO CEM FOR RUN 3-1B



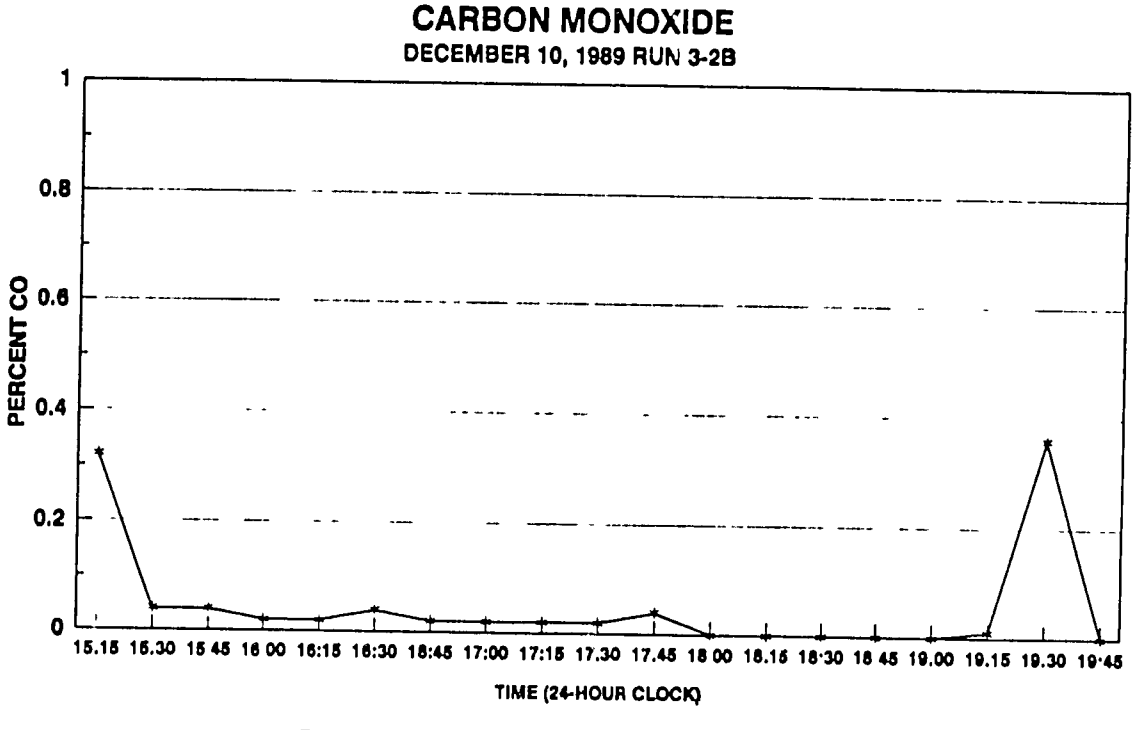


FIGURE 2.6 O_2 AND CO CEM FOR RUN 3-2B

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TABLE 2.12

D.G. KHAN CEMENT COMPANY

SULFUR DIOXIDE AND SULFURIC ACID
CONCENTRATIONS AND EMISSION RATES

Run	Date	Pollutant	Concentration (mg/dncm)	Emission Rate (g/hr)
M5-1-1B	11-24-89	SO_2	2.4	605.5
		H_2SO_4	0.25	61.80
M5-1-2B	11-30-89	SO_2	1.4	354.2
		H_2SO_4	0.15	38.73
M5-2-1B	11-29-89	SO_2	0.65	165.9
		H_2SO_4	170	42,450
M5-2-2B	11-29-89	SO_2	0.4	80.41
		H_2SO_4	34	8,001
M5-3-1B	12-10-89	SO_2	3.1	760.6
		H_2SO_4	7.3	1,811
M5-3-2B	12-10-89	SO_2	10	2,416
		H_2SO_4	2.5	606.4

(5,125 mg/Nm³). Although the spikes exceeded the EPA Punjab standard, when the concentrations were averaged over the sampling run time, all averages were below the EPA Punjab standard of 800 mg/Nm³.

It appears that the CO monitor was not operating during Run 3-1B because the CO strip chart trace was zero for the entire run. During all the other runs, there were small fluctuations in the CO concentration even when the values were near zero.

Run 3-2B had the highest average CO concentration (680 mg/Nm³) and the most CO spikes indicating the kiln operation was not as stable during this run. Shortly after the test run was completed, the CO concentration exceeded 1.5%, the point at which the ESP is automatically shut down to avoid an explosion. It is believed that the kiln operating problems had a detrimental effect on the DRE for Run 3-2B. At 99.91%, Run 3-2B had the lowest DRE measured during the testing program. Similarly, the second lowest DRE was 99.96% measured during Run 2-1B, and that run had the second highest average CO concentration, 358 mg/Nm³.

We do not believe that burning the pesticides contributed to any process problems. The quantities burned were so small relative to the amount of number 6 fuel oil burned and the quantity of material processed by the kiln that it is inconceivable that the upsets were due to the pesticides. Furthermore, similar operating problems occurred when the kiln was not burning pesticides. During the time the test team was on-site, the ESP tripped on several other occasions when no pesticides were being burned.

PRODUCTS OF INCOMPLETE COMBUSTION (PICS)

The XAD-2 resin modules from the Modified Method 5 (MM5) trains were screened for the twenty most prominent compounds to look for PICs. The compounds found in the baseline samples were compared to those found in the pesticide burn samples. Results of this screening are presented in Tables 2.13 through 2.18. No unexpected PICs were detected, with the exception of Siloxane. Triangle Labs informed us that Siloxane is a common contaminant from a silicon based plasticizer. It is probably not a part of the process. In some cases; i.e., Run 3-1B and 3-2B, only 19 peaks were reported.

PROCESS SAMPLES

Process samples were collected in five areas of the plant and analyzed for OP and OC pesticides. The kiln feed, ESP dust, and clinker samples were analyzed for the OP and OC pesticides by a USEPA contract laboratory. As shown in Tables 2.19, 2.20, and 2.21, no pesticides were found in any of the samples.

Fuel oil samples had also been collected in case it was necessary to explain any anomalies. That was not necessary, so the fuel oil samples were not analyzed.

TABLE 2.13

D.G. KHAN CEMENT COMPANY

SUMMARY OF SCREENING FOR PRODUCTS OF INCOMPLETE COMBUSTION (PICs), RUN 1-1B

Name	Amount, ug
1. C10 H8	432
2. Siloxane	289
3. Siloxane	246
4. Siloxane	166
5. Hydrocarbon, Substituted	96
6. Siloxane	89
7. Hydrocarbon, Substituted/Unsaturated	58
8. Siloxane	52
9. C12 H10	33
10. Siloxane	30
11. C11 H10	24
12. Hydrocarbon, Substituted/Unsaturated	18
13. Molecular Sulfur, S8	17
14. Unknown	16
15. Siloxane	15
16. C12 H18	12
17. Alkyl Benzoic Acid, C9	11
18. Siloxane	7
19. Hydrocarbon	7
20. Hydrocarbon, Substituted	4

TABLE 2.14

D.G. KHAN CEMENT COMPANY

SUMMARY OF SCREENING FOR PRODUCTS OF INCOMPLETE COMBUSTION (PICs), RUN 1-2B

Name	Amount, ug
1. C10 H8	724
2. Aromatic, Substituted	531
3. Siloxane	409
4. Siloxane	299
5. Hydrocarbon	281
6. Siloxane	215
7. Hydrocarbon, Substituted	209
8. Benzoic Acid	141
9. Siloxane	136
10. Siloxane	118
11. C9 H10 O	100
12. Unknown	93
13. C12 H10	77
14. Hydrocarbon, Substituted/Unsaturated	73
15. Siloxane	63
16. Unknown	62
17. C10 H14	59
18. C11 H10	52
19. C9 H8	44
20. Alkyl Benzene, C10	42

TABLE 2.15

D.G. KHAN CEMENT COMPANY

SUMMARY OF SCREENING FOR PRODUCTS OF INCOMPLETE COMBUSTION (PICs), RUN 2-1B

Name	Amount, ug
1. C10 H8	953
2. Aromatic, Substituted	628
3. Hydrocarbon	482
4. Siloxane	383
5. Siloxane	283
6. Siloxane	215
7. Benzoic Acid	188
8. Aromatic, Substituted	156
9. Siloxane	151
10. C9 H12	134
11. Alkyl Benzene, C9	137
12. Siloxane	116
13. Hydrocarbon, Substituted/Unsaturated	110
14. Benzoic Acid	83
15. Aromatic, Substituted	71
16. Hydrocarbon, Substituted	71
17. Hydrocarbon, Substituted/Unsaturated	69
18. Hydrocarbon, Substituted	69
19. Aromatic, Substituted	68
20. Siloxane	64

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TABLE 2.16

D.G. KHAN CEMENT COMPANY

SUMMARY OF SCREENING FOR PRODUCTS OF INCOMPLETE COMBUSTION (PICs), RUN 2-2B

Name	Amount, ug
1. Aromatic, Substituted	2541
2. C10 H8	1314
3. Benzoic Acid	319
4. Hydrocarbon	285
5. C12 H10	269
6. Siloxane	242
7. Siloxane	169
8. Aromatic, Substituted	164
9. Siloxane	154
10. Siloxane	146
11. C11 H10	98
12. Chlorobenzonitrile	89
13. Siloxane	86
14. Alkyl Benzene, C10	84
15. Hydrocarbon, Substituted/Unsaturated	78
16. Benzoic Acid	73
17. Hydrocarbon, Substituted	66
18. Unknown	50
19. Aromatic, Substituted	46
20. Siloxane	44

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TABLE 2.17

D.G. KHAN CEMENT COMPANY

SUMMARY OF SCREENING FOR PRODUCTS OF INCOMPLETE COMBUSTION (PICs), RUN 3-1B

Name	Amount, ug
1. Aromatic, Substituted	2930
2. C10 H8	727
3. Siloxane	530
4. Siloxane	432
5. Hydrocarbon	358
6. Siloxane	127
7. Siloxane	79
8. C10 H14	72
9. Benzoic Acid	148
10 Siloxane	37
11. Hydrocarbon, Substituted	33
12. C12 H10	40
13. C10 H14	72
14. Unknown	28
15. C11 H10	47
16. Aromatic, Substituted	10
17. Siloxane	27
18. Alkyl Benzene, C9	11
19. Hydrocarbon, Substituted	11

TABLE 2.18

D.G. KHAN CEMENT COMPANY

SUMMARY OF SCREENING FOR PRODUCTS OF INCOMPLETE COMBUSTION (PICs), RUN 3-2B

Name	Amount, ug
1. Aromatic, Substituted	2241
2. C10 H8	1167
3. Hydrocarbon	436
4. Siloxane	261
5. Siloxane	207
6. Alkyl Benzene, C9	198
7. Siloxane	154
8. Aromatic, Substituted	147
9. Siloxane	134
10. Hydrocarbon, Substituted/Unsaturated	129
11. Benzoic Acid	125
12. Unknown	120
13. Unknown	118
14. C9 H12	114
15. C11 H10	113
16. C12 H10	108
17. Hydrocarbon, Substituted	100
18. Benzoic Acid	91
19. Hydrocarbon, Substituted/Unsaturated	82

TABLE 2.19

D.G. KHAN CEMENT COMPANY

SUMMARY OF ORGANOPHOSPHATE AND ORGANOCHLORIDE PESTICIDES

IN THE PROCESS SAMPLES FOR CONDITION 1

Concentration as (mg/kg)						
	Process Samples					
	Feed		ESP		Clinker	
Pesticide	1	2	1	2	1	2
Nexion	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Fenitrothion	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Nuvacron	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Nogos	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Metasystox	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
Dimethoate	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Gusathion	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
Dieldrin	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Zolone	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
STAM F-34	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Thiodane	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Kelthane	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2

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TABLE 2.20

D.G. KHAN CEMENT COMPANY

SUMMARY OF ORGANOPHOSPHATE AND ORGANOCHLORIDE PESTICIDES

IN THE PROCESS SAMPLES FOR CONDITION 2

Concentration as (mg/kg)						
	Process Samples					
	Feed		ESP		Clinker	
Pesticide	1	2	1	2	1	2
Nexion	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Fenitrothion	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Nuvacron	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Nogos	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Metasystox	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
Dimethoate	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Gusathion	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
Dieldrin	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Zolone	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
STAM F-34	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Thiodane	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Kelthane	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2

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TABLE 2.21

D.G. KHAN CEMENT COMPANY

SUMMARY OF ORGANOPHOSPHATE AND ORGANOCHLORIDE PESTICIDES

IN THE PROCESS SAMPLES FOR CONDITION 3

Concentration as (mg/kg)						
	Process Samples					
	Feed		ESP		Clinker	
Pesticide	1	2	1	2	1	2
Nexion	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Fenitrothion	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Nuvacron	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Nogos	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Metasystox	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
Dimethoate	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Gusathion	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
Dieldrin	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Zolone	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
STAM F-34	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Thiodane	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Kelthane	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2

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CHAPTER 3

FACILITY DESCRIPTION AND OPERATION

The design of the plant and of the pesticide delivery system is important to the ability to burn pesticides efficiently. In this Chapter, the process used at the plant and the system used to feed pesticides to the kiln are described. Determination of the pesticide flow rate was also an important element in this test burn. The methodology used to calculate the pesticide feed rate is also described below.

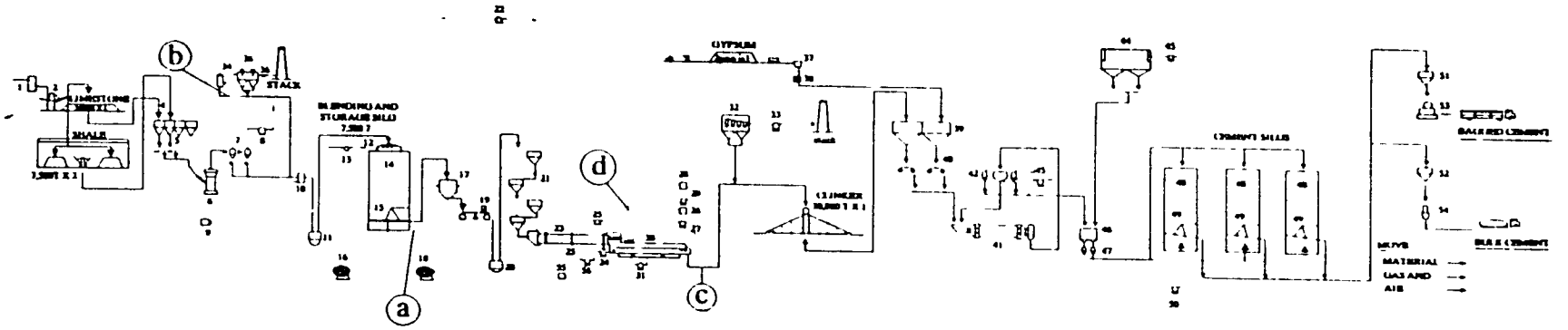
PROCESS DESCRIPTION

The D.G. Khan Cement Company plant is a modern, four cyclone, preheater type, dry process cement plant. The plant is a Sumitomo design built by Ube Industries, Ltd., Tokyo, Japan. The rated clinker production capacity is 2,000 metric tons per day (tpd). Current production is at 100 percent of capacity, 2,040 tpd.

Kiln fuel is "high C" oil (Number 6 fuel oil, or Bunker C) with an approximate heating value of 10,670 kcal/kg (19,206 Btu/lb) and a sulfur content of approximately 2.9 percent. The oil is fed to the kiln through a single Pillard burner at a rate of 175 tpd. The kiln inside diameter is approximately 4.3 m (14 feet) and the length is 78 m (256 feet). The kiln inclination is 4°and normal operating speed is 1-1/3 revolutions per minute (rpm). Figure 3.1 is a schematic of the D.G. Khan Facility. The kiln feed enters the kiln at about 800 to 850°C at the preheater end of the kiln. The gas temperature within the kiln is approximately 1,600°C at the burner end and 1,050°C at the feed end of the kiln. Gas residence time in the kiln is approximately 3 to 5 seconds.

Air from the raw material crushing and blending operations is combined with the kiln gases and exhausted to an electrostatic precipitator (ESP). The outlet of the ESP is connected to a cement stack that is approximately 3.4 m in diameter and 35 m high. The average volumetric flow rate measured 3,397 Nm^3/min. Normal (standard) conditions are 20°C and 1 atmospheric pressure.

The plant has an automatic sampling system for the raw material feed. This system allows the feed samples to be analyzed every two hours and the clinker samples every hour for SiO_2, Al_2O_3, CaO, MgO, SO_3,



No	Machine Name	Q'ty	No	Machine Name	Q'ty	No	Machine Name	Q'ty
1	Sampling Station	1	21	Suspension Preheater	1	41	Cement Mill	1
2	Stacker	1	22	Preheater Fan	1	42	Air Seperation	1
3	Reclaimer	1	23	Rotary Kiln	1	43	Circulating Fan	1
4	Hopper	4	24	Nose ring Fan	1	44	Bag Filter	1
5	Constant Feed Weigher	2	25	Shell Cooling Fan	1	45	Exhaust Fan	1
6	Raw Mill	1	26	Gas Firing Unit	1	46	Hopper	1
7	Cyclone	1	27	Primary Fan	1	47	Pneumatic Conveyor	1
8	Exhaust Fan	1	28	Oil Firing Unit	1	48	Cement silo	1
9	Oil Fired Furnace	1	29	Primary Fan	1	49	Aeration Unit	1
10	Sampling Station	1	30	Clinker Cooler	1	50	Boots Blower	4
11	Pneumatic Conveyor	1	31	Cooler Fan	4	51	Bin	2
12	Distribution	1	32	Multiclone	1	52	Bin	1
13	Air Slide Fan	1	33	Exhaust Fan	1	53	Rotary Packer	2
14	Blending and Storage Silo	1	34	Gas Conditioning Tower	1	54	Bulk Loader	1
15	Aeration Unit	1	35	Electrostatic Precipitator	1	55	Diesel Generator	1
16	Boots Blower	4	36	Exhaust Fan	1	56	Tyre Cooling Fan	1
17	Hopper	1	37	Hopper	1			
18	Boots Blower	1	38	Crusher	1			
19	Constant Feed Weigher	1	39	Hopper	2			
20	Pneumatic Conveyor	1	40	Constant Feed Weigher	2			

FIGURE 3.1 SCHEMATIC OF D.G. KHAN CEMENT PLANT FACILIITY

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Na_2O, K_2O, and Cl using an X-Ray fluorescent analyzer. The raw material feed rates are computer controlled based on the feed sample analysis. The system was not operating, however, during the demonstration burn.

PESTICIDE DELIVERY SYSTEM

The waste pesticides were fed through a burner designed specially for the testing program. The system transferred the waste pesticides by pumping them from a storage tank and injecting the wastes into the kiln at an average rate of 4.9 l/min for the OPs and 0.77 l/min for the OCs. The injector achieved fine atomization of the liquid waste by using 60 psig compressed air. Figure 3.2 is a schematic of the basic flow diagram.

The pesticides used for the demonstration burn were collected from eight different stores in the Punjab province of Pakistan. USAID/Pakistan and the Pakistan Department of Plant Protection Services under the direction of Mr. Ray Kruger, a contractor to AID/OFDA collected the pesticides. The pesticides had been stored since 1980 or earlier. The active ingredients in the pesticides were approximately half of their original concentration.

It was originally intended to burn a clear liquid OP as one condition and a clear liquid OC as another condition with each type containing only one kind of pesticide. Unfortunately, sufficient quantities of any one OP or OC pesticide could not be found within an acceptable distance from the plant. That dictated mixing several different pesticides together to provide sufficient quantity for the burn. Two such mixtures were prepared under Mr. Kruger's direction; one was a mixture of OP pesticides and the other was thought to be a mixture of OC pesticides. It was discussed later, however, that Zolone, one of the major ingredients in the OP mixture, is actually an OC, and STAM F-34 is an amide. The only OC pesticide present a significant quantity was Dieldrin. The contents of the two mixtures were as follows:

Organophosphate Mixture

Pesticide	Liters
Nexion	6,187
Fenitrothion	1,641
Nuvacron	1,411
Nogos (DDVP)	1,128
Metasystox	600
Dimethoate	205
Gusathion	200
Total	11,370

Organochloride Mixture

Pesticide	Liters
Dieldrin (OC)	2,620
Zolone (OP)	2,404
STAM F-34 (Amide)	200
Thiodane (OC)	180
Kelthane (OC)	140
Total	5,544

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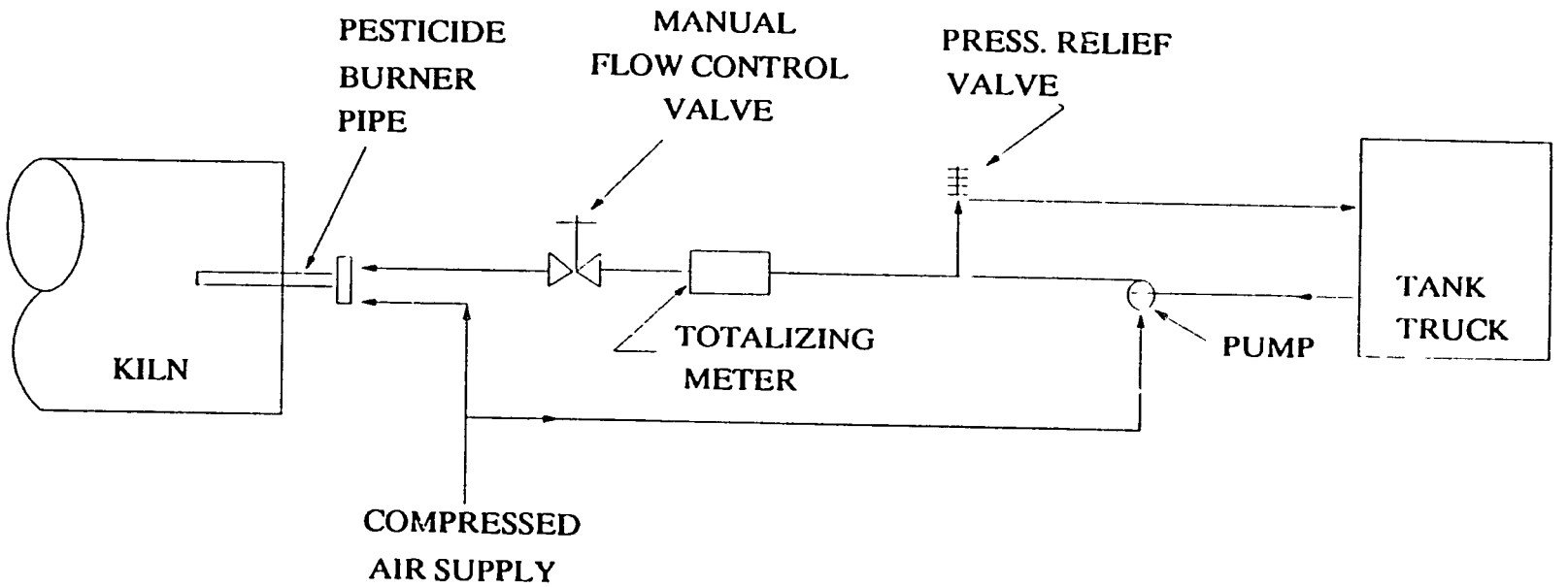

FIGURE 3.2 SCHEMATIC OF THE BASIC FLOW DIAGRAM

The pesticides were brought to the cement plant in 5 gallon cans and 55 gallon drums. The OP mixture was prepared first. The selected pesticides were poured into a tank truck from which they were pumped into the kiln. The OC mixture was stored in a holding tank until the OP mixture was burned and was then pumped into the empty tank truck to be fed to the kiln.

