IN-DEPTH SURVEY REPORT

CONTROL TECHNOLOGY ASSESSMENT OF HAZARDOUS WASTE DISPOSAL OPERATIONS IN CHEMICALS MANUFACTURING

AT

E.I. DU PONT DE NEMOURS AND COMPANY
CHAMBERS WORKS INCINERATOR
DEEPWATER, NEW JERSEY

REPORT WRITTEN BY:
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REPORT NO. 103-15

National Institute for Occupational Safety and Health
Division of Physical Sciences and Engineering
Engineering Control Technology Branch
Chemical Industry Section
Cincinnati, Ohio 45226

PLANT SURVEYED:	E.I. Du Pont De Nemours and Company Chambers Works Incinerator Deepwater, New Jersey
STANDARD INDUSTRIAL CLASSIFICATION OF PLANT:	Chemical and Allied Products Sector (SIC 28)
SURVEY DATE:	October 18-21, 1982
SURVEY CONDUCTED BY:	Mazen Anastas, Ph.D. Phillip A. Froehlich Paul E. Caplan
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INTRODUCTION

The Resource Conservation and Recovery Act (RCRA) (PL-94-580) of 1976 was enacted to provide technical and financial assistance for the development of management plans and facilities for the recovery of energy and other resources from discarded materials, for the safe disposal of discarded materials, and for the regulation of hazardous wastes management. Under Subtitle C of RCRA, the Environmental Protection Agency (EPA) was required to promulgate regulations on identification and listing of hazardous wastes and regulations affecting the generators, transporters, and owners/operators of facilities for the treatment, storage, and disposal of hazardous wastes. These regulations appeared in the Federal Register on May 8, 1980. Amendments affecting the listing of hazardous wastes appeared in the Federal Register November 12, 1980.

There are between 35 and 60 million tons of hazardous wastes generated annually, of which, about 15 million are generated by industries in the Chemical and Allied Products Sector (SIC 28). These wastes contain toxic substances which may also be carcinogenic, mutagenic, and teratogenic. Some of the companies in SIC 28 treat, store, and dispose of the wastes that they generate. Wastes may also be transported to companies who specialize in the treatment, storage, and disposal of these wastes. This group of companies is classified as "Refuse Systems" (SIC 4953). It is estimated that about 6,200 workers are directly involved in the transportation, treatment, storage, and disposal of hazardous wastes from SIC 28.

There are many companies in both SIC 28 and SIC 4953 which are currently treating and disposing of hazardous wastes from chemicals manufacturing. Many of these companies also have hazard controls in place that are designed to protect the workers from known hazards, both during normal operations and during upsets or emergencies. The objective of this control technology study is to document and disseminate information on effective engineering controls, work practices, monitoring programs, and personal protective equipment. The NIOSH study will result in a technical report which will be designed to assist hazardous waste operators in their efforts to prevent worker exposures to occupational health hazards. Furthermore, an attempt will be made to present a spectrum of available alternatives for hazard control in various treatment and disposal operations.