The pesticide delivery system was designed by Four Nines, Inc. under contract to AID/OFDA assuming that the pesticides would be free flowing liquids with a viscosity near that of water. The pesticides received, however, contained a sludge that settled to the bottom of the tank truck. As a result, the actual viscosity of the pesticides changed depending on the temperature and amount of agitation. These unexpected conditions posed obvious problems for the operation of the pesticide delivery system.

The pesticide delivery system had to be modified because of problems encountered with the pumps in the original design and with the viscosity of the pesticides. The original system used two gear pumps, one for actual pumping and the other for back up. The pesticide delivery system was tested first with diesel fuel. This burn was successful. When testing began with the pesticides, the viscosity of the mixture was too high, even when both pumps were operated in tandum. The flow rate was marginal at best. An attempt was made to remove the sludge by heating, mixing, and decanting. Although the OPs could be pumped with this design configuration, rust from the delivery lines plugged the flow meter and rotameter. To clear the obstruction the lines were backflushed with compressed air. Although this procedure cleared the lines, rust got into the pumps and destroyed the nonmetallic gears. Two centrifugal pumps capable of handling the viscous pesticide mixture were purchased. The rated capacity and head of these pumps was about double that needed to pump the pesticides. However, these pumps proved to be incapable of pumping the pesticides 30 feet up to the burner floor. Finally, a 5-horsepower, 120 psi cast iron gear pump was acquired that had the power to pump the pesticides up to the kiln at the flow rates required. After burning the OPs remaining after the actual test burn was complete, the OCs were fed to the kiln successfully.

Another problem with the pesticide delivery system was repeated plugging of the flow meter. The Spangler electronic flow meter provided with the original system did not operate properly because of a short in the wiring system. The backup rotameter had a continuing problem of being plugged by the sludge. This was a particular problem for the OC burn because DGKCC plant personnel wanted the delivery rate closely monitored. Too much chlorine will upset the process and cause the preheater downcomers to plug. The DGKCC Works Manager requested that the OC delivery rate be not more than 0.5 l/min for the first run and 1.0 l/min for the second run. He also wanted the flow rate monitored with a flow meter rather than taking periodic liquid depth measurements in the tank truck as was done for the OP burn. The plant found and installed a totalizing water meter, however, this meter lasted only about 1 hour before failing due to the corrosivity of the pesticides on

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the plastic meter gears. A meter capable of withstanding corrosive materials could not be found for the low flow rate required. After cleaning the low flow rate rotameter, fuel filters were added to the system prior to the rotameter. With this modification, the pesticide feed rate could be monitored as requested by DGKCC. In order to maintain the low flow rate at the burner, about 95 percent of the pump output was bypassed back to the tank truck. This had the added advantage of keeping the mixture well agitated.

DETERMINATION OF PESTICIDE FLOW RATES

The volumetric flow rates for the pesticide demonstration burn conducted at the D.G. Khan Cement Company were determined by calculating the volume of pesticide which was pumped to the kiln during each test and dividing by the total time of the test. The following is a description of these calculations.

Volume of Tank Truck

On-site measurements were taken of the interior dimensions of the tank truck from which the pesticides were drawn. The tank was approximately 14 feet long, 7 feet wide and nearly 5 feet high. The total volume of the tank was roughly 11,750 liters. The measured variable for determining the volume of pesticide was the height of liquid in the tank. The tank was divided into two unequal sections. Figures 3.3 and 3.4 show the dimensions of both sections of the tank. The volume of each section of the tank was calculated geometrically.

An incremental approach was taken to determine the tank volumes, so that the volume at any height of either section of the tank could easily be interpolated. Appendix E.6 shows the calculational procedure used to calculate the tank volumes. The width of each tank section was measured at intervals ranging from one to two and a half inches. Near the bottom and top of the tank where the width was changing rapidly, the volume was calculated every inch, while approaching the center of the tank where the width was essentially constant, the intervals were increased to two and a half inches. Since the divider and the end of the tank were essentially flat, the volume of each increment was determined by the simple (length) x (height) x (width) equation. As shown in Appendix E.6, the width at the midpoint of each section was used as the width in this calculation. In Appendix E.6, the volume of each increment of both sections of the tank and the cumulative volume at each height are given.

Volumetric Flow Rate

During the OP burn runs, pesticides were extracted from both sections of the tank. To determine the volume dispensed for each of these tests, the sum of the initial volumes of each section was subtracted from the sum of the final volumes of each section. For the OC test runs, the front section of the tank was not used. Therefore, the

Volume of Front Section of Tank

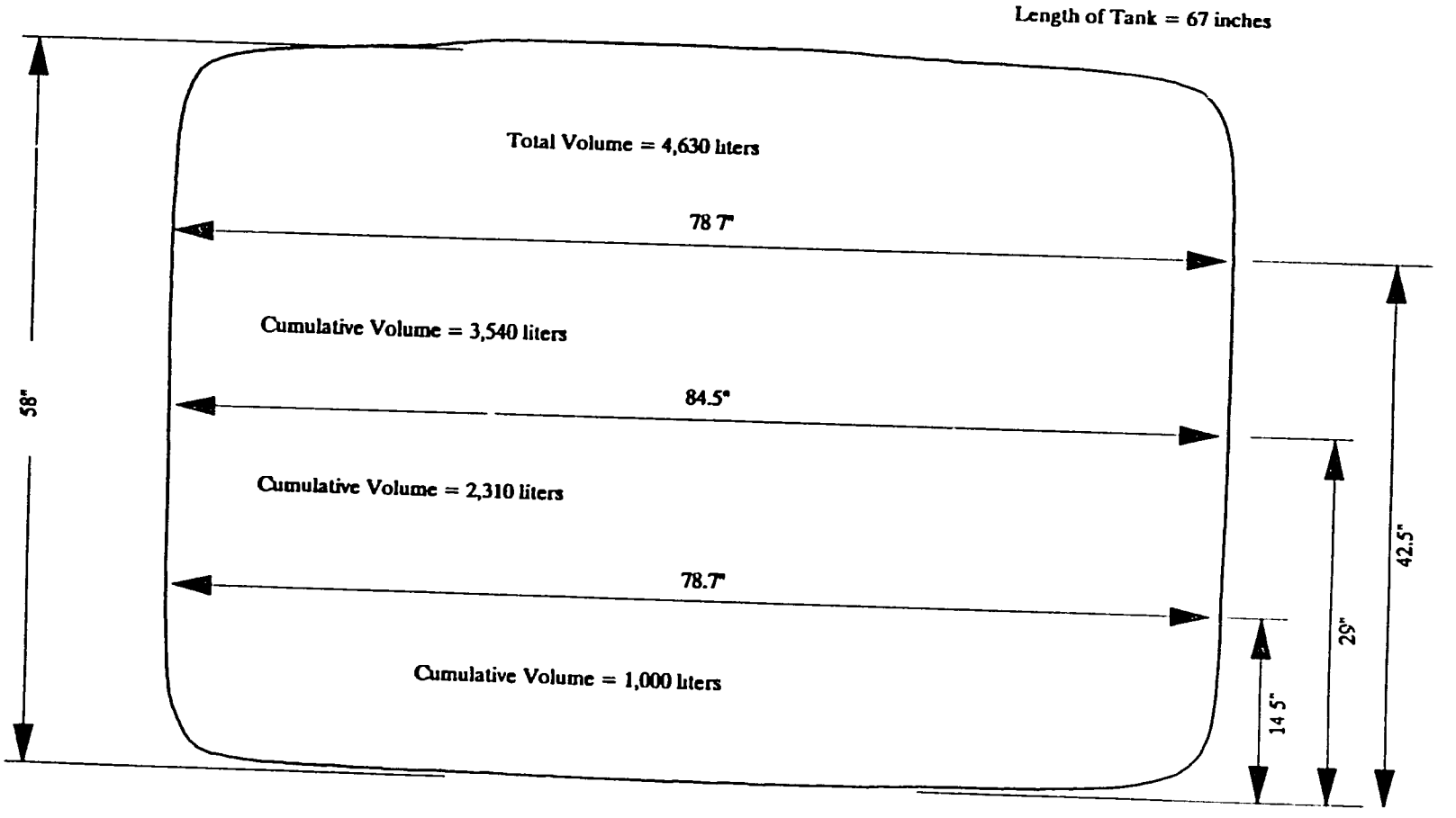

FIGURE 3.3 VOLUME OF FRONT SECTION OF TANK

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Volume of Rear Section of Tank

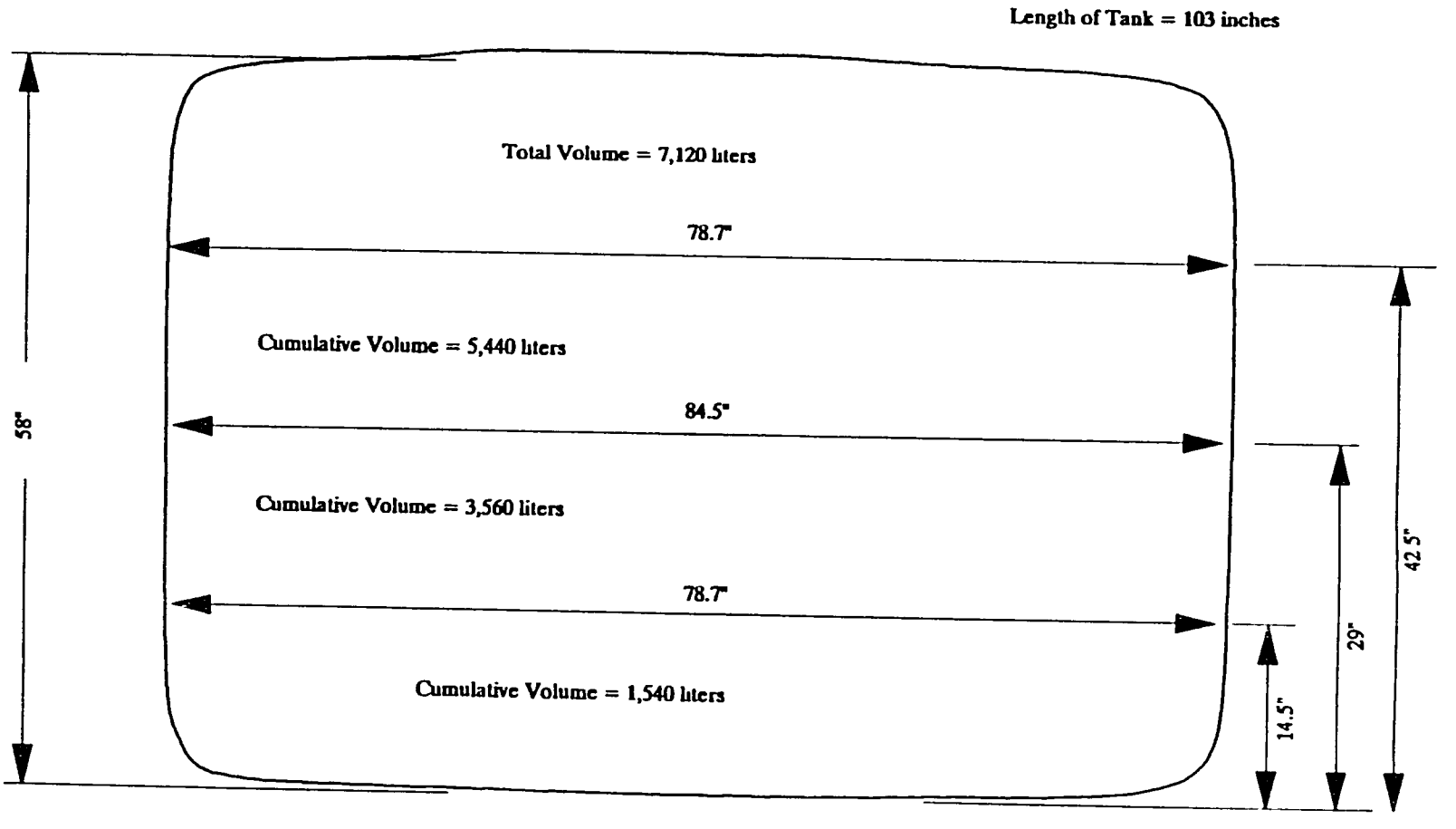

FIGURE 3.4 VOLUME OF REAR SECTION OF TANK

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volume used was the difference in the initial and final volumes of the rear section.

The flow rate was then calculated by dividing the total volume delivered to the kiln by the time of the run. Table 3.1 shows the initial volume, the final volume, the time interval, and the volumetric flow rate for each test. All the calculations performed in the determination of these flow rates and the raw measured data are included in Appendix E.7.

TABLE 3.1

SUMMARY OF PESTICIDE FLOW RATES

Run Number	Initial Volume	Final Volume	Time Interval	Flow Rate
2-1B	9,475 liters	8,050 liters	348 minutes	4.2 l/min
2-2B	7,100 liters	5,800 liters	236 minutes	5.6 l/min
3-1B	3,350 liters	3,260 liters	240 minutes	0.5 l/min
3-2B	3,150 liters	2,875 liters	249 minutes	1.1 l/min

CHAPTER 4

SAMPLING LOCATIONS

In this chapter, the locations at which air emissions and process samples were collected are described. The air emission sampling locations are discussed first.

AIR EMISSIONS SAMPLING LOCATION

The original plan was to collect the kiln exhaust gas samples from the ESP stack. The DGKCC had built a permanent sampling platform on the stack, and had installed sampling ports through the walls of the concrete stack. The location and number of traverse points on the ESP stack were determined as specified in Method 1. The stack ports were not located in the most ideal location for sampling, but they were within the minimum criteria for distances from flow disturbances specified by Method 1. There were two 3-inch sampling ports located 90° apart. The ports were located 3.5 duct diameters downstream from the nearest flow disturbance (the breaching), and 5.3 duct diameters upstream from the nearest flow disturbance (the stack exit). Ideally, the ports should have been located eight diameters downstream and two diameters upstream from the flow disturbances.

When the test team made a routine check to verify the absence of cyclonic flow, the test showed cyclonic flow was present at the sampling site. Two separate tests were conducted using the procedure specified in USEPA Reference Method 1. (See Chapter 5 for a description of USEPA Method 1.) Cyclonic flow occurs when the direction of the gas flow is not parallel to the longitudinal axis of the stack or duct. USEPA Method 1 does not allow sampling a gas stream where the average direction of flow deviates by more than 20° from the longitudinal axis of the duct or stack. The two cyclonic flow checks averaged 32.5° and 36.5°, respectively. An attempt was made to install flow straightening vanes in the stack, but the magnitude of the cyclonic flow made it impossible to lower the vanes into the stack. The vanes began to spin as soon as they were lowered into the top of the stack.

Because the stack proved to be an unacceptable sampling location, an alternate sampling site had to be selected. It was important that the site be located downstream of the ESP, so that the sampled gases would be representative of what was being discharged to the atmosphere.

The next best candidate sampling location was in the duct that connected the induced draft (ID) fan to the stack. This duct, known as the breaching, did not have as long a straight run of duct as required by USEPA Method 1, but it was better than the ductwork between the ESP outlet and the ID fan. A check for cyclonic flow showed the gas flow was parallel to the duct axis, so the plant installed sampling ports in the breaching for the test team.

The breaching cross-section measured 1.8 m by 2.5 m. There was 1.4 m of straight, undisturbed run. Figure 4.1 shows the sampling port locations for the breaching. Five port holes were installed vertically in the side of the breaching, each 36 cm apart. Each port hole was 10 cm in diameter. The distance to the nearest upstream disturbance (expansion joint) was 112 cm or 0.53 equivalent duct diameters. The nearest downstream disturbance (transition section in the breaching) was 28 cm or 0.13 diameters from the ports.

USEPA Method 1 states that sampling ports should be located such that the nearest upstream and downstream flow disturbances are at least 2.0 and 0.5 equivalent diameters away from the ports, respectively. In situations where this criteria cannot be met and there is no better sampling site, it is normal practice, if the flow is parallel, to go ahead and sample using the maximum number of sampling points specified by USEPA Method 1 (25 for a rectangular duct.)

The test team elected to sample in the breaching using a 5 x 5 matrix of sampling points. Mr. Robert Mournighan, the USEPA advisor, concurred with this decision. The five ports were designated A through F. The sampling point locations are shown in Figure 4.2.

PROCESS SAMPLES

There were a total of five different process sampling locations. The process samples collected included the following: feed, fuel oil, ESP dust, clinker, and OP and OC pesticides. A description of each location follows.

Kiln Feed

The kiln feed, which was a mixture of limestone and shale, was collected as a 1,000 gram grab sample in a polyethylene bottle. The feed was sampled once per test run. The sample location is designated as "a" on Figure 4.3.

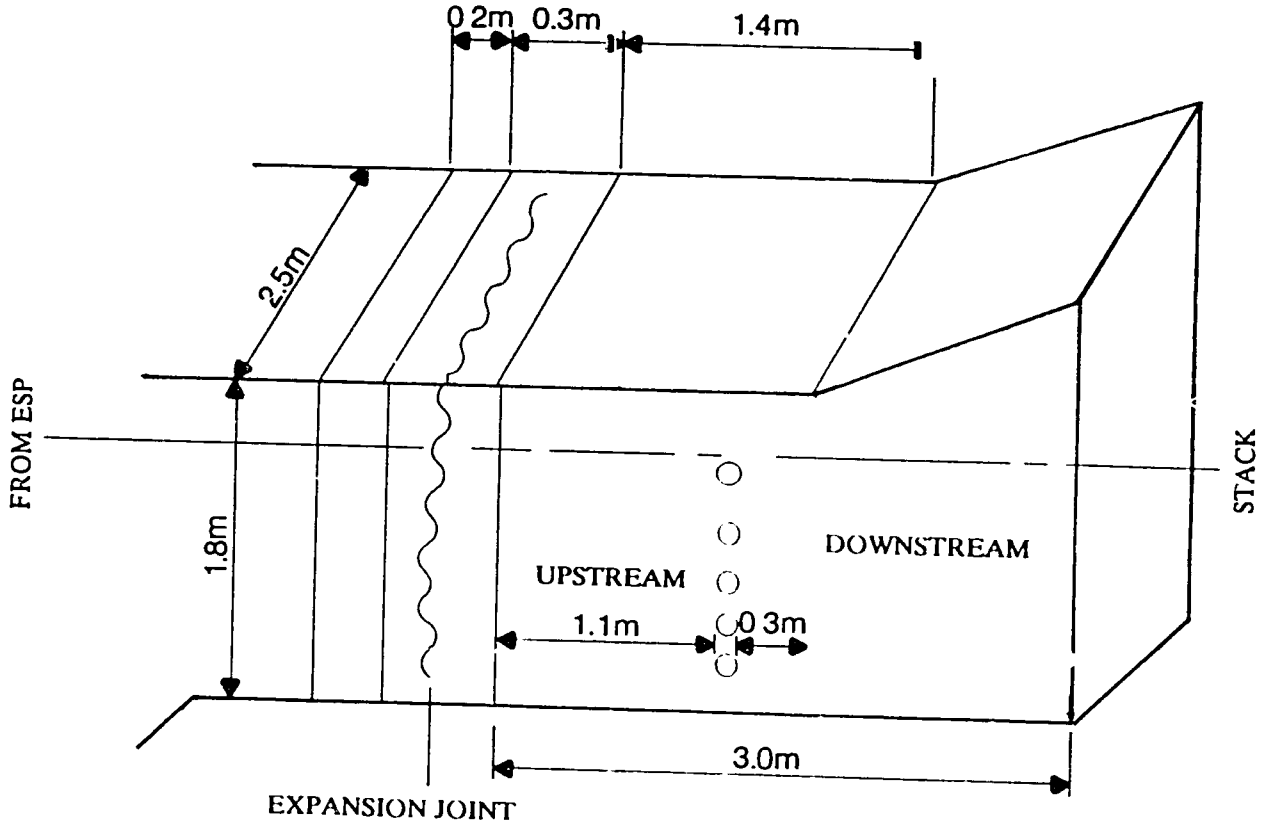


FIGURE 4.1 D.G. KHAN CEMENT COMPANY SAMPLING PORT LOCATIONS, ESP OUTLET

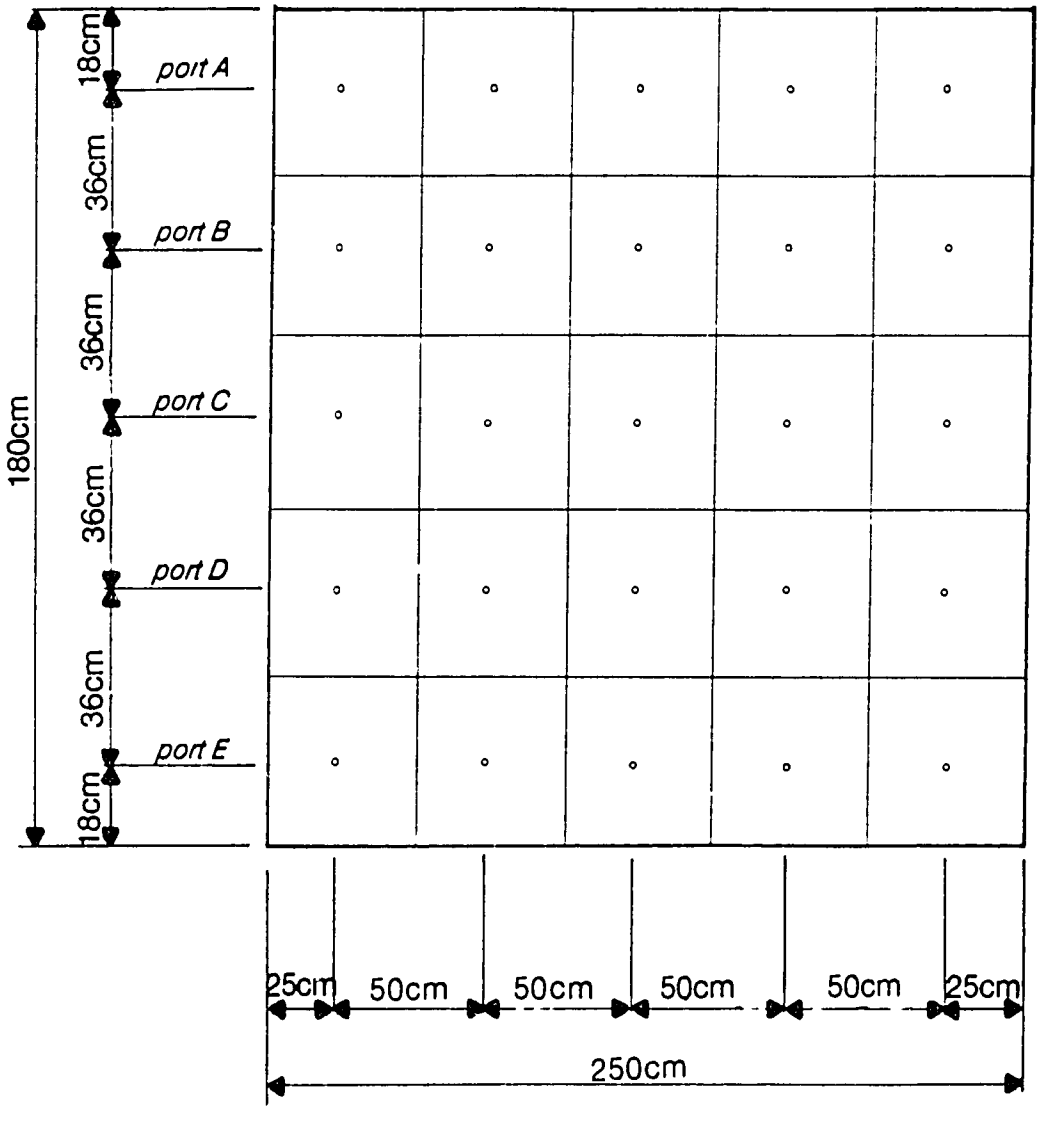
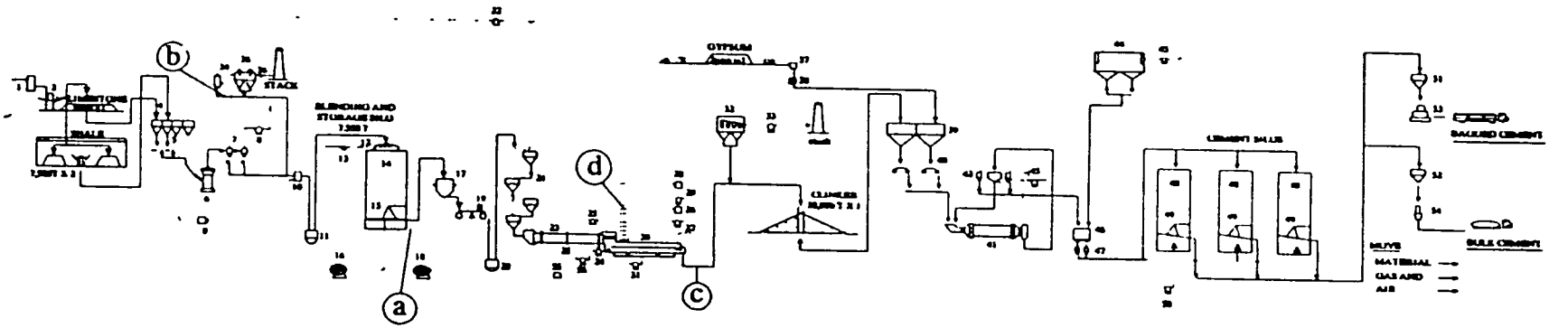


FIGURE 4.2 D.G. KHAN CEMENT COMPANY TRAVERSE POINT LOCATIONS AND BREACHING DIMENSIONS



Sample Collection Points	No	Machine Name	Q'ty	No	Machine Name	Q'ty	No	Machine Name	Q'ty
Kiln Feed - (a)	1	Sampling Station	1	21	Suspension Preheater	1	41	Cement Mill	1
ESP Dust - (b)	2	Stacker	1	22	Preheater Fan	1	42	Air Seperation	1
Clinker (c)	3	Reclaimer	1	23	Rotary Kiln	1	43	Circulating Fan	1
Fuel Oil - (d)	4	Hopper	4	24	Nose ring Fan	1	44	Bag Filter	1
	5	Constant Feed Weigher	2	25	Shell Cooling Fan	1	45	Exhaust Fan	1
	6	Raw Mill	1	26	Gas Firing Unit	1	46	Hopper	1
	7	Cyclone	1	27	Primary Fan	1	47	Pneumatic Conveyor	1
	8	Exhaust Fan	1	28	Oil Firing Uni	1	48	Cement silo	1
	9	Oil Fired Furnace	1	29	Primary Fan	1	49	Aeration Unit	1
	10	Sampling Station	1	30	Clinker Cooler	1	50	Boots Blower	4
	11	Pneumatic Conveyor	1	31	Cooler Fan	4	51	Bin	2
	12	Distribution	1	32	Multiclone	1	52	Bin	1
	13	Air Slide Fan	1	33	Exhaust Fan	1	53	Rotary Packer	2
	14	Blending and Storage Silo	1	34	Gas Conditioning Tower	1	54	Bulk Loader	1
	15	Aeration Unit	1	35	Electrostatic Precipitator	1	55	Diesel Generator	1
	16	Boots Blower	4	36	Exhaust Fan	1	56	Tyre Cooling Fan	1
	17	Hopper	1	37	Hopper	1			
	18	Boots Blower	1	38	Crusher	1			
	19	Constant Feed Weigher	1	39	Hopper	2			
	20	Pneumatic Conveyor	1	40	Constant Feed Weigher	2			

FIGURE 4.3 LOCATION OF PROCESS SAMPLE COLLECTION

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ESP Dust

A 500 gram grab sample of ESP dust was collected for each test run and stored in a polyethylene bottle. The sample location is designated as "b" on Figure 4.3.

Clinker

A 500 gram grab sample of the clinker was collected for each test run and stored in a polyethylene bottle. The clinker collection site location is designated as "c" on Figure 4.3.

Fuel Oil

DGKCC uses Number 6 fuel oil (furnace oil) for its cement kiln operations. The fuel oil samples were collected in a 500 gram polyethylene bottle. One grab sample was collected for each test run. The sample location is designated as "d" on Figure 4.3.

Organophosphate Pesticide

A 100 ml sample of OP pesticide mixture was collected from the OP delivery system at the tank truck each half hour. These OP samples were composited in a 1000 ml amber glass bottle.

Organochloride Pesticide

A 100 ml sample of OC pesticide mixture was collected each half hour from the OC delivery system at the tank truck. These OC samples were composited in a 1000 ml amber glass bottle.

DGKCC CONTINUOUS EMISSION MONITORS

The plant has two continuous emission monitors (CEMs): one for carbon monoxide (CO) and one for oxygen (O_2). The CEMs were located at the exit of the preheater.

CHAPTER 5

SAMPLING AND ANALYTICAL PROCEDURES

In this chapter, the sampling and analytical procedures used during the demonstration burn of pesticides at the D. G. Khan Cement Plant in Pakistan are described All procedures were in accordance with U.S. Environmental Protection Agency (USEPA) specifications. PES sampled the kiln exhaust gases for pesticides, particulate matter, SO_2, H_2SO_4, HCl, and Cl_2. The procedures employed for these tests are defined in USEPA Reference Methods 1, 2, 3, 4, 5, 8, and a draft Method 26 for HCl and free Cl_2. These methods are published in the Code of Federal Regulations, Title 40, Part 60, Appendix A (40 CFR 60, Appendix A). These methods are listed below:

Method 1 - Sample and Velocity Traverses for Stationary Sources.

Method 2 - Determination of Stack Gas Velocity and Volumetric Flow Rate (Type S Pitot Tube)

Method 3 - Gas Analysis for Oxygen, Carbon Dioxide, Excess Air, and Dry Molecular Weight.

Method 4 - Determination of Moisture Content in Stack Gases.

Method 5 - Determination of Particulate Emissions from Stationary Sources.

Method 8 - Determination of Sulfuric Acid Mists and Sulfur Dioxide Emissions from Stationary Sources.

USEPA's Modified Method 5 (MM5) procedure was used to determine the pesticide and PIC emissions in the kiln exhaust gases. The MM5 procedures are published in the USEPA document "Test Methods for Evaluating Solid Waste," Volume II: Field Manual, Physical/Chemical Methods, SW-846, Third Edition. In addition to the promulgated USEPA Reference Methods, an USEPA draft procedure for HCl and Cl_2 emissions was used. The HCl and Cl_2 sampling procedure used as a guideline was entitled "The Determination of HCl Emissions from Municipal and Hazardous Waste Incinerators."

Table 5.1 summarizes the emission sampling and analytical program used during each test condition. Table 5.2 lists the methods used in

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TABLE 5 1

OVERAGED PESTICIDE PILOT BURN, D.G. KHAN, PAKISTAN

SUMMARY OF SAMPLING AND ANALYTICAL PROGRAM
FOR EACH TEST BURN CONDITION

Parameters	Sampling Method	Analytical Method	Sampling Frequency	Sampling Period	Total Number of Samples
Stack gas					
Particulate Matter	EPA Method 5	Gravimetric	1/test run	75 minutes	2
Pesticides	Modified Method 5	GC/MS and SIR	1/test run	4 hours	2
HCl and Cl_2	Method 26	Ion chromatography	1/test run	1 hour	2
SO_2	EPA Method 8	Titration	1/test run	75 minutes	2
CO_2	EPA Method 3	ORSAT	1/test run	75 minutes	2
O_2	EPA Method 3	ORSAT	1/test run	75 minutes	2
		Zirconium oxide	Continuous	Concurrent with MM5	2
CO	EPA Method 3	ORSAT	1/test run	Concurrent with MM5	2
	EPA Method 10	NDIR	Continuous	Concurrent with MM5	2
Gas flow rate	Pitot tube	Differential pressure	Continuous	Concurrent with MM5	2
Pesticide					
Feed rate	Rotameter and dipstick	Manual	1/2 hour	4 hours	2
Blanks					
Pesticides	SW-846 Modified Method 5	GS/MS	1	N/A	3[a]
HCl and Cl_2	Proposed Method 26	Ion chromatography	1	N/A	1[b]
Particulate Matter	EPA Method 5	Gravimetri.	1	N/A	2[c]

[a] One laboratory, one trip and one field blank for entire study.
[b] One trip blank on unused absorbing reagents for entire study
[c] One blank filter and one blank of acetone rinse solvent for entire study.

BEST AVAILABLE DOCUMENT

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TABLE 5.2

OVERAGED PESTICIDE DEMONSTRATION BURN, D.G. KHAN, PAKISTAN

METHODS USED IN SAMPLING AND ANALYSIS FOR ORGANO-PHOSPHATE AND ORGANO-CHLORIDE PESTICIDES FROM A MODIFIED METHOD 5 SAMPLING TRAIN

Method	Parameter	Detection Limit
Method 0010[a]	Modified Method 5 Sampling Train	N/A
Method 0540[a]	Preparation of XAD-2 Sorbent Resin	N/A
Method 8270[a]	Gas Chromatography/mass spectrometry for semi-volatile organics: capillary column headings	150 μg/l (cpd dependent)

[a] Test methods for Analysis of Solid Waste (SW-846)

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the preparation, sampling and analyses of the MM5 sampling train. Table 5.3 is a list of the methods used in the analyses of the process samples and the OP and OC pesticide samples. In the discussion below, further detail is provided on the procedures used to measure total particulate matter and sulfur dioxide emissions, emissions of organophosphate and organochloride pesticides, and the constituents in the process samples.

TOTAL PARTICULATE MATTER/SULFUR DIOXIDE EMISSIONS

To measure mass emission rates and concentrations of particulate matter, USEPA Reference Methods 1-4 and Method 5 (M5) were used. These methods are described briefly below.

USEPA Reference Method 1, "Sample and Velocity Traverses for Stationary Sources" as described in 40 CFR 60, Appendix A was used to select the sampling locations for the test program. During cyclonic flow measurements, it was determined that the exhaust gas flow in the stack was cyclonic. As a result, it was necessary to sample in the breaching. The breaching location did not meet USEPA Method 1 criteria; i.e., the nearest upstream and downstream disturbances were only .53 and .13 diameters from the sampling location, respectively. However, based on the consistency of the velocity profile, the sampling was conducted in the breaching.

USEPA Reference Method 2, "Determination of Stack Gas Velocity and Volumetric Flow Rate (Type-S pitot tube)" as described in 40 CFR 60, Appendix A was used to determine the average velocity of the gas stream and calculate the gas flow rate. The sampling probe assembly was equipped with a Type-S pitot tube for measuring gas velocity pressure and a Type-K thermocouple for determining stack gas temperature. The pitot tube was examined prior to field use to verify proper alignment of the face openings and conformity with the dimensional criteria specified in the method. Only pitot tubes meeting the specified criteria were used, and the specified coefficient of 0.84 was assigned. Velocity head pressure was measured with an inclined/vertical manometer having minor divisions of ± 0.01 inches water column for the 0 to 1.0 inch inclined section and 0.10 inch minor divisions for the 1.1 to 10.0 inch vertical section. The pitot tubes, pitot lines, and manometer were successfully leak-checked before and after each run in accordance with the procedures described in Reference Method 2.

USEPA Reference Method 3 "Gas Analysis for Carbon Dioxide, Oxygen, Excess Air, and Dry Molecular Weight" as described in 40 CFR 60, Appendix A was used to determine CO_2 and O_2 concentrations and dry molecular weight of the sample from the gas stream. A variable speed, Teflon™ lined diaphragm pump was used for the collection of an integrated gas sample. The stack gas was withdrawn from the stack into a Tedlar™ bag at a constant rate via the pump. The gas was analyzed using an Orsat analyzer. The Orsat analyzer was assembled in the field and a new

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TABLE 5.3

OVERAGED PESTICIDE PILOT BURN, D.G. KHAN, PAKISTAN

METHODS USED FOR ANALYSES OF ORGANOPHOSPHATE AND ORGANOCHLORIDE PESTICIDES IN THE PLANT PROCESS SAMPLES AND THE PESTICIDE FEED SAMPLES

Method	Physical Property	Detection Limit
	Active Ingredient	
ASTM 1429	Specific Gravity	N/A
ASTM D-2983	Viscosity	N/A
EPA 300.0	Total chloride	0.1 mg/l
ASTM D-2015	Btu	N/A
SM209C	TSS	1 mg/l
GC/FID;GC/MS	Pesticide	<0.2 mg/kg*

* All detection limits were <0.2 mg/kg with the exception of Gusathion and Metasystox which was <0.4 mg/kg.

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supply of reagents were added to ensure absorption accuracy. The Orsat analyzer was leak-checked according to Method 3 procedures. The integrated gas samples were collected for each Modified Method 5 run. This gas sample was analyzed and the results were then used to represent all samples collected in that time frame. The collection pump was turned off during each port change and during any downtime.

The Orsat analyzer can also be used to measure CO, if the CO concentration exceeds about 1 percent, by volume. For lower concentrations, such as those expected from a cement kiln, the Orsat analyzer is not suitable. CO is an important parameter because the CO concentration is generally inversely proportional to combustion efficiency. Therefore, CO was monitored on a continuous basis from the plant's non-dispersive infrared (NDIR) continuous emission monitor (CEM). This monitor, Fuji's ZAL Micro-Flow Detector, can accurately measure CO at low concentrations. This particular instrument will detect CO in the 0 to 2 percent range. Also, this instrument demonstrates excellent stability with zero and span drift of less than 2 percent of full scale per week. To ensure accurate emission monitoring, the zero level is calibrated and the measuring span adjusted on a weekly basis.

The plant also monitored O_2 continuously with a CEM. DGKCC uses a Fuji magnetic oxygen analyzer, OXIMAT II Type ZAJ which is capable of accurately measuring in the 0-5 percent and 0-25 percent ranges. The 0-5 percent range was used during the pesticide destruction process. This instrument demonstrates excellent stability with zero and span drift less than 1.5 percent and 2 percent of full scale per week respectively. To ensure accurate monitoring, the following routine procedures are performed: (1) the sample gas flow is adjusted to the specified level on a daily basis; (2) the zero level and span are adjusted weekly; (3) the auxiliary gas is checked for correct pressure monthly; and (4) the sampling system is checked as required by the instruction manual.

USEPA Reference Method 4 "Determination of Moisture Content in Stack Gases" as described in 40 CFR 60, Appendix A was used to determine the stack gas moisture content. The moisture was determined gravimetrically from the condensed moisture collected in the impingers of the Method 5/8 sampling train. A known weight of liquid was placed in the first three impingers and the fourth contained a known quantity of silica gel. A thermometer was placed in the outlet of the fourth impinger for monitoring purposes. Assembly of the sampling train and recovery of the samples was performed in a laboratory near the sampling site.

The sampling and analytical procedures for particulate emission determinations were as described in USEPA Reference Method 5 (M5) "Determination of Particulate Emissions from Stationary Sources". The sampling probe consisted of a stainless steel sheath with a heated pyrex liner and a stainless steel sampling nozzle. A Type-S pitot tube and a Type-K thermocouple were attached to the probe assembly to facilitate isokinetic sampling.

Two M5 test runs performed in the breaching location for each of the three conditions. The breaching had a 5 x 5 sampling matrix for a

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total of 25 traverse points. Each traverse point was sampled for 3 minutes, giving a total sample time of 75 minutes for each M5 test run. All of the M5 test runs met the USEPA requirement for a minimum sample volume of 30 dscf or 0.85 dscm.

PES combined the collection of the particulate emissions with the collection of SO_2 emissions in one sampling train. In order to determine SO_2 emissions, a modified version of USEPA Reference Method 8, "Determination of Sulfuric Acid Mist and Sulfur Dioxide Emission from Stationary Sources" was used. The modification entailed combining a Method 5 with a Method 8 sampling train. The M5/8 train was the same as a Method 5 train except that 100 ml of 80 percent isopropanol (IPA) was placed in the first impinger and 100 ml of 3 percent hydrogen peroxide (H_2O_2) in both the second and third impingers. The remainder of the M5 train set-up and operation were the same. The sample recovery involved collection of the IPA and H_2O_2 impinger catches for analyses by titration. SO_2 and H_2SO_4 analyses were done on site by PES personnel. There were a total of six SO_x test runs, two samples from each test condition. Figure 5.1 is a schematic of the Method 5/8 sampling train.

ORGANOPHOSPHATE/ORGANOCHLORIDE PESTICIDE EMISSIONS

The procedure and apparatus used for sampling the OP and OC content of the exhaust gases are defined in "Test Methods for Evaluating Solid Waste, Physical Chemical Methods, Field Manual, Vol. II SW-846, Part III, Chapter 10, Method 0010, Modified Method 5 Sampling Train" for compounds with boiling points between 100°C and 300°C. The sampling train is referred to as a modified Method 5 (MM5) train, and is similar to the Reference Method 5 train except that a water-cooled condenser and XAD-2 sorbent resin module are located between the filter assembly and the impinger train. Also, a Pyrex™ nozzle was used instead of a stainless steel nozzle. Figure 5.2 is a schematic of the Modified Method 5 sampling train.

In order to collect enough pesticide for demonstration of a 99.99 percent DRE, the MM5 sampling train was operated longer than the M5 sampling train. There were a total of 6 MM5 test runs at the breaching location. During Runs 2-1B, 2-2B, 3-1B, and 3-2B, sampling was conducted for a total of 225 minutes (9 minutes for each of 25 traverse points). During Runs 1-1B and 1-2B, sampling lasted for a total of 200 minutes (8 minutes for each of 25 traverse point). All of the MM5 test runs met the minimum sample volume requirement for the method (105.9 dscf or 3 dscm) with the exception of Run 1-2B which had a total sample volume of 98.6 dscf or 2.8 dscm.

The sorbent module contained approximately 20 g of XAD-2 resin. During sampling, the sample gas temperature was monitored to insure that the gas temperature was 20°C, or less, before the gas entered the sorbent module. The procedure used for the preparation of the XAD-2 resin for use in the USEPA MM5 train was identical to that outlined in USEPA SW-846, Method 0010. The resin was cleaned using a series of Soxhlet extractions starting with water (8-hr extraction), followed by

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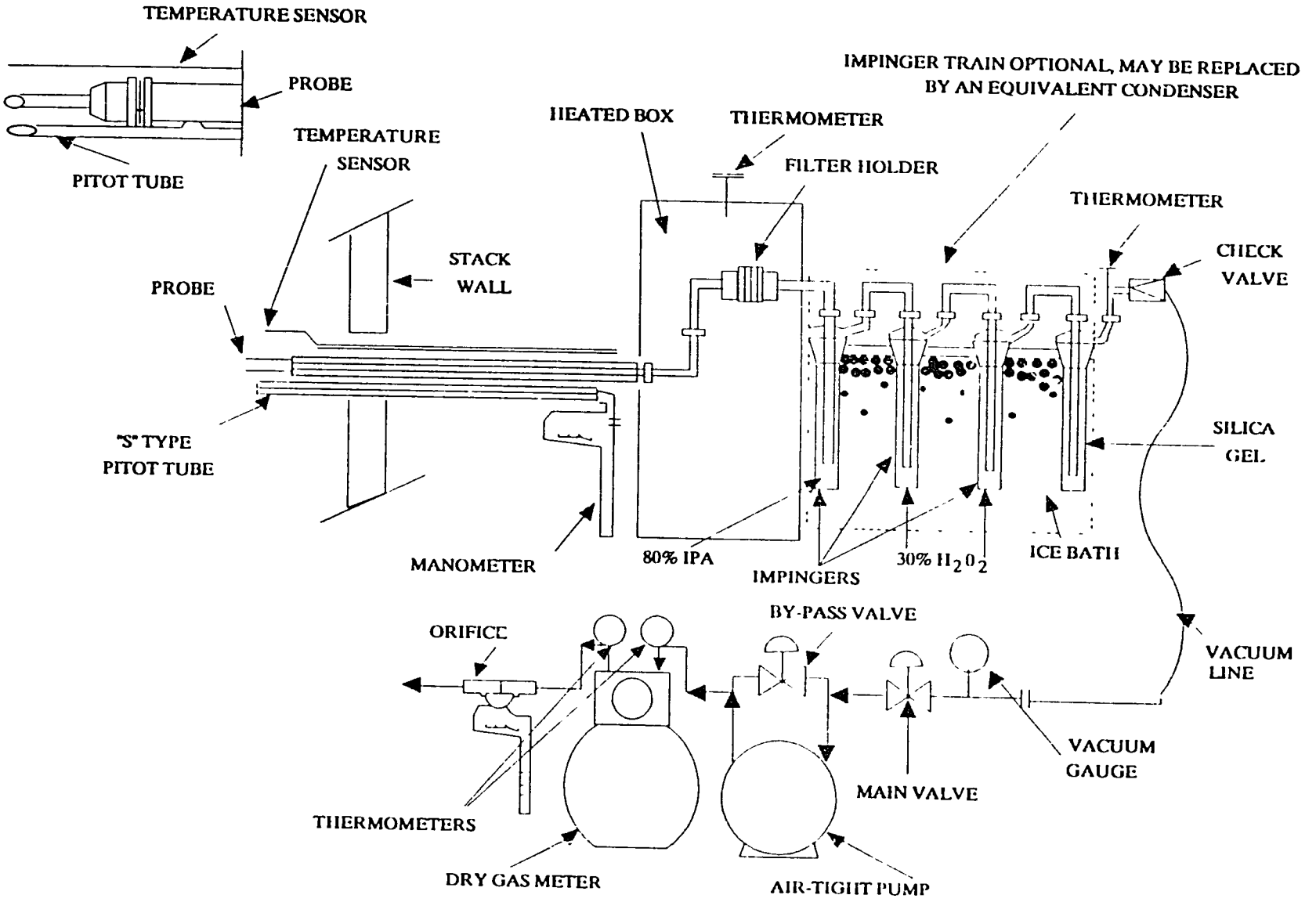

FIGURE 5.1 SCHEMATIC OF THE METHOD 5/8 SAMPLING TRAIN

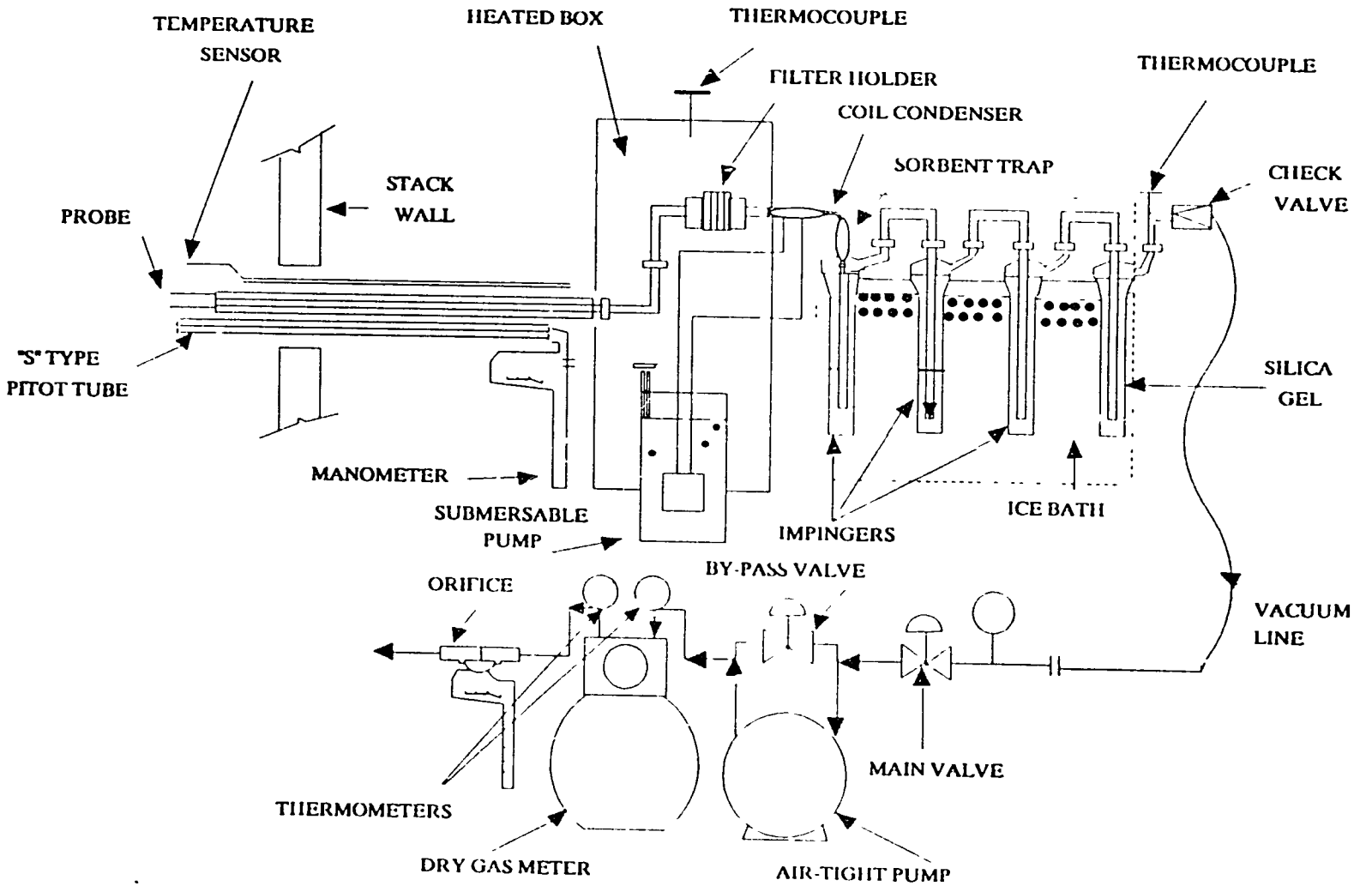

FIGURE 5.2 SCHEMATIC OF THE MODIFIED METHOD 5 SAMPLING TRAIN

an intermediate extraction with methanol (22 hr) and methylene chloride (22 hr), and a final extraction with fresh methylene chloride (22 hr). The residual methylene chloride was removed from the XAD-2 by a clean nitrogen purge in a fluidized bed apparatus, (Method 0010, Appendix A).

Prior to use, the clean XAD-2 was subjected to three quality control (QC) checks to determine acceptability for field use. The criteria for acceptability were: (1) no more than 1 mg residual methylene chloride per gram of resin; (2) no more than 10 μg of total gravimetric residue per gram of resin; and (3) no more than 25 μg of total gravimetric residue per gram of resin. Appropriate solvent blanks were used in each QC check procedure.

After sampling, extractions were performed on the particulate matter, XAD-2 resin, and the condensate. The XAD-2 from the MM5 train was extracted with methylene chloride (24 hr) in a Soxhlet extractor. Any water that accumulated in the Soxhlet pot was separated from the methylene chloride (separator funnel) and combined with the sampling train condensate. A solvent blank determination was made in parallel with the resin extraction. Particulate matter from the MM5 train was extracted with methylene chloride in an identical manner. A blank determination was conducted as a parallel extraction.

All condensate was extracted with methylene chloride in a separator funnel. Serial extractions were performed with the condensate first made acidic (pH 2), then basic (pH 12). The base/neutral and acid fractions were worked up separately. The extraction blank for this procedure involved parallel extraction with pre-extracted, organic-free, distilled, de-ionized water.

The extracts were analyzed using methods that are appropriate for waste fuels. Each extract was analyzed by capillary GC prior to GC/MS analysis to ascertain levels for GC/MS and general sample complexity. Quantitative analysis was performed as described for waste fuels. Analysis was conducted in the U.S. by the AID Contract Laboratory, Triangle Laboratories, in Research Triangle Park, NC. In addition to the OP and OC sample analyses, Triangle Laboratories ran USEPA Appendix VIII screening procedure on the 20 most prevalent compounds found. This procedure was used to determine PICs.

HCl AND FREE CHLORINE EMISSIONS

Sampling and analysis for hydrogen chloride (HCl) emissions was conducted according to the draft USEPA Reference Method 26, "Determination of Hydrogen Chloride Emissions From Stationary Sources". Integrated HCl samples were collected from the stack in dilute sulfuric acid. The HCl gas was dissolved in the dilute acid to form chloride (Cl^-) ions. The Cl^- was analyzed by specific ion electrode. Free Cl_2 was collected in dilute NaOH and analyzed by ion chromatography.

The samples were collected through a borosilicate glass probe. A series of five midget impingers with leak-free glass connectors were used. The first impinger was a knock-out impinger which remained empty.

The second and third impingers contained 15 ml of 0.1N H_2SO_4. The fourth impinger contained 15 ml of 0.1N NaOH. The fifth impinger contained approximately 30 g of silica gel to collect any remaining moisture. The sample train did not include a Teflon™ filter. Figure 5.3 is a schematic of the HCl sampling train. The were a total of 6 HCl test runs; 2 for each of 3 conditions. All HCl tests were run for 60 minutes at a sampling rate of 2 liter/min meeting the draft Method 26 criteria for HCl sampling Both the H_2SO_4 and NaOH solutions were analyzed with an ion chromatograph with a conductivity detector and electronic integrator operating in the peak area mode. Because there was a concern that the H_2SO_4 reagent may have caused interference during the analysis with IC, reanalysis of the H_2SO_4 samples with a specific ion electrode was requested. Analyses for both free chlorine and Cl^- were performed by the AID contract laboratory.

PROCESS SAMPLES

Table 5.4 details the sample location, equipment used for sample collection, general procedure, frequency of sample collection, and analyses performed for all the process samples. There were a total of five process sampling locations including kiln feed, fuel oil, clinker, ESP dust, and OP and OC pesticide from the pesticide delivery system. The details of the sampling and analytical procedures are presented below.

Kiln Feed

The feed consisted of a mixture of limestone and shale. A 1000 g grab sample was collected for each test run in a polyethylene bottle. Analyses for the OP and OC pesticides were performed by an EPA contract laboratory in Cincinnati, Ohio.

Fuel Oil

A sample of the Number 6 fuel oil (furnace oil) was collected for each test run. One 1/2-liter grab sample of fuel oil was collected during each test run. The samples were to be analyzed for PICs, but after reviewing the PIC results, PES and USEPA decided that analysis of the fuel oil samples was not necessary.

Clinker and ESP Dust

The clinker and ESP dust samples were collected at the end of each day. Analyses were performed for OP and OC pesticides. A 500 gram sample of both the clinker and ESP dust were collected for each test run and then analyzed by the USEPA contract laboratory in Cincinnati, Ohio.

OC and OP Pesticide

A composite sample was collected from the pesticide delivery system during each test run. A 250 ml sample was collected every 30 minutes. After each test was completed, a composite was formed. The composite

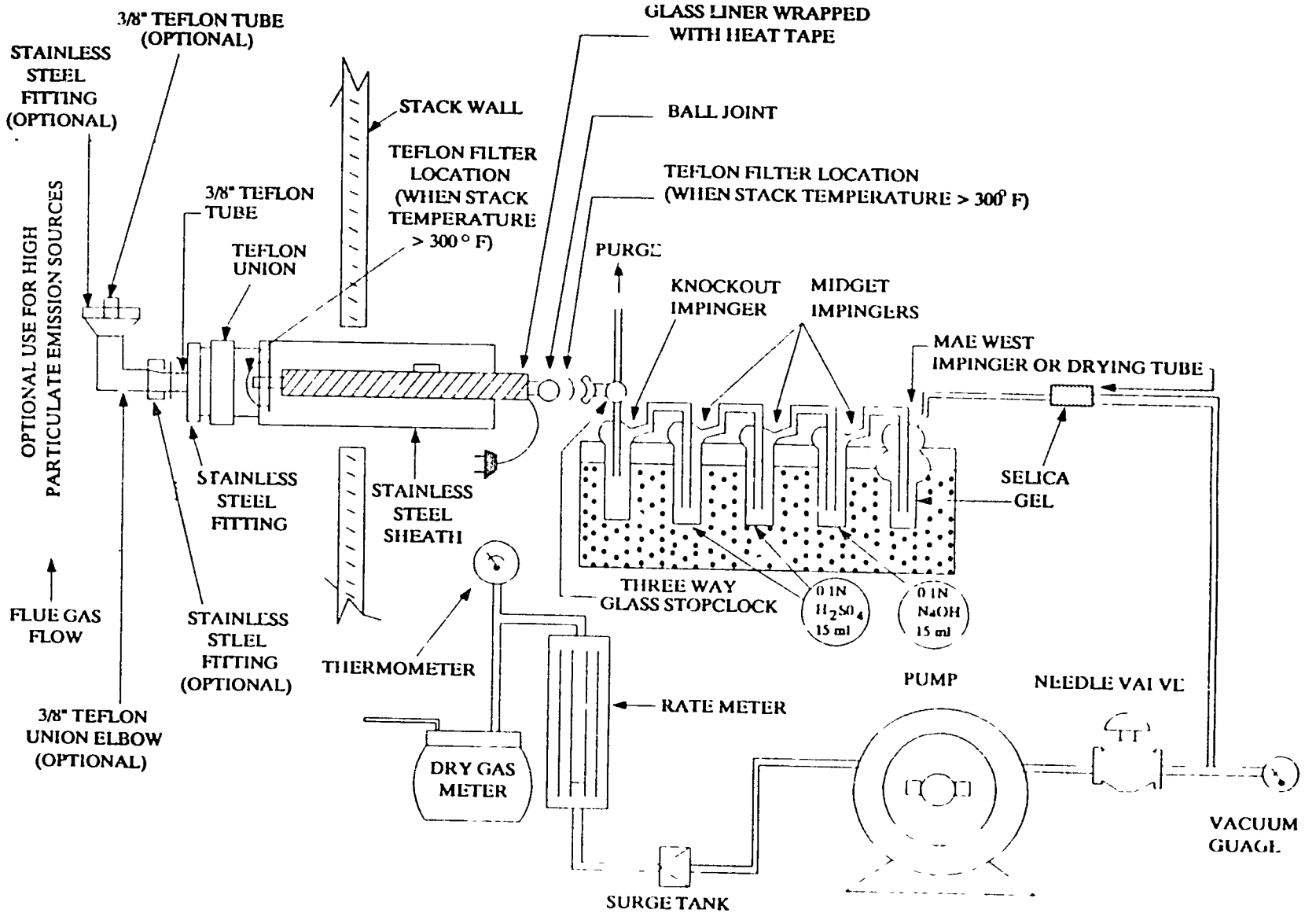

FIGURE 5.3 SCHEMATIC OF THE HCl SAMPLING TRAIN

TABLE 5.4

OVERAGED PESTICIDE PILOT BURN, D.G. KHAN, PAKISTAN

PROCESS SAMPLING AND ANALYSIS

Sample Location	Equipment	General Procedures/ Frequency	Analyses
Feed	1000g Poly Bottles	One grab from each test run	PICs, archive
Fuel oil	500ml Poly Bottles	One grab from each test run	PICs, archive
Clinker	500g Poly Bottles	One grab at the end of each test run	PIC, O-P, O-C
ESP Dust	1000g Poly Bottles	One grab at the end of each test run	PIC, O-P, O-C
O-C and O-P	1 liter glass jar, shatter protected, amber	Composite 30 minute grabs for each run	Percent AI, specific gravity, viscosity, Btu, GC/MS screening, and Cl^-

sample was analyzed for percent AI, specific gravity, viscosity, BTU, GC/MS screening for degradation products, and Cl^-.

CHAPTER 6

QUALITY ASSURANCE AND QUALITY CONTROL

In any sampling and analysis effort, quality assurance and quality control (QA/QC) are necessary to ensure that the data collected are meaningful in practical terms. In this Chapter, the QA/QC procedures used in sampling equipment preparation, general sampling, sample recovery, sample custody, sample analysis, data documentation and verification, preparation of samples for analysis, and sample completeness are described. Throughout this effort, QA/QC procedures defined by the U.S. Environmental Protection Agency (EPA) for source sampling were followed.

SAMPLING EQUIPMENT PREPARATION

Prior to testing, the sampling equipment must be prepared. The two types of equipment that must be prepared include glassware used to store samples and the sampling train equipment. It is important that the glassware be properly prepared to prevent contamination of the samples. The sampling train equipment must be constructed in accordance with EPA specifications and properly calibrated. In the discussion below, the procedures used for this test program are described.

Glassware

Four sets of glassware were prepared for this testing program. MM5 sampling trains are notoriously difficult to leak-check because no sealant grease is allowed on the glassware connecting joints (no grease was used on any of the sampling trains MM5, M5/8 or HCl), because of the additional glass components, and because of the general awkwardness of the assembly. To minimize leaking glassware connections, the four glassware sets were hand-picked. Once a leak-free set was obtained, the components were identified as matched sets by baking on enamel numbers derived from a special numbering sy tem established to identify the set number and sequence piece. In addition, arrows were applied to show direction of stack gas flow. This aided in the setup of sampling trains and made it easier to obtain acceptable leak-checks. After the identifying numbers were baked on the glassware, the openings were sealed with Parafilm Tar™ and the pieces were packaged into separate boxes.

Prior to shipment to Pakistan, all sample train glassware were soaked in a caustic acid bath to remove any residue. The glassware was then rinsed three times with tap water followed by three deionized, distilled water rinses. Once in Pakistan, the glassware was rinsed six times, three times with distilled-in-glass methanol (MeOH) and then three times with distilled-in-glass methylene chloride ($MeCl_2$). The glassware was then capped with solvent-rinsed aluminum foil until use.

Emissions Sampling Equipment

The remaining preparations included calibration and leak-checking of all the sampling train equipment, including pitot tubes, nozzles, thermocouples, meter boxes, and CEMs. Referenced calibration procedures were followed, and the results properly documented and retained. A discussion of the techniques used to calibrate this equipment is presented below. The calibration data are presented in the appendices.

Type-S Pitot Tube Calibration

The USEPA has specified guidelines concerning the construction and geometry of an acceptable Type-S pitot tube. If the specified design and construction guidelines are met, a pitot tube coefficient of 0.84 can be used. Information related to the design and construction of the Type-S pitot tube is presented in detail in 40 CFR 60, Appendix A. Only Type-S pitot tubes meeting the required USEPA specifications were used during this test program. Pitot tubes were visually inspected and documented as meeting USEPA specifications prior to the field sampling.

Sampling Nozzle Calibration

Both stainless steel and pyrex nozzles were used for isokinetic sampling. The Method 5 train used stainless steel nozzles. The MM5 sampling train used pyrex nozzles. Calculation of the isokinetic sampling rate requires that the cross sectional area of the sampling nozzle be accurately and precisely known. All nozzles used on this test program were thoroughly cleaned, visually inspected and calibrated according to the procedure outlined in 40 CFR 60, Appendix A.

Temperature Measuring Device Calibration

Accurate temperature measurements are required during source sampling. Bimetallic stem thermometers and thermocouple temperature sensors were calibrated using the procedure described in 40 CFR 60, Appendix A. Each temperature sensor was calibrated over the anticipated range of use against a NBS-traceable mercury-in-glass thermometer.

Meter Box Calibration

Dry gas meters and orifice meters were used in the M5/8, MM5, and HCl sampling trains to measure the sample volume and the sampling rate.

All meter boxes were calibrated prior to shipment of the equipment to the field. Post-test calibration checks were performed upon return to the PES laboratory. The calibrations were performed as specified in the USEPA document "Quality Assurance Handbook for Air Pollution Measurement Systems," (EPA-600/9-76005b).

GENERAL SAMPLING QC PROCEDURE

During sampling, QA/QC procedures must be followed. In the discussion below, specific QA/QC procedures used for the Modified Method 5, particulate matter, HCl, and process sampling are described.

Modified Method 5

The MM5 sampling train was charged and then partially assembled in the laboratory. Once at the sampling location site, the MM5 sampling train was fully assembled and the entire train was leak-checked. The results of the leak-checks, pretest and post-test, were documented on data sheets.

All data during the tests were recorded on standard data sheets. The data sheets were compiled and accounted for at the end of each test day.

The equipment used for the OP and OC (MM5) sampling such as the thermocouples, pyrex nozzles, pitot tube, and meter box, were documented on the data sheets. All of the equipment was calibrated as described previously. Calibration data can be found in the appendices.

Particulate Matter

The particulate/SO_x (M5/8) train was charged and then partially assembled in the laboratory. Once at the sampling site, the M5/8 sampling train was fully assembled and allowed to heat to operating temperature. Once the train reached operating temperature, a leak-check was conducted prior to and following each test. The results of the leak-checks were documented on the data sheets.

All of the data collected during the test were recorded on standard forms. These data sheets were compiled and accounted for at the end of the test day.

The equipment used for the M5/8 sampling such as the thermocouples, stainless steel nozzle, pitot tube, and meter box were documented on the data sheets. All of the equipment was calibrated as described previously. Calibration data can be found in the appendices.

HCl

The HCl sampling train was charged and assembled in the laboratory. The HCl train was leak-checked prior to and following the sampling to ensure that no leaks occurred during the run. The data were recorded on data sheets that were compiled and accounted for at the end of the test day.

The meter box used in the HCl sampling was documented on the data sheet. Calibration data can be found in the appendices.

Process Samples

There were five process areas where samples were collected. These include the kiln feed, fuel oil, clinker, ESP dust, and OP and OC pesticides. The QA/QC procedures for the analyses of each of these processes can be found in the appendices.

SAMPLE RECOVERY

Once samples have been collected in a train, they must be recovered so that they can be submitted to a laboratory for testing. QA/QC procedures during sample recovery are important to avoid loss of sample or contamination. QA/QC procedures used for sample recovery specific to the sampling methods and pollutants sampled are described below.

Modified Method 5

The MM5 recovery was conducted in one of the DGKCC's on-site laboratories. The samples were recovered into two sample containers. The probe was rinsed at least 3 times, first with distilled-in-glass MeOH and then with distilled-in-glass $MeCl_2$. The condensate that was collected in the back-half of the sampling train and all MeOH and $MeCl_2$ rinses from the probe and connecting glassware were recovered into a pre-labeled, solvent rinsed amber bottle. The filter was folded such that the particulate cake was inside of the fold. The folded filter was stored inside the respective XAD-2 module for that run. All utensils that were used in sample recovery were rinsed with the recovery solvents. The recovery solvents were distilled-in-glass grade MeOH and $MeCl_2$. The solvents were stored in their original glass container and poured into Teflon™ squeeze bottles as needed. After the samples were recovered, the liquid level was marked on the sample bottle and the opening was capped with a Teflon™ lined screw cap and sealed with Teflon™ tape to prevent leakage. At the end of the test day the samples obtained were listed on the field sample log and on the Chain-of-Custody data sheets. One set of blanks was set-up, leak-checked in the same manner as an actual sample, and submitted to the laboratory for analysis along with the samples. The samples were individually packaged

in "Sturdee Seal" packaging systems. Each system has a vermiculite blanket and pads to provide optimum protection against leakage in the event of bottle breakage, polypropylene bags to wrap each bottle, a metal can to hold the vermiculate and the bottle, an inner cardboard box, and an outer cardboard box. The packing system complied with U.S. Department of Transportation specifications. The XAD-2 resin traps were wrapped in bubble wrap, placed in plastic bags, and then packed in a cooler.

When the samples were received in the PES laboratory, they were unpacked and visually inspected to verify that no leakage had occurred during shipment. All samples were received in good condition.

Particulate Matter/SO_x

The M5/8 sample recovery was performed in the field laboratory. The probe was washed with acetone at the sampling site. The probe and front half glassware were rinsed at least three times with acetone. The samples were recovered into pre-labeled, acetone rinsed borosilicate glass bottles. The filter was recovered into it's original petri dish. The front half recovery constituted the Method 5 portion of the M5/8 sampling train. The Method 8 portion of the M5/8 sampling train was recovered by first weighing the contents of the first impinger for moisture determination purposes to the nearest 0.1 g. The impinger contents were then transferred to a 250 ml sample bottle. The back half glassware from the filter through the first impinger was then rinsed with 80 percent isopropyl alcohol (IPA) and the rinses were added to the sample bottle containing the contents of the first impinger.

The second and third impingers were weighed and recorded to the nearest 0.1 g. The contents of these impingers were transferred to a 1000 ml volumetric flask. All connecting glassware was rinsed with deionized, distilled water and added to the impinger solution. Sample analyses were conducted on site.

The silica gel was weighed and recorded to the nearest 0.1 g.

HCl

Recovery of the HCl sampling train was performed in the field laboratory. Distilled, deionized water was used as the recovery solvent. PES quantitatively transferred the contents of the first three impingers (the knock out impinger and the two 0.1N H_2SO_4 impingers) to a leak-free polyethylene sample bottle. The impingers and connecting glassware were rinsed at least three times with distilled, deionized water and the rinses were added to the sample bottle. The contents of the fourth impinger (0.1N NaOH) was recovered in a similar manner into a second leak-free polyethylene sample bottle. The sample bottles were labeled and the liquid level marked.

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Following recovery, the samples were logged and stored. Prior to departure from the test site, the samples were packed for shipping to the PES Laboratory. Once in the PES laboratory, the samples were unpacked and visually inspected to verify that no leakage had occurred during shipment.

SAMPLE CUSTODY

To ensure the validity of the results, chain-of-custody procedures were used in the handling of the recovered samples. In the discussion below, these procedures are described

Modified Method 5

The MM5 samples were recovered and the samples packed and shipped to the PES Laboratory. Except for the international shipping, the samples remained in PES custody until they were shipped to Triangle Laboratories, Inc. (TLI) for analysis. TLI acknowledged receipt of the samples by returning PES' chain-of-custody sheets with a form describing the samples that were received, their condition, and the project reference number. TLI's internal chain-of-custody was also documented on their Sample Management and Tracking form.

Particulate Matter/SO_x

M5/8 samples were recovered and analyzed on the premises of the DGKCC. There was no transfer of samples, therefore, a sample chain-of-custody was not necessary.

HCl

The HCl samples were recovered into two containers for each test run, an H_2SO_4 and a NaOH solution. These samples were packed and shipped to the PES laboratory. The samples remained in PES custody until they were shipped to TLI for analysis. TLI acknowledge receipt of the samples by returning PES' chain-of-custody sheets with a form describing the samples that were received, the condition, and the project number. TLI's internal chain-of-custody was also documented on their Sample Management and Tracking form. TLI, in turn, subcontracted the analyses to ETS Laboratories.

SAMPLE ANALYSIS

The laboratories that provided analytical support to PES included Triangle Laboratories, Inc. and ETS Analytical Services. Both have internal QA/QC procedures which they followed. PES verified with the contract laboratories that proper QA/QC procedures were used.

The laboratories (including PES) have provided data documenting their QA/QC procedure results including internal audits such as spikes, known concentration standards, and duplicates. This information can be found in the appendices

DATA DOCUMENTATION AND VERIFICATION

All of the data collected in the field were recorded on standard data forms. The use of these data forms provided a means for documentation of process conditions. identification of run number, amount of sample collected, sampling time, etc A portion of the raw data was reduced in the field using a computer program. These data calculations included gas volumes, stack gas velocities and flow rates, stack gas moisture content, and isokinetic sampling rates.

After the laboratory results were received and the final calculations were performed, the data were summarized. The data summaries were reviewed for anomalies (extremely high or low values not within the range of similar data). If an error was found, the result was flagged and then recalculated.

The calculated data were also reviewed to ensure that all raw information was input correctly. The input data were printed on a summary sheet and these data were compared with the data from the field data sheet.

Finally, this report was subjected to PES' internal review process.

PREPARATION OF SAMPLES FOR ANALYSIS

The samples that were submitted to contract laboratories included the MM5, HCl, and process samples. When the samples were shipped to the laboratories, instructions were provided as to what analyses were to be performed and the analytical method to be used.

The samples that were retained and analyzed by PES included the Method 5 filters, front half acetone rinses, and SO_x. In preparation for analysis, the Method 5 filter numbers were recorded in the laboratory notebook along with the initial weight of that particular filter. The Method 5 front half acetone rinses were assigned a tared beaker in which they were to be evaporated. The sample number and tare weight of the beaker were recorded on a data sheet in a notebook.

SAMPLE COMPLETENESS

PES initially intended to collect 3 MM5 samples, 3 M5/8 samples and 3 HCl samples from the stack location, for each of the 3 conditions. Because of the cyclonic flow in the stack, only 2 MM5 samples, 1 M5/8 sample and 2 HCl samples were collected under Condition 1 at the stack location. The sampling location site was changed to the breaching where PES intended to follow the same protocol as for the stack location. Because of a shortage of pesticide and the extended time on-site, it was agreed to collect only 2 sample sets for each of the three conditions. Therefore, 2 MM5, M5/8 and HCl samples were collected under each condition. Sample information on CEMs, including CO and O_2 for each sample run time period, were received from DGKCC. Process samples were collected on days of sample runs. All sampling procedures were the same for each condition Table 6.1 is a summary of the sample completeness for each sampling location and sample type.

TABLE 6.1

OVERAGED PESTICIDE PILOT BURN, D.G. KHAN, PAKISTAN

SAMPLE COMPLETENESS

Sample Location Sample Type	No. of Samples to be Collected	No. of Samples Actually Collected	No. of Samples Analyzed	Percent Complete
Exhaust Gas Samples				
Pesticides (MM5)	6	6	6	100
Particulate Matter (M5/8)	6	6	6	100
HCl and Cl_2 (M26)	6	6	6	100
SO_2 (M5/8)	6	6	6	100
CO (CEM)	6	6	6	100
O_2 (CEM)	6	6	6	100
Process Samples				
Kiln Feed	6	6	6	100
Fuel Oil	6	6	6	100
Clinker	6	6	6	100
ESP Dust	6	6	6	100
OP Pesticides	2	2	2	100
OC Pesticides	2	2	2	100

APPENDICES

Project Participants -- chart

EPA Punjab letter from Director General, 9-14-89, giving clearance for burn with caveats

Annex 1 + 2 to above: Environmental Quality Standards for Industrial Gaseous Emissions

PES letter of 10-10-89 commenting on EPA Punjab conditions

USEPA letter of 10-24-89, comments on sampling plan by Robert Mournighan

State Cement Corporation of Pakistan, 10-8-89 letter, approval to use DGKCC for the pilot burn

"D.G. Khan Cement Co. Ltd, Country's Biggest Cement Plant," article which appeared in Dawn, November 14, 1989

Agriculture Department, Government of the Punjab, 11-6-89, text of official release of obsolete pesticides

USEPA letter of 8-27-90, summarizing results of analyses of process samples, by Robert Mournighan

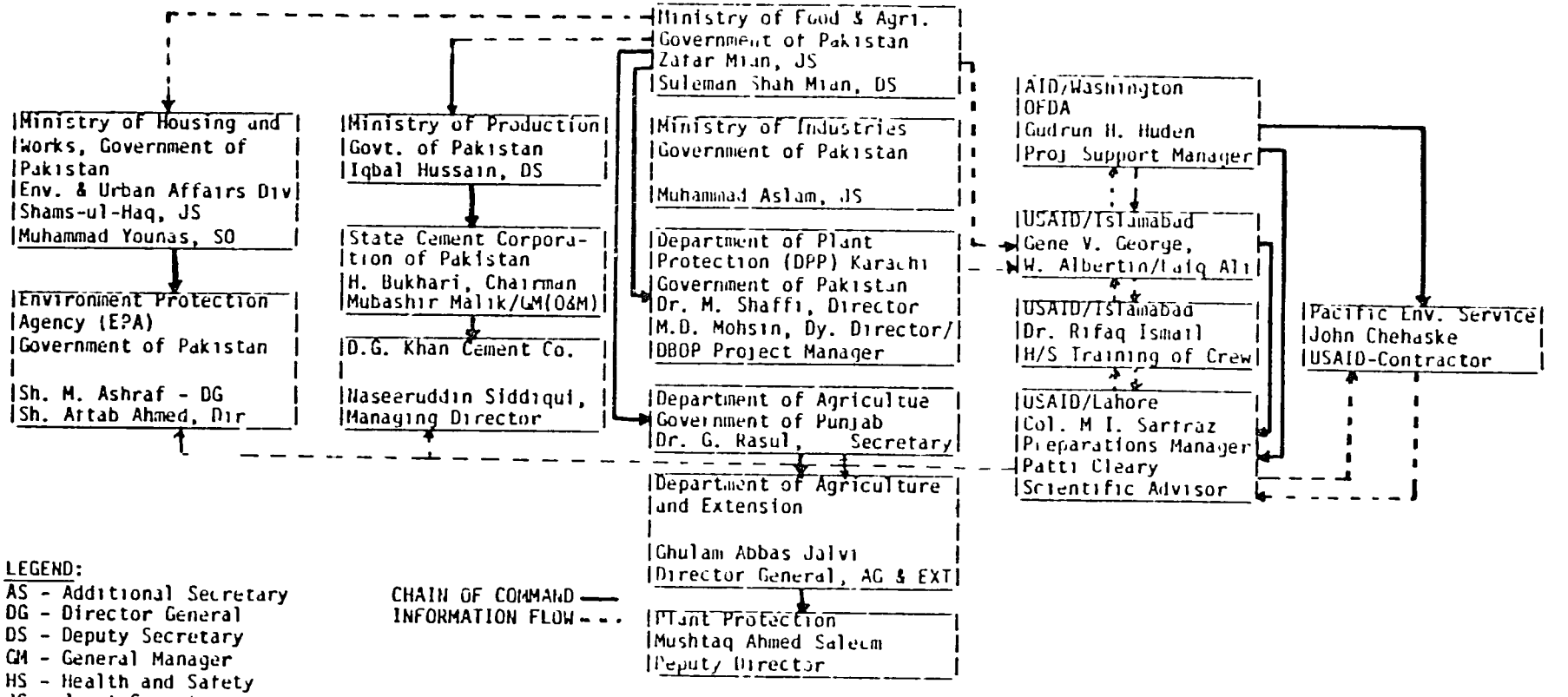
Environmental Assessment for the Demonstration Incineration of Overaged Pesticides in a Cement Kiln in Pakistan, pages 4-21, October 1989

Draft Logistic Plan, page i - Appendix-2, and transmittal letter, 11-2-89

Selected country emission standards compared by AID/OFDA

Bibliography

DEMONSTRATION BURN OF OVERAGED PESTICIDES
PROJECT PARTICIPANTS



BEST AVAILABLE DOCUMENT

[illegible] ON THE ROAD
[illegible] DEPUTY COMMISSIONER
[illegible] ENVIRONMENTAL PROTECTION AGENCY
[illegible] ROAD LAHORE.

To

Mr. Abdul Latif Lodhari,
Section Officer,
Food & Agriculture Division,
Government of Pakistan, Islamabad.

Memo No. [illegible] Dated [illegible].

Subject:- [illegible]

References:- Your letter No. [illegible] dated 22nd August, 1989.

Clearance for burning of overaged Pesticides for demonstration in the D.G. Khan Cement Kiln Incineration is hereby accorded subject to the following conditions:-

1. Proper care will be taken during the transportation of Pesticides from the site of storage to the kiln to ensure safety & pollution-free journey.

2. The personnel engaged in the transportation & handling of pesticides will be fully conversant with the precautions to be adopted in case of any emergency.

3. The rate of Pesticides injection into the kiln will be kept such as would ensure keeping the stack emissions within Environmental Protection Agency Punjab, Standards (copy attached).

4. The stack emissions will be continuously monitored and chemically tested to avoid any pollution due to upset operation caused by rapid movement of klinker down the kiln into the klinker coolers, incomplete combustion of toxic organic compounds or any other reasons whatsoever.

5. The Ministry of Food & Agriculture, Department of Plant Protection will also arrange for the stack gas testing of toxic metals, carbon monoxide and oxides of nitrogen & sulphur.

6. The Environmental Protection Agency representatives will be associated throughout the process of incineration & will supervise the same.

Contd....P/2.

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This clearance is only for the demonstration of 20 tons each of organo-phosphate & organo-chlorine overaged pesticides. The Ministry of Food, Agriculture & Co-operation, Department of Plant Protection shall provide the results of analysis. Further clearance for burning of overage pesticides shall be decided by Environmental Protection Agency Punjab in the light of evaluation analysis report.

D.N/As above.

DIRECTOR (CO-ORDINATION)
ENVIRONMENTAL PROTECTION AGENCY
PUNJAB, 4-LITTON ROAD, LAHORE.

BEST AVAILABLE DOCUMENT

ANNEXURE I

ENVIRONMENTAL EMISSION STANDARDS FOR MUNICIPAL AND LIQUID INDUSTRIAL EFFLUENTS (mg/l) UNLESS DEFINED.

SL. NO.	PARAMETER.	RELAXED STANDARD (UP TO 1990)	ULTIMATE STANDARD (AFTER 1990)
1.	Temperature	40 C°	40 C°
2.	pH	5.5-9.5	6.0-9.0
3.	5-days Biochemical Oxygen Demand* (BOD) at 20 C°	200	60
4.	Chemical Oxy en demand* (COD).	400	150
5.	Total Suspended Solids.	400	200
6.	Total Dissolved Solids.	5000	3500
7.	Grease and oil	20	10
8.	Phenolic compounds (as phenol).	1.5	0.3
9.	Chloride (as Cl^-)	1000	1000
10	Fluoride (as F^-)	20	10
11.	Cyanide (as CN^-)	2	1
12.	Anionic Detergents** (as MBAS)	30	20
13.	Sulphate (SO_4^{2-})	1000	1000
14.	Sulphide (S^{2-})	2.0	1.0
15.	Ammonia.	75	40
16.	Pesticides, herbicides, fungicides and insecticides.	0.75	0.15
17.	Cadmium#	2.0	0.1
18.	Chromium# (trivalent and hexavalent)	2.0	1.0
19.	Copper#	4.0	1.0
20.	Lead#	2.0	0.5
21.	Mercury#	0.1	0.01
22.	Selenium#	1	0.5
23.	Nickel#	2.0	1.0
24.	Silver#	2.0	1.0
25.	Total toxic metals#	10.0	2.0
26.	Zinc	10	5
27.	Arsenic	2.0	1.0
28.	Barium	4.0	1.5
29.	Iron	10.0	2.0
30.	Manganese	10.0	1.5
31.	Boron	10.0	6.0
32.	Chlorine	1.0	1.0

*. assumes minimum dilution 10:1 on discharge, if not more stringent local standards necessary.

**. assuming biodegradable (stringent standards required for nonionic surfactants).

#. Subject to total toxic metal discharge.

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Annexure:-2

Environmental Quality Standards for Industrial Gaseous Emissions (mg N^{-3} unless defined).

Sr. No.	parameter	Source of Emission	Relaxed standard (up to 1990)	Ultimate standard (after 1990)
(1)	Smoke	Smoke capacity not to exceed.	40% (Ringlemann Scale)	40% (Ringlemann Scale)
(2)	Particulate matter*	boiler and furnace		
		Using oil	600	300
		Using coal	750	500
		Cement Kilns,	600	300
		grinding, crushing clinker coders, and related processes		
		metallurgical processes, converters, blast furnaces and cupoles	700	500
(3)	Hydrogen chloride	any	500	400
(4)	Chlorine	any	200	150
(5)	Hydrogen fluoride	any	200	150
(6)	Hydrogen sulphide	any	10	10
(7)	Sulphur oxides	sulphuric acid plants	8000	6000
		others	500	400
(8)	Carbon monoxide	any	1000	800
(9)	Lead	any	100	50
(10)	Mercury	any	30	10
(11)	Cadmium	any	30	20
(12)	Arsenic	any	50	20
(13)	Copper	any	100	50
(14)	Antimony	any	50	20
(15)	Zinc	any	300	200
(16)	Oxides of Nitrogen (NO_x)	any nitric acid manufacture	4000	3000
		other Sources.	1000	400

* In defining more stringent standards attention should be paid to particle sizes of $< 10\mu$. Account should also be given to the total mass emission per unit time for large emitters.

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PACIFIC ENVIRONMENTAL SERVICES, INC.

3708 Mayfair Street Suite 202
Durham North Carolina 27707
(919) 493-3536
Fax (919) 493-7779

October 10, 1989
WP/3860-1

Ms. Gudrun Hartig Huden
Environmental Officer
Office of U.S. Foreign Disaster Assistance
Agency for International Development
U.S. Department of State
22nd & C Streets, NW, Room 1262-A, N5
Washington, DC 20523

Re: Memo No. DD (T-T) EPA/1952, dated 14 September, 1989, from Government of Punjab, Office of the Director General, Environmental Protection Agency to Mr. Abdul Latif Leghari, Section Officer, Food and Agriculture Division, GOP, Islamabal.

Dear Gudrun:

The above referenced letter outlines six conditions which must be met as part of the Government of Punjab Environmental Protection Agency's clearance for the overaged pesticides demonstration burn. I have reviewed the conditions and have the following comments.

Condition 1 - The Department of Plant Protection will be responsible for transporting the pesticides. I'm sure they will take the proper precautions in transporting the pesticides.

Condition 2 - I understand that personnel training is, or has been, provided by USAID/Lahore.

Condition 3 - The pesticide injection nozzle is designed for a maximum flow rate of 4.0 liters per minute. The supplier indicated it could probably be pushed to 6.0 liters per minute if needed. This compares to the fuel firing rate of about 130 liters per minute. The pesticide feed rate is so low that there should be no measurable impact on any of the regulated emissions when burning the organophosphate pesticide. When burning the organochloride pesticide there may be an increase in hydrogen chloride emissions. Previous test have shown that more than 90 percent of the chlorine will end up in the ESP dust as calcium chloride, sodium chloride, and potassium chloride.[1] Assuming the maximum pesticide feed rate of 6 liters per minute and a

[1] Ravishankar and Mitter, "Cement Kilns for Hazardous Waste Disposal," Pacific Basin Consortium for Hazardous Waste Research.

PES

chlorine content of 25 percent by weight, the maximum possible chlorine feed rate will be 1,500 grams per minute. Assuming a worst case condition where half of the chlorine is emitted through the stack, that would be an emission rate of 750 grams of chlorine per minute. The chlorine is expected to react quickly with moisture in the stack gases, converting to hydrogen chloride. No free chlorine is expected. The exhaust gas flow rate was previously measured at 2,160 Normal m^3/min. That would be a concentration, expressed as HCl, of 357 mg/m^3 which is less than either the current or the 1990 Punjab standards which are 500 and 400 mg/m^3, respectively.

Condition 4 - The plant has monitors which continuously measure and record the oxygen and carbon monoxide concentration of the kiln exhaust gases. These two parameters are routinely used by the plant to determine if the kiln is operating properly. If there is an upset, the pesticide feed will be shut off until the kiln is operating normally again.

Condition 5 - I do not believe the Ministry of Food and Agriculture, Department of Plant Protection is planning to do any stack gas testing; that is to be done by PES under our contract with AID. We plan to test for carbon monoxide and oxides of sulfur, but not toxic metals and oxides of nitrogen.

The CO sampling will be done with an Orsat analyzer on 1-hour composite grab samples; one or two per day. The SO_2 will be collected in the back-half of the Method 5 particulate sampling train. The NO_x was originally going to be collect using EPA Method 7D. However, Bob Mournighan has stated he does not believe NO_x sampling is necessary, based on other kiln test data he has seen which shows little if any change in NO_x when burning hazardous wastes. If you agree, we will not measure NO_x.

For the toxic metals, the lowest 1990 metals standard set by the Punjab EPA is 10 mg/m^3 for mercury. At a concentration of 10 mg/m^3 and the previously measured stack gas flow rate of 2,160 m^3/min, the stack emission rate would be 21.6 gm/min. At the maximum pesticide feed rate of 6 liters per minute (6,000 grams per minute) the pesticide could contain up to 0.36 percent by weight mercury (21.6 ÷ 6,000 = 0.36%) before the standard would be exceeded. This is a very high metals content; much higher than would be expected in the waste pesticides. The Punjab standards for the other metals are 2 to 20 times higher than the mercury standard, so the pesticides would have to contain 2 to 20 times more of the other metals before the standards would be exceeded. Therefore we do not believe it is necessary to measure toxic metals in the stack gases.

PES

Condition 6 - The Punjab EPA representatives will be more than welcome to supervise the demo burn. We will work with them in any way that is desired.

Sincerely,

PACIFIC ENVIRONMENTAL SERVICES, INC.

John

John T. Chehaske
Vice President

JTC:bw

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF RESEARCH AND DEVELOPMENT
RISK REDUCTION ENGINEERING LABORATORY
CINCINNATI, OHIO 45268

October 24, 1989

Ms. Gudren Huden
AID/OFDA/AFR
Room 1262-A NS
Washington, DC 20523

Dear Gudren:

With regard to the tests at the Khan Cement plant in Pakistan, I feel that the current sampling plan is adequate for our purposes. Because the plant is of relatively new design (precalciner/preheater plant built since 1970), operating conditions in the kiln combustion zone do not vary. The plants of this design typically operate at low SO_2 (<70 ppm) and low CO (<300 ppm). Measurement of temperature, SO_2, O_2, and CO is sufficient to pin down combustion conditions in the kiln. Although NO_x measurements were proposed for this project, I feel that NO_x measurements are not critical to our needs and are not necessary.

Sincerely yours,

Robert E. Mournighan
Chemical Engineer
Thermal Destruction Branch
Waste Minimization, Destruction and
Disposal Research Division

OFFICIAL FILE

STATE CEMENT CORPORATION OF PAKISTAN (Private) LTD.
P.E.C. BUILDING, NEAR LIBERTY MARKET, GULBERG-III, LAHORE-PAKISTAN

GRAMS: "CEMENT"
TELEX : 44836 SCCP PK

Tele : Ex. I 87 03 41 - 44 & 87 02 18
Ex. II 87 03 45 - 49

GENERAL MANAGER(OPS & MAINT)

NO.TD/OPS/MOP/89/ 6253
Dated: October 8,1989

ACTION
Date

RECEIVED OCT 18 1989

Mr. Waldemar Albertin
Mission Environmental Advisor
Office of Engineering
United States Agency for
International Development
18-Sixth Avenue, Ramna 5
Islamabad (Pakistan)

Date 19/29
Action Taken Sent to Gudinn
Date 1/24
Action

SUB: OVERAGED PESTICIDES DEMONSTRATION BURN AT D. G. KHAN CEMENT PLANT

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Dear Sir,

Kindly refer to your Endt. NO.ENG/ES/L-1289/10/89 dated 3.10.1989 on the above subject.

We convey our approval to use D.G. Khan Cement Plant for this demonstration burn. We are also informing Managing Director D.G. Khan Cement Plant to make necessary arrangements for its implementation as per Project Schedule and work plan.

Regards

LOG # 3821

	ACTION		

Yours faithfully

(MOBASHAR A. MALIK)

RECEIVED OCT 18 1989

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DAWN, TUESDAY, NOVEMBER 14, 1989

hazi Khan Division

D.G. Khan Cement Co. Ltd

Country's biggest cement plant

A view of the D.G. Khan Cement Factory

By Naseer ud-Din Siddiqui

Managing Director, D.G. Khan Cement Co. Ltd.

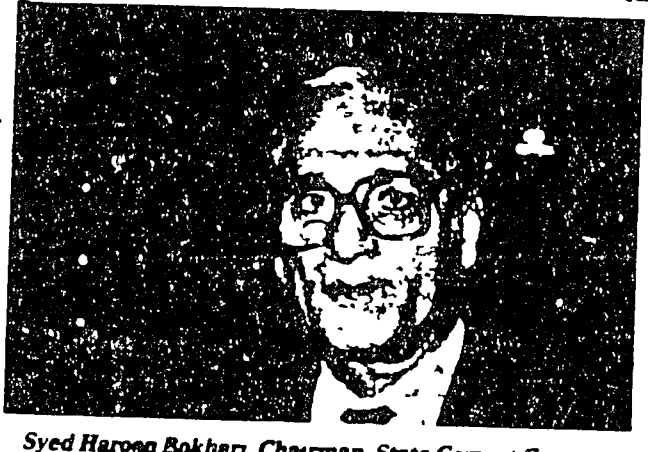
D G KHAN Cement Factory, a unit of State Cement Corporation, is one of the largest and the most modern unit in Pakistan at 2000 tons/day and 630,000 tons production annually It caters to a very large segment of our country's population, which has in the past suffered greatly due to shortages

Prior to the commissioning of this plant, cement used to be supplied to the central market ing zone, consisting of important areas like Multan, Bahawalpur, Bahawalnagar, Okara Sahiwal, Vehari and D G Khan, from the factories as remote as Zealpak in Sindh and Gharibwal in upper Punjab High freight charges resulted in prohibitive landed prices which created depression in the construction activities in the region

With the coming into operation of the D G Khan cement plant, availability of cement has been ensured, besides reduction in landed prices to a great extent, which only goes to prove that the setting up of a cement plant in D G Khan was a dire necessity

A brief history of the plant is as under :

Feasibility of the project was completed in September, 1977 and the project was approved in the public sector (under the Ministry of Production), by the National Economic Council in July 1978 Subsequently, a loan agreement was signed with the Asian Development Bank and the final approval for setting up a single production line of 2000 tons per day was conveyed on 10-1 1980 The size of the plant was chosen both from the point of view of demand forecasts and the availability of high quality raw material reserves sufficient for a period of over 100 years in



Syed Haroon Bokhari, Chairman, State Cement Corporation of Pakistan.

Koh i-Suleman Range

Location of the plant was selected at Kohfli Satai, a village in the foothills of the Koh i-Suleman Range, at a distance of approximately 40 kilometres from D G Khan city

Originally, the project was considered with an estimated

Continued on page II

Production since 1986-87

Year	Clinker production (tons)	Proportional cement (tons)	Profit ton/ Rs in 000)
1986 87	608,696	630,000	65762
1987 88	614,371	636,000	92304
1988 89	620,333	641,000	93648

(unaudited)

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Most modern cement factory

Continued from page 1

cost of Rs 1060 500 million which figure was later revised to Rs 1251 397 million (with Foreign Exchange component of Rs 604 546 million) The project was finally completed at a cost of Rs 1431 592 million (Rs 843 444) million in foreign exchange) The increase of Rs 236 544 million over the revised estimates was due to exchange fluctuations, which was beyond the control of the management In a way, it can be safely said that the project was completed within the cost estimates

The erection/installation work of the project was completed in March, 1986 and the plant started commercial production w e f 1-4 1986 Since its start up, the plant has given trouble-free operation and its production is more than the rated capacity Clinker production during the first full year of operation 1986 87 has been 608,696 tons with a corresponding cement production of 630,000 tons Over the years, the production and profits rose steadily which will be evident from the table published here

The Plant has an inbuilt capacity for expansion, which can be increased to 4000 tons/day by incurring much less expenditure than a green field project

The existing plant enjoys a very high degree of automation and all operational control is affected from a Central Control Room (CCR) which is equipped with the latest computerised control system For quality control, there is an on line X-ray Analyser, which ensures a very high quality of cement

The raw material (Limestone and Shale) is extracted from a quarry adjacent to the plant and is conveyed to the storage yard through a 7Km long belt conveyor From this storage, the material is conveyed to a roller mill where it is air lifted to a silo for blending purposes

The blending silo produces a meal, which is fed into the kiln through a four stage suspension preheater tower The rotary kiln is 78 metres long and 4 7 metres in dia It is lined with high quality refractory bricks to sustain temperatures as high as 1400 C Clinker produced from the kiln is cooled and stored in the clinker silo

Cement is finally made by grinding clinker with roughly 4% gypsum and is stored in 3 silos of 18,000 tons capacity Packing is done through two rotary packers, each of 100 tons/hour capacity Cement is packed in 50-Kg bags and transported through trailers of upto 40-ton capacity

At present, the plant has a total strength of 470 including 110 officers It has residential facilities for both officers and workers, which also include a school, mosque, shopping centre, hospital, community centre and a number of playfields Special attention has been given to plantation and, over the last few years, the entire 450 acres of the area has been transformed into a very green area It is due to the excellent facilities available within the plant that we have been able to attract specialised engineers and technicians from all over the country for running our factory

The cement factory has contributed substantially to the socio-economic development of the D G Khan Division Infrastructure base for industrialisation has been amply provided and a lot of small and medium size enterprises have developed over the last few years Besides direct employment of locals in the factory, plenty of indirect opportunities for employment have been created due to the establishment of infrastructural facilities within the area

The Management of D G Khan Cement Plant hopes to continue contributing significantly in the development of the area for a long time to come. *Inshallah*

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GOVERNMENT OF THE PUNJAB

Subject: DESTRUCTION OF [illegible]

Will the Secretary to Government of the Punjab, Agriculture Department, kindly refer to his D.O. letter No.SO(EXT)IV-10/89, dated 1-11-1989, on the above subject?

2. Finance Department agrees to allow the A.D. to hand over 20,000 liters of phosphatic compound and 20,000 liters of chlorinated compound to the WAPDA Authority for the purpose of incineration to be carried out in cement kilns at Wah.

(FAZAL ABBAS)
SECTION OFFICER E&P (AGRI)

The Secretary to
Government of the Punjab,
Agriculture Department.

U.O.No.8/299-Agri(FD)/89, Dated Lahore, the 6th Nov. 1989.

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF RESEARCH AND DEVELOPMENT
RISK REDUCTION ENGINEERING LABORATORY
CINCINNATI, OHIO 45268

August 27, 1990

Ms. Gudren Huden
Agency for International Development
OFDA/AFR
Rm. 1262-A NS
Washington, DC 20523

Dear Gudren:

Attached are the completed pesticide analyses for the feed, ESP dust, and clinker samples taken during the demonstration test burn at D.G. Khan Cement Company in Dera Ghazi Khan, Pakistan. None of the pesticides were found in the samples. The Fuel Oil samples were not processed because after I discussed the need to analyze the Fuel Oil samples with John Chehaske and Helen Yoest of Pacific Environmental Services, we agreed that these samples are not critical to the results of the project and would delay the analyses of the rest of the samples. We decided it is not necessary to analyze the Fuel Oil samples, because the Fuel Oil is: 1) A process input stream, and 2) no pesticides were detected in the other samples. However, if you wish, we can run the samples at a later time. All of the samples are archived so that further analyses can be run, if need be.

The samples were analyzed by GC/FID and, to confirm positively each compound, by GC/MS. The results speak for themselves. Since no response was found in any of the samples for any of the pesticides, the results are listed as being less than the detection limit for the method. The detection limit for all the pesticides was 0.2 mg/Kg, or 200 parts per billion (ppb), except for Metasystox, Gusathion-M, and Gusathion-A, where it was 400 ppb.

The Quality Assurance samples and blanks corroborate the results. None of the laboratory blanks, used to take precaution against laboratory contamination, showed any detectable quantities of pesticides (Page 3). Duplicate Analyses of Sample for one of the feed samples (F-2-1) show identical results (Page 5). You may have noted that in the preliminary results sent to you previously, Endosulfan was reported in the sample and the laboratory blanks. These latest and final analyses rerun with GC/MS indicate that no such contamination existed.

Surrogate recoveries (the practice of spiking a known amount of a compound into the sample and measuring the response) ranged from 49.8 to 87.7 percent (Page 6). Recoveries of 50 to 100 percent are considered good to excellent for these compounds and this method, according to EPA's reference on standard methods of analyses, SW-846. Surrogate recoveries give us an idea how well the lab performs, technically speaking.

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I might mention here that these were difficult samples to analyze. The lab did not have reference standards for all of these compounds on hand and had to procure them. Also, the samples were more complex than first thought, the cement dust and clinker not lending themselves to a straight-forward, routine analysis. It was no small undertaking, requiring considerable research effort, to complete the analyses. Although it took more time than desired, the job is conclusive, credible and is well done.

Sincerely yours,

Robert E. Mournighan
Chemical Engineer
Thermal Destruction Branch
Waste Minimization, Destruction and
Disposal Research Division

Enclosure

cc: John Chehaske - Vice President, Pacific Environmental Services
Helen Yoest - Pacific Environmental Services
Robert C. Thurnau - USEPA. Chief, Technology Research Section, RREL
Robert Thomas - USEPA. Project Officer, Contract Lab Program, RREL
Donald Oberacker - USEPA
Joe Thornton - Greenpeace, Chicago
George Patrick - USEPA Office of International Activities

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ENVIRONMENTAL ASSESSMENT
FOR THE
DEMONSTRATION INCINERATION OF OVERAGED PESTICIDES
IN A CEMENT KILN IN PAKISTAN

October, 1989

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Author

Patti Cleary is an Environmental Scientist with the U. S. Environmental Protection Agency. Ms. Cleary is a scientific advisor to U. S. AID for the demonstration burn project of overaged pesticides. Ms. Cleary's areas of expertise include hazardous waste management, safe use of pesticides and project management.

Acknowledgements

Preparation of this document was sponsored by the Office of Engineering, US AID Islamabad, Pakistan. The author greatfully acknowledges the assistance of the following people who contributed to this report: Dr. Waldemar Albertin, Chaudhary Laiq Ali, Dr. Rifaq Ismail, Col. Sarfraz, Mushtaq Saleem and Gudrun Huden.

II The following pesticides were collected and incinerated at D.G. Khan Cement Kiln.

Pesticides Type	
Organophosphate	Organochlorine
Azodrin	Kelthane
Stem F-34	Dieldrin
Dimethoate	Thiodan
Guzathion	
Fenitrothion	
Nexion 25%	
Nogas	
Novacron	
Metasystox	
DDVP	
Zolone	

These pesticides were collected from storage areas located in the Agricultural districts of Rahim Yar Khan and Bahawalpur.

Although the Government of Pakistan released for incineration up to 20 tons of each pesticide type, the quantity incinerated was much less because many of the overaged pesticides were in a solid or semi solid physical state. The pesticide injection system is designed to incinerate only liquid pesticides. Approximately 5344 liters of organochlorines and 10,970 liters of organphophates were collected and transported to the D.G. Khan cement kiln for incineration.

III. Expected Environmental Hazards

It is AID's policy to ensure that environmental consequences of AID-financed activities are considered and appropriate safeguards and mitigative actions are adopted. The policy is stated and dicussed in title 22 of the Code of Federal Regulations, Part 216,"AID Environmental Procedures" (22 CFR 216). This section addresses the probable environmental impacts of this project and provides recommended mitigative actions to minimize and negative impacts that may occur as a result of this Project.

Physical Location and Setting

The D.G. Khan cement kiln is located approximately 140 kilometers from the city of Multan in the south east portion of the Punjab. The geographical area of D.G. Khan can be characterized as a semi-arid region in the Indus plain. The surrounding area is sparsely populated and can be classified as semi desert area with sparse vegetation and sandy soil. The D.G. Khan cement plan was selected primarily because of its close proximity to the overaged pesticide storage facilities. The cement kiln is well equipped to handle the incineration of pesticides. The remote location of the D.G. Khan cement plant and the plant officials' cooperative attitude further added to the use of the D.G. Khan cement kiln for the incineration.

Air Releases

A potential route of exposure for this project is from the risk of kiln emissions during incineration at the cement kiln. The cement kiln is located in a sparsely populated area. Within one mile of the kiln the population at risk is a fairly small number. Under normal operating procedures the kiln emissions likely to result will be minimal. Summaries of other case studies indicate that emissions of particulates can range from 5 to 300 Kg/hr depending on the efficiency of the air pollution control equipment. Carbon monoxide concentration can range from 5 to 10,000 ppm depending on the type of process control with average near the 50 to 250 ppm range. Sulfur dioxide, from the sulfur in the fuel oil, is scrubbed by the alkaline environment of the kiln and air pollution control device filter cake, and tends to be in the 50-5000 ppm range. Nitrogen oxides, caused by the combination of air and oxygen at high combustion temperatures, tends to range from 50-300 ppm. Hydrogen chloride emissions exist at trace levels from fuel and feed chlorine content at the 0.1 to 0.3 kg/hr range. Unburned hydrocarbons, from fuel or volatilized from shale feed, tends to range from 5 to 25 ppm. 1/.

Mitigating Factors for Air Releases

For this project, the cement kiln has an electric precipitator that is designed to capture and remove from the atmosphere dust particles during plant operations. The precipitator operates continuously 24 hrs/day and emits 150 miligrams per cubic meter of particles per day. This emission rate for particles is well below Pakistan Environmental Protection Agency's standard for particulate emissions.

During the demonstration stack emissions will be continuously monitored for particulates, semi-volatile organic compounds, chloride gas and hydrochloric acid. It is anticipated that the feedrate of the pesticides into the kiln will be adjusted to keep air pollutant emissions below the standards set forth by the regulatory agencies overseeing this project. If unacceptable air emissions are detected during the demonstration, immediate action will be taken to minimize any threat to human life of the environment. The Environmental Protection Agency of the Punjab has granted clearance of the demonstration and has provided air emission standards for chemical constituents that should be observed during the demonstration.

1/ In conclusion by adjusting the operating protocols during the incineration, it is anticipated that kiln emissions will be kept low and within appropriate regulatory standards set forth for incineration. Facility modifications will be carefully designed and monitored to ensure that environmental hazards are minimized. Under optimum operating conditions it is anticipated that inhalation risks will be insignificant. In the event of an accident emergency evacuation procedures are discussed in the health and safety section of this report.

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Release to Surface Waters

The next likely route and exposure that may result in environmental damage is in the event of a spill or accident during the transportation of these pesticides to the cement kiln.

Consequently, the impact of the project to sensitive environments such as surrounding surface water merits evaluation. The main rivers of concern that are located near the transportation routes are the Chenab River, the Sutlej River, the Ravi River and the Indus River. There are also many canal systems along the transportation routes that may be adversely affected in the event of a spill or truck accident. Recent studies indicate that surface waters in Pakistan are in a poor state of water quality. Rivers in the study area are in an existing state of pollution due to primarily direct discharge of domestic sewage and direct discharge of industrial waste. The use of agricultural chemicals and perhaps overuse with expectation of increasing food production also contributes to the environmental degradation of these rivers and canals. The seriousness of this pollution is demonstrated by the fact that forty percent of human deaths is Pakistan are related to waterborne diseases. Fish kills and destruction of other forms of aquatic life are widespread. 2/ The Chenab River receives sewage and other industrial waste from both the cities of Multan and Faisalabad. In comparison to the surface water pollution of the other rivers, the Sutlej River is of less concern from an environmental pollution standpoint because it is primarily a dry river filling in times of flooding or monsoon. The Sutlej is not used as a regular irrigation or drinking water source. It is anticipated that the impact of this project on surrounding surface waters will not be significant because the quantity of pesticides to be transported is not significantly high.

Mitigating Factors for Spill Release

The highest risk of release to surface waters for this project will be in the event of a spill or accident during the transportation of the overaged pesticides to the incineration site. To decrease the risk of accident or spill only main transportation routes between pesticide collection points will be utilized. The condition of the tanker trucks to assess the reliability of the tanks, valves, flowmeters and nozzles should be evaluated prior to the transport of the overaged pesticides to the cement kiln. If possible pesticides liquids will be obtained from one central loading area within each District. Drivers and handlers of the pesticide will receive professional health and safety training in the handling of hazardous materials. They will also receive training in emergency and contingency planning procedures in the event of a spill or accident. Special precautionary measures are addressed in the health and safety section of this report to mitigate the effects of a spill or truck accident. The transportation routes used will be ones that are the safest and have the least river and canal crossings.

2/ Pollution of Inland Waters and its Effects on Aquatic Life, Dr. Mohammad Yaqub Javaid, Director General Fisheries, Punjab, Lahore, June 1988.

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Population at Risk

The demonstration area is located in a remotely unpopulated area. Within a one mile radius from the cement kiln there are approximately 1000 people living near the cement kiln. These people are mostly employees and their families residing in a housing colony near the plant. The housing colony is about a one mile walking distance from the demonstration area. The cement kiln has on site a fire department and hospital in the event of an emergency. The hospital has a staff of two doctors and nurses. The hospital has an oxygen supply that can be used in the event of an emergency or for Level B protection.

Decontamination of Tanker Trucks

Trucks will be decontaminated prior to leaving the pesticide loading areas and the cement kiln. The health and safety officer will be responsible for decontaminating the trucks. Trucks will decontaminated with an appropriate solvent such as kerosene and soap and water.

Summary of Pesticide Toxicity

The toxicity of pesticides are usually expressed by a dose respose relationship. LD50 values are used as a relative index of toxicity. LD50's are usually calculated from animal experiments that are designed to measure the dose that kills 50% of the test organisms. The table below contains the LD50's for some of the pesticides for the demonstration project.

Dieldrin: Highly toxic. Very low oral concentrations lethal in rats. Deildrin may be stored in body tissue for an extended time. Skin contact - low doses are lethal in rats and rabbits. No data available on chronic exposure effects.

Fenitrothion: Acute oral LD50 (rat) 500 mg.kg; acute dermal LD50 (rat), 1300 mg/kg. Very soluble in water. No known carcinogenic, teratogenic or neurotoxic effects. Does not accumulate in body tissue.

Gusathion (Guthion, Fusithion or Azinophosmethyl): Technical: Acute Oral LD50 (rat), 13-16.4 mg.kg, dermal LD50, 220 mg/kg. Soluble in water to about 29 ppm at 25° C; subject to hydrolysis; Decomposes at elevated temperatures with gas evolution.

Metasystox: Acute oral LD50 (rat) 64-180 mg/kg.

Dichlorovos (DDVP): Acute oral LD50 (male) 50-80 mg/kg, acute dermal LD50 (male rat) 107 mg/kg

Dimethoate: Acute oral LD50 (male rat, 320-380 mg/kg acute dermal LD50(rat) (guinea pig) 650 mg/kg

Kelthane: Acute oral LD50 (rat) 809 mg/kg

Zolone: Acute oral LD50 (rat) 120 mg/kg.

Nexion: Acute oral LD50 (rat), 3750-7700 mg/kg. Soluble in water to 40 ppm

Relative Index of Toxicity

Probable Oral Lethal Dose for humans

Toxicity Rating or Class	Dose	For Average Adult
1. Practically nontoxic	15 g/kg	More than 1 quart
2. Slightly toxic	5-15 g/kg	Between pint and quart
3. Moderately toxic	0.5-5 g/kg	Between ounce and pint
4. Very toxic	50-500 mg/kg	Between teaspoonful and ounce
5. Extremely toxic	5-50 mg/kg	Between 7 drops and teaspoonful
6. Super toxic	_5 mg/kg	A taste (less than 7 drops)

Source: Toxicology: The Basic Science of Poisons, 2 ed. Casarret and Doull (eds.), 1975

Disposal of Pesticide Containers

If there are any empty pesticide drums remaining after the demonstration, their disposal and cleaning will need to be addressed. All remaining empty pesticide drums should be rinsed with water and/or a suitable solvent to rid the container of any pesticide residue. All drums at the demonstration site will be collected, resealed and returned to storage. Another alternative in the disposal of empty drums that could be considered would be to burn the empty drums in a rotary kiln. For this project is is not anticipated that there will be a large quantity of drums that will require re-disposal after the demonstration because the pesticides will be collected and transported by tanker trucks.

Procedures for Management of Empty Containers

1. Empty containers will be drained to remove most of the pesticide residual.

2. Containers should be tripled rinsed with a suitable solvent such as diesel fuel or kerosene. Each rinse should use suffucient solvent to fill the containers adequately. The containers should be drained for at least 30 seconds after each rinse. Rinsate should be collected in another barrel and labeled as such.

3. Protective clothing should be worn while rinsing containers.

4. After barrels are rinsed, they may be crushed buried or returned to the pesticide formulation facility. Burial of containers should be in areas that are distant from surface and ground water. Records should be kept on location of burial.

5. Containers can also be crushed and recycled as scrap matel. Container must be drained and rinsed prior to recycling.

6. Records should be maintained to track containers from delivery until they are destroyed or recycled. Records should be distributed to key offices involved in the project.

IV. Site Safety Plan

Protecting the health and safety of those involved in this project is of utmost concern and a priority for all those involved in the demonstration burn. Hazards to which people may be exposed include known and unknown chemicals, heat stress, physical stress, biological agents, equipment related injuries, confined space entry, fire and explosion. Toxicity hazards range from acute effects with clincal symptoms such as headache, dizziness and skin rash, to chronic or irreversible impacts, including impaired health, cancer, birth defects, and death. This site specific safety plan will prescribe the specific personnel, procedures and protective equipment to be used during the pesticide demonstration project.

A site Safety Officer will be desigated and will be responsible for implementing this site safety plan. The site safety officer will have the overall responsibility for safety and will be in charge of all safety operations. These responsibilities include but are not limited to the following activities; use of air monitoring equipment, supervising the use of protective equipment, medical emergencies, decontamination and emergency contingency plans. Each team member will be responsible for complying with the site safety plan and alerting others to observed or suspected hazards. Workers will be informed of the potentioal hazards and the need to use personal protective equipment. All personnel will be familiar with potential routes of exposure (inhalation, skin or mucous membranne contact and injestion) by which toxic materials enter the body and specific measures to prevent exposure.

The site safety officer or other workers may perform air monitoring to track potential worker exposures to airborne contaminants. Air monitoring equipment will include total organic vapor analyzers, explosimeters and exygen detectors. A brief description of the air monitoring equipment is provided.

Air Monitoring

Oxygen Detectors

The oxygen content in a confined space is of prime concern to anyone about to enter that space. Removal of oxygen by combustion, reduction reactions, or displacement by gases is difficult to detect without equipment. The portable oxygen indicator will read the percent oxygen in the immediate atmosphere. The normal ambient oxygen concentration is 20.8%. Most indicators have meters which display oxygen content at 0-25%. This range is the most useful readout since decisions involving air-supplying respirators fall into this range.

Explosimeters

The combustible Gas Indicator readings are taken concurrently with 02 level readings. It measures the concentration of a flammable vapor or gas in the air, indicating the results as a precentage of the lower explosive limit (LEL) of the calibration gas.

The LEL of a combustible gas or vapor is the lowest concentration by volume in air which will explode, ignite or burn when there is an ignition source. The upper explosive limit (UEL) is the maximum concentration. Above the UEL, there is insufficient oxygen to support combustion so ignition is impossible. Below the LEL, there is insufficient fuel to support ignition.

Organic Vapor Analyzer (OVA)

OVA can detect the presence of some common organic compounds. This air monitoring equipment requires an individual trained specifically to maintain and operate it.

All air monitoring equipment and other safety gear will need to be imported to Pakistan as it is not readily available here. The objective of air monitoring is to help in the determination of level of protective personnel equipment to be used. Although total vapor/gas contamination measurements are useful for the selection of protection equipment, caution should be exercised in interpretation. An instrument does not respond with the same sensitivity to several vapor/gas combinations of contaminants as it does to a single contaminant of similar levels.

Therefore the protection level should not be based sole on the total vapor/gas but rather the level of protection will depend on the particular job with special emphasis on potential exposure taking into account the chemical and toxicological characteristics of the overaged pesticides.

Level of Protection

The level of protection will depend on the work activity such as pesticide sampling, transferring the material from drums to tanker trucks, feeding material into the kiln and cleaning of drums, tanks and equipment and other activities. Any potential for direct contact with the waste material must be minimized. Levels of protection can be upgraded or downgraded depending on site conditions and work activity. Tasks such as moving drums, opening containers, and bulking of materials, which increase the probability of liquid splashes or generation of vapors, gases or particulates will require a higher level of protection. It is anticipated that level A protection will not be used. With the hot climatic conditions prevalent in Pakistan (Temp. 100 deg. -120 deg. F) the negative aspects of level A protection need to be considered. In level A protection the physical stress caused by heat buildup in fully encapsulation suits may pose more of a hazard and health problem and therefore may not be appropriate for this project. Life threatening pesticide levels are not anticipated for this project.

For the demonstration burn project it is anticipated that Level C health and safety protective gear will be used for the majority of work involved in the handling and transport of the overaged pesticides to the cement kiln and during the demonstration incineration at the cement kiln. Zones of hazards during the project will be determined by the Health and Safety Officer. These zones are necessary so that employees know the hazards in different areas where their presence is not required. This will help control the activities and movements of workers and equipment during the collection, transport and demonstration incineration of the overaged pesticides. Level B personal protective equipment will be on hand during the demonstration project and will be used if it is determined that it is needed to protect the health and safety of those involved in the project.

Levels of Protection are briefly described:

Level A Protection (Concentrations of 500 to 1,000 part per million above background).

Level A Protection provides the highest degree of respiratory tract, skin and eye protection. The following equipment constitutes Level A Protection:

1. Pressure-demand full-face piece self contained breathing apparatus SCBA, or pressure-demand supplied air respirator with escape SCBA, approved by the National Institute for Occupational Safety and Health.

2. Totally - encapsulating chemical protective suit.

3. Coveralls.

4. Long underwears.

5. Gloves, outer, chemical resistant.

6. Gloves, inner, chemical resistant.

7. Boots, chemical-resistant, steel toe and shank.

8. Hard Hat (under suit).

9. Disposable protective suit, gloves and boots (depending on suit construction, may be worn over totally - encapsulating suit).

Level B Protection (5 to 500 ppm above backgroun):

Level B Protection is the minimum level of protection for initially entering a site a site where the types, concentrations and presence of airborne vapors are unknown. This level of protection provides a high degree of respiratory procection. Skin and eyes are also protected, although a small portion of the body, neck and sides of head may be exposed.

A lower limit of 500 ppm total atmospheric vapor/gas concentration of portable air monitoring equipment has been selected as the upper restriction on the use of level B.

The following equipment constitute Level B Protection:

1. Pressure-demand full-face piece self contained breathing apparatus (SCBA) or pressure-demand supplied air respirator with escape SCBA (NIOSH approved)

2. Chemical-resistant clothing.

3. Coveralls.

4. Gloves-outer, chemical resistant.

5. Gloves, inner, chemical resistant.

6. Boots, outer, chemical resistant steel toe and shank.

7. Boots-covers, outer chemical resistant (disposable).

8. Hard Hat.

Level C Protection (Background to 5 ppm above background):

A range of background to 5 pmm above ambient background concentrations of vapors/gases in the atmosphere has been established as guidance for selection Level C Protection.

The following equipment constitute Level C Protection:

1. Full face or half mask, air purifying respiration (NIOSH approved) and cartridges.

2. Hooded chemical-resistant clothing, splash suit.

3. Coveralls.

4. Gloves, outer chemical resistant.

5. Gloves, inner chemical resistant.

6. Boots (outer) chemical resistant, steel toe and shank.

7. Boot covers, outer chemical resistant (disposable).

8. Hard Hat.

Level D Protection - Minimal Health protection work uniform. The following constitute Level D Protection:

1. Coveralls.

2. Gloves.

3. Boots/shoes, chemical-resistant steel toe and shank.

4. Boots, outer chemical-resistant/disposable.

5. Safety glassess or chemical splash goggles.

6. Hard Hat.

Level A Protection should be used when:

- The hazardous substance has been identified and requires the highest level of protection for the skin, eyes and the respiratory system based on either the measured (or potential for) high concentrations of atmospheric vapors, gases or particulates: or site operations and work functions involve a high potential for splash, or exposure to unexpected vapors, gases or particulates of materials that are harmful to skin or capable of being absorbed through the skin.

- Substances with a high degree of hazard to the skin are known or suspected to be present and skin contact is possible.

- Operations that are conducted in poorly ventilated areas.

Level B Protection should be used when:

- The type and atmospheric concentration of substances have been identified and require a high level of respiratory protection but less skin protection.

- The atmosphere contains less than 19% of oxygen.

- The presence of incompletely indentified vapors or gases is indicated by a direct reading organic vapor detection instrument but vapors and gases are not suspected of containing high levels of chemicals harmful to skin or capable of being absorbed through the intact skin.

Level C Protection should be used when:

1. The atmospheric contaminants, liquids or other direct contact will not adversely affect or be absorbed through any exposed skin.

2. The types of air contaminants have been identified, concentrations measured and an air purifying respiration is available that can remove the contaminants.

Level D Protection should be used when:

1. The atmosphere contains no known hazards.

2. Work activities preclude splashes, immersion or the potential for unexpected inhalation of or contact with hazardous levels of any chemicals.

Decontamination Procedures

All workers will be trained in decontamination procedures: Site access will be controlled to minimize worker contact with equipment that has contacted hazardous materials. Decontamination will be conducted in specific areas that will minimize the exposure of uncontaminated employees or equipment. All workers leaving a contaminated area shall be appropriately decontaminated. All clothing or equipment leaving contaminated area shall disposed of or decontaminated. All equipment and solvents used or decontamination shall be disposed of properly. Protective clothing and equipment shall be cleaned, laundered or replaced as needed to maintain their integrity. Workers whose clothing becomes saturated with hazardous materials shall immediately remove the clothing and shower. Water and soap shall be provided for decontamination of equipment, clothing and workers at the pesticide loading and unloading areas.

Emergency Information

Hospitals near D.G. Khan	Medical Center D.G. Khan Cement Co. Ltd. Phones: 3889-3760 Ext. 61
Fire Department	Factory Site: 3889-3760/61 D.G.Khan: 3000
Police Department	S.P., D.G. Khan, Office: 2166 Res : 2167

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Ambulance Service	Available at Factory Site: 3889-3760/61
Transportation Route	Main road from Rahimyar Khan and Bahawalpur to D.G. Khan

Transportation routes will be thoroughly discussed in the logistic plan for this project.

Training

A training session will be held for two days in Lahore for those involved in the handling and transportation of the materials. Drivers, workers and handlers will be trained in Urdu and English by Dr. Rifaq, a recognized expert in the safe handling of pesticides. Indviduals will receive information on the following areas:

- Names of personnel and alternates responsible for site safety and health.
- Use of personal protective equipment.
- Work practices that will minimize risks from hazards.
- Safe use of equipment during the operation.
- Recognition of medical symptoms and signs which might indicate overexposure to pesticides. Baseline cholinesterase testing.
- Site specific health and safety plan.
- Medical treatment and first aid.

Handling of Drums Safety Precautions.

Transferring the liquids from drums to tanker truck shall be organized to minimize the amount of drum or container movement.

Prior to handling the drums all workers exposed to the transfer operation shall be warned to the potential hazards associated with the contents of the drums.

Suitable quantities of proper absorbents will be kept available and used in the event of spills, reptures or leaks.

Workers not actually involved in opening drums shall be kept at a safe distance from the drums being opened.

Drums shall be opened in such a manner that excess interior pressure will be safely relieved. If pressure cannot be relieved that drum will not be emptied of its content but left alone to reduce the risk of worker injury.

Workers shall not stand on or work from drums and containers.

Workers will not smoke, drink or eat during the transfer of materials.

Transfer areas shall have adequate access and egress routes.

Bulking of the waste pesticides shall be permitted only after a thorough characterization of material.

Do not put fingers in mouth or rub eyes while working. Emergency eye wash will be on hand.

Heat Stress

High temperatures are prevalent in Pakistan, so care should be exercised during the demonstration to avoid the ill effects of heat exhaustion and heat stroke. Those workers engaging in strenous physical activity need to be aware of the problems of overheating and take actions to reverse the effects of heat exhaustion.

Heat Cramps

Heat cramps are painful voluntary cramping of muscles following prolonged exposure to heat. It is caused by excessive loss of salts from the body through sweating. Body temperature is normal. Treatment of heat cramps is to replace the lost fluids with water and salt.

Heat Exhaustion

Heat exhaustion occurs as the result of excessive loss of water and salts from the body. Signs and symptoms of heat exhaustion include; profuse sweating, pale skin, weakness and mental confusion. Treatment for heat exhaustion should include cooling the person immediately, resting and replacing lost fluids with water and salt.

Heat Stroke

Heat stroke is a medical emergency. In heat stroke the person will stop sweating. Signs of heat stroke include; deep breathing following by shallow breath;rapid strong pluse followed by rapid weak pluse, dry hot skin, large dilated pupils, loss of consciousness, convulsions and muscular twitching. Treatment should include cooling the person down, assuring an open airway and making sure person is breathing and medical attention should be sought.

Emergency Contingency Plans and Logistics

The health and safety officer is responsible for all aspects of the emergency contingency plans. In the event of an emergency the following procedures will be followed. Local fire departments, police and emergency medical personnel will be alerted and may be called upon to respond to an emergency situation for this project. All personnel will be trained to recognize an emergency situation and will alert other employees. The health and safety officer will be responsible for overseeing all responses to an emergency. Employees will be knowledgeable of evacuation routes that lead to safe places away from the danger area. Emergency medical treatment and first aid will be available at the D.G. Khan hospital. All operations will cease until the emergency is safely abated. After the emergency is brought under control, the health and safety officer will determine when operations can resume. Operations will start only after equipment has been restored to a functional level.

Life threatening situations will be avoided at all times during the demonstration. The area will be continuously monitored by the health and safety officer so that unnecessary exposure to hazards do not occur. Fire extinguishing equipment will be on hand and ready for use to control fires. Continuous communications between the health and safety officer and employees will be maintained to assure that there are not unnecessary exposures to hazards during the demonstration. The health and safety officer will be responsible to train employees in the recognition of health and safety hazards, methods to minimize the risks from hazards, safe use of equipment techniques and procedures for stopping or controlling leaks, use of protective equipment and medical first aid.

The D.G. Khan site will provide adequate security and control to limit access of unnecessary personnel. Unauthorized persons will not be allowed in the plant during the demonstration.

If an emergency arises during the course of the operation these protocols will be followed:

- In case of medical emergency, the hospital will be alerted. First aid and emergency CPR will be administered. The injured worker will immediately be taken to the medical facility for treatment .

- Fire extinguishers will be available in the event of an unforeseen fire or explosion. Workers will be knowledgeable on evacuation routes in case of fire or explosion.

- Site will have security to control unwarranted access by unauthorized individuals.

UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT
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ENG/ES/L-1461/11/89
November 02, 1989

Dr. Muhammad Shafi
Director/Advisor
Department of Plant Protection
Government of Pakistan
Karachi

Subject: Overaged Pesticides Demonstration Burn at D.G. Khan Cement Plant

Dear Dr. Shafi:

Please find attached the "Logistic Plan" for the collection of candidate pesticides to be burned during the subject demonstration.

Sincerely,

Chaudhary Laiq Ali
Mission Environmental Engineer
Office of Engineering

Encl: a/s

cc (w/Enclosures):

Mr. Suleman Shah Mian, DS, Ministry of Food and Agriculture
Mr. Shamsul Haq, JS, Ministry of Housing & Works, E&UAD
Mr. Muhammad Iqbal Hussain, DS, Ministry of Production
Mr. M.D. Mohsin, Deputy Director, DPP, Karachi
Sheikh Muhammad Ashraf, Director General, EPA, Punjab
Mr. Haroon Bokhari, Chairman, SCCP, Lahore
Mr. Mohbashir Malik, General Manager (O&M), SCCP, Lahore
Mr. Naseeruddin Siddiqui, Managing Director, D.G. Khan Cement Company
Dr. Ghulam Rasul, Secretary Agriculture, GOPUN, Lahore
Mr. Ghulam Abbas Jalvi, Director General (Agri. & Ext.)
Gudrun H. Huden, Chief, OFDA, AID/W
Col. M.I. Sarfraz, USAID/Lahore
Patti Cleary, USAID/Lahore
Mr. Masoud H. Khan, Administrative Officer, Karachi
Mr. S.A. Chughtai, Liaison Officer, Lahore

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1102L

DEMONSTRATION BURN OF OVERAGED PESTICIDES
OFDA/USAID PROJECT

DRAFT LOGISTIC PLAN

PREPARED BY
COL. (R) M.I. SARFRAZ
PREPARATIONS MANAGER

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DRAFT LOGISTIC PLAN
DEMONSTRATION BURN OF OVERAGED PESTICIDES
OFDA/USAID PROJECT

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DRAFT LOGISTIC PLAN
DEMONSTRATION BURN OF OVERAGED PESTICIDES
OFDA/USAID PROJECT

1. Introduction

The Logistic Plan will cover the following aspects of the DBOP Project.

a) Transportation of EQUIPMENT, SAFETY KIT and CHEMICALS to DGK Cement Plant.

b) Collection and delivering of ineffective pesticides for Demo Burn to DGK Cement Plant.

c) To establish the team of Experts in DGK Plant.

d) Reception of Foreign Guests.

e) Meeting of recurring demands of the Experts at DGK.

2. Transportation of Demonstration Burn Material to DGK Cement Plant

a. The consignment received at Karachi will be transported to DGK under arrangement of DPP, Karachi. The transport will leave Karachi on November 4, 1989 and will reach DGK on November 5, 1989. For availing the facility of unloading and temporary storage, the driver will report to Mr. Mohammad Bashir, Deputy General Manager, DGK Cement Company. Mr. Bashir has been designated as Plant Engineer to deal with the DBOP Project by the Managing Director, DGK Cement Company. The transport after unloading the EQUIPMENT will report to Deputy Director Agriculture, Rahimyar Khan on November 6, 1989 at 1700 hrs. for help in the collection/carriage of Pesticides.

b. The three consignments received in Lahore will be despatched to DGK Cement Plant on November 5,1989. With a night stay at Multan, the transport will reach DGK Cement Plant on November 6, 1989 at 1300 hrs. The driver will hand over the consignment to Mr. Mohammad Bashir, Deputy General Manager. At Multan a package containing Safety gear for Pesticides Collection team will be handed over to Mr. Ray Krueger.

3. Routes to be used by the Transport

The transport coming from Karachi will use main National Highway. Starting at 0700 hrs. on November 4, 1989 will have its first halt and night stay at Rahimyar Khan (RYK). The transport will leave RYK at 0700 hrs. on the next day and will reach DGK via Bahawalpur, Multan, Muzaffargarh and DGK at 1600 hrs on November 5, 1989.

4. Transport coming from Lahore and carrying the Safety gear and other material will use National Highway from Lahore to Multan. With a night stay at Multan will reach DGK via Muzaffargarh on November 6, 1989.

5. Pesticide Collection and Delivering at DGK Cement Plant

The pesticide collection program has been based on the assumption that the pesticides would be released by November 4, 1989. At least 2-3 days will be required to collect the pesticides. Following efforts will be required to execute the pesticide collection plan:

a. Pesticide Collection Composite team

1) Safety Officer 1
2) Doctor..... 1
3) Field Assistant Agriculture (FAA)..... 2
4) Beldar (Field workers)..... 8
5) Drivers..... 9

Total..... 21

b. Transport

The transport requirement and its schedule starting from November 5, 1989 to November 22, 1989 is attached as **Annex-A.**

1)	1 x Station Wagon	For Safety Officer and Doctor)
2)	2 x Jeeps	For Collection Crew
3)	4 x Open Trucks OR	For Carriage of Pesticides
	2 x Tank Trucks	- Do -

c. Ancillary Equipment

1. 2 x Fire extinguishers
2. 1 x Suction Pump with rubber noze pipe
3. 1 x Pick
4. 1 x Shawal
5. Decontaminating absorbants, Cotton Rags/Waste and Soap
6. Six Open Top 55 gal drums
7. Polythene bags
8.
9.
10.

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d. Safety/Kit/Gear

Safety kit for eight with extra gloves and Respirator cartridges will be carried by the Collection Team. The items of Safety gear will be sorted out for use in the field by Patti Cleary. Some of those items are:

Sr.#	Description	Qty
1.	Engineers' Hat	6
2.	Med Tyvek Jumpsuits	25
3.	L Tyvek Jumpsuits	3
4.	Pairs - Booties	12
5.	Rubber Gloves	12
6.	Cotton Gloves	12
7.	Full-Face Respirator	5
8.	1/2-Face Respirator	3
9.	Cartridges	30
10.	Prefilters	10
11.	Cartridge Retainers	10
12.	Face Shield Headgear	3
13.	Eye Wash	2
14.	Duct Tape	1
15.	Batteries Pack 8	1
16.	OVA's 1-Model TLV Sniffer Model K Sniffer	2
17.	Atropine Sulphate Injection	4
18.	Pralidoxine Chloride Injections Safety Tape	6
19.	Steel Toed Safety Boots	4

e. Medical Aid

1. First Aid Box
2. Anti-dotes
3. General Medicines

6. Pesticides Collection Areas

Pesticides collection will be done mostly from Districts Rahimyar Khan, Bahawalpur, Bahawalnagar and Toba Tek Singh. The major Pesticides collection sites are as under:

a. Sajanpur
b. Sadiqabad
c. Kot Samababa
d. Khanpur
e. Liaquatpur
f. Tarinda Mohammad Pinah
g. Bahawalpur

7. Pesticide Collection Schedule

Pesticide Collection will start with effect from DAY-X. (Most likely it will be November 7, 1989). All participants forming Pesticides Collection team will report at 0800 hrs. on DAY-X in front of the Office of the Deputy Director Agriculture, Rahimyar Khan, Mian Anwar Hussain with their transport.

8. The duration of Pesticide Collection will be between 2-3 days. The Pesticides Collection is planned as under:

a. FIRST DAY

0900 hrs.....	Sajanpur
1130 hrs.....	Sadiqabad
1430 hrs.....	KotSamababa
1630 hrs.....	Khanpur

b. SECOND DAY

0830 hrs.....	Liaquatpur
1000 hrs.....	Tarinda Mohammad Pinah
1630 hrs.....	Bahawalpur

c. THIRD DAY

1000 hrs.....	Multan
1100 hrs.....	Muzaffargarh
1300 hrs.....	DGK City
1430 hrs.....	DGK Cement Plant

9. After the completion of Pesticide Collection at Bahawalpur, one Jeep and 5 men will report back to their Headquarters. The second Jeep with 4 men will accompany the Pesticides carrying trucks right up to the DGK Cement Plant. The second Jeep will also leave and join their Headquarters. 4 Field workers will stay till the end of the Demonstration, i.e., up to November 22, 1989 to assist the Experts.

10. Briefing for the Convoy Participants

A paper covering the general briefing to the convoy participants is attached as **Annex-B.**

11. Reception for the Experts

Mr. John Chehaske, Mr. Ray Krueger and Ms. Yoest will be received at Multan Airport by the Transport arranged by USAID/Lahore. USAID/Lahore team will arrive Multan by PK-384. Both teams will have a MEETING in Multan for which venue will be fixed on November 5, 1989 on telephone. After the meeting the experts will proceed to

DGK Cement Plant. The Pick carrying the Safety gear will trail behind them. Ray Krueger, Patti, Sarfraz and Dr. Rifaq will proceed to Rahimyar Khan for the collection of pesticides. The transport used/detailed for John Chehaske will stay with him till the end of the Project. Two members joining him on November 9, 1989 will be received under arrangements of John Chehaske.

12. Reception of Foreign Guests

One Station Wagon will be available for the foreign guests. Ms. Gudrun H. Huden will be received in Multan on November 14, 1989 and will be driven to DGK Cement Plant. She will be staying in the Guest Room of the Cement Plant Officer's Mess. The other guests will have choice of staying in HOTEL SINDBAD, Multan or HOTEL SHALIMAR, D.G. Khan city. A transport will be detailed for guests coming and going to these hotels in Multan and D.G. Khan city.

13. Boarding and Lodging

Mr. Naseeruddin Siddiqui, Managing Director of the Cement Plant wishes to accomodate maximum number of guests in the compound. It is assumed about 12 persons will be accomodated inside the compound. In case the number of guests increases, arrangements of their stay can be made in HOTEL SINDBAD in Multan which is 140 Km from DGK. The other HOTEL SHALIMAR is in DGK city which is about 40 Km from the Cement Plant. This hotel has reasonably good standard. Hotel facilities and their charges are given in Table 1&2.

14. Recurring Demands of Experts at DGK

Arrangements of certain types of supplies like the Solvent, Dry Ice, despatching of samples to Fuel Research Center lab and the U.S. will be discussed with the experts on their arrival in Multan on November 6, 1989.

15. Telephone/Telex

DGK Cement Plant management has installed a telephone in Office-cum-Lab room for the experts. Telex can also be used which is in main Admin Block. Some important telephone numbers are attached as Annex-C.

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LOGISTIC:11/1/89

ANNEX-A

TRANSPORT REQUIREMENT
FOR
DEMONSTRATION BURN OF PESTICIDES
AT DGK CEMENT PLANT, D.G. KHAN

Duration of Duty		Vehicle		Place and Time to Report		Agency/Dept	
From	To	Type	No	Place	Time	supplying	Duty
11/6/89	11/22/89	S/Wagon	1	Multan Airport	1000 hrs	USAID/ISL	Reception. Duty with Experts in DGK.
11/5/89	11/7/89	Pickup	1	Multan Airport	1000 hrs	USAID/LHR	To carry DBOP equipment from Lahore to D.G. Khan.
11/6/89	11/10/89	S/Wagon	1	Multan Airport	1000 hrs	USAID/LHR	Report to Patti, Ray Krueger and Sarfraz for Pesticide Collection duty
11/6/89	11/10/89	Jeeps	2	Rahimyar Khan Dy. Director, Agriculture	1700 hrs	DG, Agriculture and Extension	To carry Pesticide collection team from RYK to BWP and DGK.
11/6/89	11/10/89	Trucks	2	Rahimyar Khan Dy. Director, Agriculture	1700 hrs	DPP, GOP	Collection of Pesticides and to deliver at DGK Cement Plant.
11/6/89	11/10/89	Tank Trucks	2	Rahimyar Khan Dy. Director, Agriculture	1700 hrs	OFDA/USAID	To be arranged by DD/AG, of RYK. Hire charges will be paid by OFDA/USAID.
11/14/89	11/22/89	HIACE	1	Multan Airport	1000 hrs	USAID/ISL	To receive Ms. Huden, PSM, OFDA and other foreign guests.

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LOGISTIC:10/31/89:P/7

ANNEX-B

DEMONSTRATION BURN OF OVERAGED PESTICIDES
BRIEFING FOR THE PARTICIPANTS

1. Introduction

All participants detailed for the collection and delivering of the Overaged Pesticides selected for Demo Burn in DGK Cement Company will be given a thorough briefing about the task. This briefing will touch upon the following in particular:

a. Preparation

Field Assistant (FA), an Agriculture Officer, will lead a team of eight Beldars for picking/collection of Pesticides from the ordered places. He will make sure that his team members are the same persons who have been trained for this specific job by Dr. Rifaq Ismail.

b. Special Kit

Field Assistant (FA) will make sure that the special kit carried by the Personnel is the one which has been decided by the Safety Officer to suit the safety level A, B, C and D.

c. Medical Cover

FA, with the help of Dr. Rifaq, will check that all the necessary arrangements to provide the medical-cover during the travel and halts have been made as planned.

d. Roadworthiness of Transport

FA will check that the transport detailed for the task is roadworthy. All fuel/gasoline tanks of the vehicles will be full. All venicles should have servicable fire extinguishers.

e. Bedding/Clothing

FA will check that his team has their bedding and clothes carried with them.

f. Food/Catering

FA will be responsible for making arrangements for food/water for his team during travel and halts.

2. Duration of the Task

The task will last for 2-3 days for collection and delivering of the Pesticides at D.G. Khan Cement Company. Another 7-8 days will be spent on the demo burn.

3. Starting Station and the Destination

The convoy column will be marshelled in Rahimyar Khan and will move to different sites in the districts of Punjab for the collection of ineffective pesticides for demo burn. Date and time will be fixed when all other preparations have been made. The destination is D.G. Khan Cement Company, Dera Ghazi Khan.

4. Composition of Teams

There will be three teams working in close coordination throughout the task of collecting/delivering the pesticides:

a. Pesticides Handling Team

Field Assistant (FA) (Agriculture)	Leader
Eight Beldars (Labor)	Members

b. Medical Team

Medical Officer
Two nuring staff

c. Safety Officer

5. Transport

The transport will comprise of the following vehicles:

a.	Jeep	Two	For Field Assistant and eight Beldars (labor)
b.	Tank Truck	Two	For pesticide collection
c.	Station Wagon	One	For Medical Officer and Safety Officer

Total vehicles: Five

6. Responsibility for the provision of Transport

The responsibility for the provision of the vehicles along-with other expenditures will be of the department shown against each:

a.	Jeeps	Agriculture Department of GOPUN
b.	Tank Trucks	OFDA/USAID
c.	Station Wagon	USAID/Islamabad

7. Route

Road map will be provided to each one of the Officers travelling with the convoy. The route card will give the places, the distance and the travel time. Speed generally would be 40-50 Km/hour. The road map and route card are attached Appendix 1&2 to this paper.

8. Contact Points (CP)

In case of breakdown of vehicles or loss of direction, following contact points will be used:

	CP#	Place	Phone
a.	CP - 1	Rahimyar Khan	3223
b.	CP - 2	Khanpur	2937
c.	CP - 3	Liaquatpur	72
d.	CP - 4	Trinda Mohmmad Pinah	
e.	CP - 5	Bahawalpur	3096/4086
f.	CP - 6	Multan	34354
g.	CP - 7	Muzaffargarh	AG Office
h.	CP - 8	Dera Ghazi Khan	AG Office
i.	CP - 9	DGK Cement Plant	3761

9. Pesticide Collection Points (PCP)

Following are the collection points for pesticides:

a. Sajanpur
b. Sadiqabad
c. Kot Samababa
d. Khanpur
e. Liaquatpur
f. Tarinda Mohammad Pinah
g. Bahawalpur

10. Control, Reporting and Despatch of Convoy

The convoy leader will report to the Deputy Directors Agriculture (DDAG) of the Districts/Tehsils for the collection of the pesticides. The respective DDAG will provide all the facilities to the team to perform their task. They will release the required quantity of the pesticides to the leader and will provide all assistance in the collection. On completion of the task in their jurisdiction of a particular DDAG, he will inform the neighboring DDAG district on phone about the departure of convoy and its expected time of arrival at the next District Headquarters.

MISarfraz:aa
BRIEFING:10/30/89

DEMONSTRATION BURN OF OVERAGED PESTICIDES PROJECT
TIME AND SPACE CHART FOR PESTICIDE COLLECTION

Distance in KMs and time in Minutes is given below for organising the Pesticides Collection trip between different sites:

Place	Time and Distance	Place
Sajanpur	30 Min 20 Km	Sadiqabad
Sadiqabad	40 Min 27 Km	Rahimyar Khan
Rahimyar Khan (RYK)	30 Min 20 Km	Kot Samababa
Kot Samababa	30 Min 23 Km	Khanpur
Khanpur	60 Min 47 Km	Liaquetpur
Liaquetpur	40 Min 30 Km	Tarinda M. Pinah
Tarinda M. Pinah (TMP)	120 Min 120 Km	Bahawalpur
Bahawalpur (BWP)	120 Min 100 Km	Multan
Multan (MUL)	40 Min 28 Km	Muzaffargarh
Muzaffargarh	90 Min 75 Km	Der Ghazi Khan
Dera Ghazi Khan (DGK)	50 Min 40 Km	DGK Cement Plant

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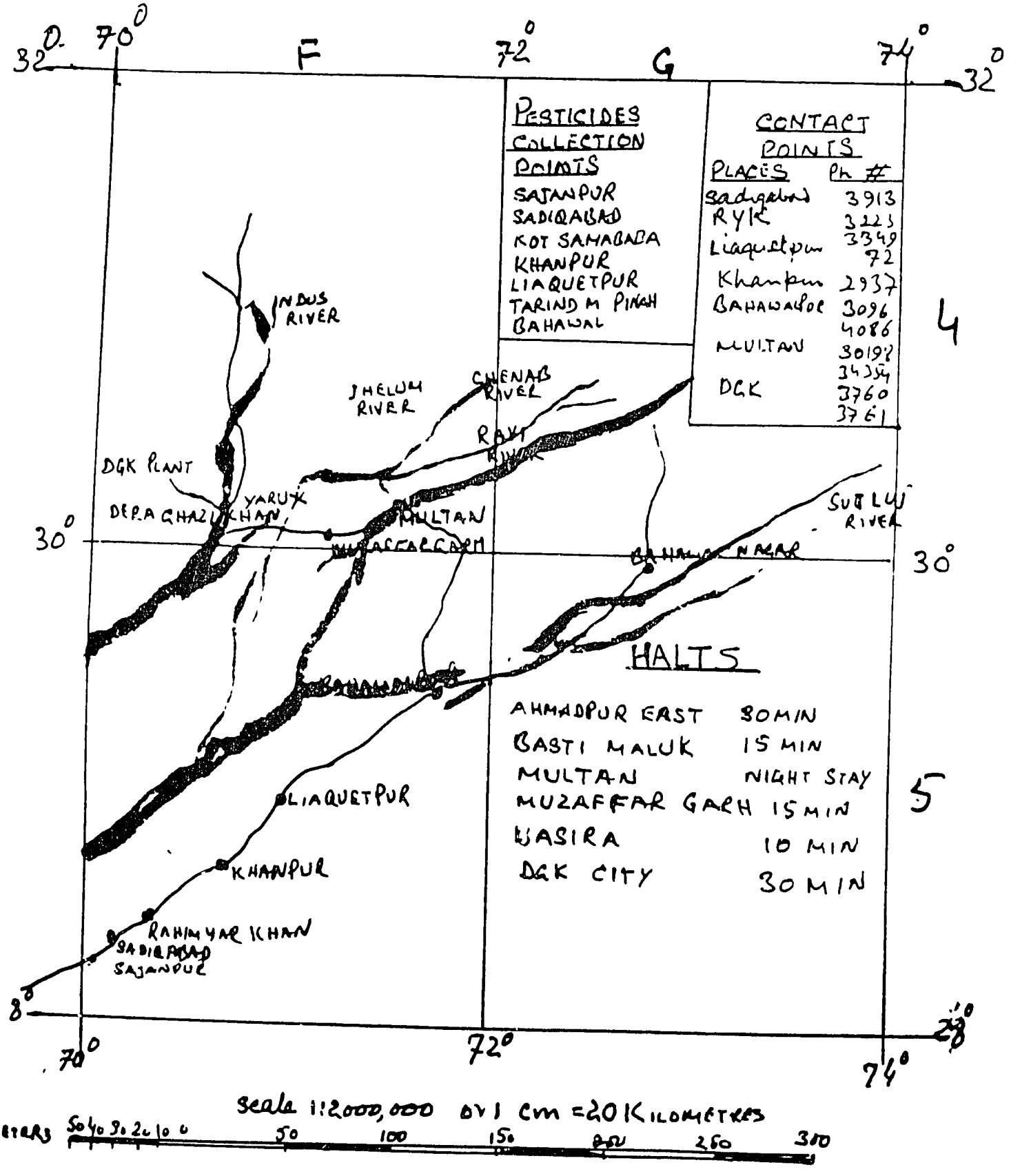
ROAD MAP OF PUNJAB



BEST AVAILABLE DOCUMENT

ANNEX-C

DEMONSTRATION BURN OF OVERAGED PESTICIDES
LIST OF IMPORTANT TELEPHONE NUMBERS

		CODE	OFFICE	RESIDENCE
A.	FOOD AND AGRICULTURE SECRETARIAT, PUNJAB			
1.	Secretary Agriculture Dr. Ghulam Rasul	LHR	66578	
2.	Additional Secretary Mr. Ghias-ud-Din	LHR	219320	
3.	Deputy Secretary Planning Mr. Inayat Ullah Shah	LHR	65064	
4.	Under Secretary Ch. Ghulam Sarwar	LHR		
5.	Section Officer Ehsan Ullah Khan	LHR	219320	
B.	DEPARTMENT OF PLANT PROTECTION, GOVERNMENT OF PAKISTAN			
1.	Director/Advisor Dr. Muhammad Shafi	KHI	480111	
2.	Deputy Director, DPP, and Project Manager, DBOP Project Mr. M.D. Mohsin	KHI	480111	
3.	Deputy Director, Lahore Ch. Saggir Ahmad Gumnam	LHR	330355	
C.	AGRICULTURE AND EXTENSION DIRECTORATE GENERAL, PUNJAB, AGRICULTURE HOUSE, LAHORE			
1.	Director General, Agriculture & Extension Mr. Ghulam Abbas	LHR	305368	
2.	Director Agriculture & Extension Ch. Ghulam Mohammad	LHR	302068	840238
3.	Deputy Director, Plant Protection HQs Mr. Mushtaq Saleem	LHR	302609	

		CODE	OFFICE	RESIDENCE
4.	Deputy Director, Headquarters Mr. Manzoor Ahmad	LHR	304151	
5.	Assistant Chemist, Headquarters Mr. Abdul Waheed Khan	LHR	302609	

D. AGRICULTURE OFFICERS OF THE DISTRICTS

I. RAHIM YAR KHAN

1.	Deputy Director Agriculture Mian Anwar Hussain	RYK	3223	
2.	EADA Headquarters Mr. Chatha	RYK	3349	
3.	EADA, Sadiqabad Ch. Abdul Ghaffar	SBD	3913	
4.	EADA, Liaquetpur Haji Siddique Mushtaq	LR	72	72
5.	EADA, Khanpur	KR	2937	
6.	Civil Hospital, SADIQABAD	SBD	3380	
7.	Fire Station, SADIQABAD	SBD	3305	
8.	Civil Hospital, Rahim Yar Khan	RYK	3281	
9.	Civil Hospital, Khanpur	KR	2930	
10.	Fire Station, Khanpur	KR	2939	
11.	Civil Hospital, Liaqatpur	LR	52	

II. BHAWALPUR

Deputy Director Agriculture Mr. M. Rashid	BWP	3096/4086	

III. MULTAN

1.	Director Agriculture Ch. A. Ghaffar	MUL	30198	
2.	Deputy Director Agriculture Meher Rab Nawaz Luck	MUL	34354	

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		CODE	OFFICE	RESIDENCE
E.	STATE CEMENT CORPORATION OF PAKISTAN (SCCP), LAHORE			
	General Manager (Ops. &Maintenance)	LHR	872378	
	Mr. Mobashir Malik	LHR	870218	
		LHR	870346 (EXC)	
		LHR	870341 (EXC)	
F.	DERA GHAZI KHAN CEMENT COMPANY			
1.	Managing Director, D.G. Khan Cement Co.	DGK	3760/3761	
	Mr. Naseeruddin Siddiqui	LHR	871752/ 873661	891513
2.	Deputy General Manager (Electrical)	DGK	3760	
	Mr. A. Faisal Khatlani	DGK	3889	
	TELEX NO. 04292 DGKCF PK			
3.	Manager (Electrical)	DGK	3760	
	Mr. Saeed Akhund			
G.	LABORATORIES			
I.	FAISALABAD: PLANT PROTECTION INSTITUTE			
	1. Director Plant Protection Institute	FD	26324	
	Dr. M.A. Hashmi			
	2. Deputy Director/Chief Chemist, PPI	FD	31409	
	Mr. Siddique Hamdard	FD	32885	
II.	KARACHI: FUEL RESEARCH CENTER			
	Director, Fuel Research Center	KHI	462604	
	Dr. Nisar Ahmad			
III.	KARACHI: HEJ CHEMISTRY LABS			
	1. Dr. Attaur Rehman	KHI	471641	
		KHI	466896	
	2. Dr. A. Malik	KHI	463414	
	3. Ch. Mohammad Iqbal	KHI	472780	

	CODE	OFFICE	RESIDENCE
IV. KARACHI: WELLCOME PHARMACEUTICAL			
1. CHEMIST; Dr. A. Salam	KHI	295233	
2. COUNTRY MANAGER; F.H. Bukhari	KHI	295233	
	KHI	290151-55	
H. MINISTRY OF HOUSING AND URBAN AFFAIRS, E&UAD			
1. Mr. Shamsul Haq, JS	ISL	822757	
2. Mr. Sarfraz Ahmad Syed, DS	ISL	822644	
3. Mr. Mohammad Younas, SO	ISL	810503	
I. MINISTRY OF FOOD AND AGRICULTURE			
1. Mr. Zafar Mian, JS	ISL	822936	
2. Mr. Suleman Shah Mian, DS	ISL	820336	
3. Mr. Abdul Latif Laghari, SO	ISL	828389	
J. USAID LIAISON OFFICES			
I. ISLAMABAD			
TELEPHONE NUMBER	051	824071-9	
TELEX NUMBER		825427 USAID PK	
FAX NUMBER	051	824086	
II. LAHORE			
TELEPHONE NUMBER	041	305082-4	
TELEX NUMBER		44928 USAID PK	
FAX NUMBER	041	305081	
III. KARACHI			
TELEPHONE NUMBER	021	440091-5	
TELEX NUMBER		54270 AIDK PK	
FAX NUMBER	021	44173	

MISarfraz:aa:TELEFON:10/30/89

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Selected National Emissions Standards

Compared by AID/OFDA

(mg/Nm^3)

	Sweden (87)	Germany (86)	Netherlands (89)	Austria (88)	Proposed Common Market Values	Punjab (91)	Range DGKCC
Particulates "Dust"	20	30	5	25	30	300	88.5-121
SO_2		100	40	100	300		0.34-10.0
SO_x						400	
H_2SO_4							0.15-170
HCl	100	50	10	15	50	400	24-77
Cl_2						150	2.3-15
CO		100	50			800	37-358

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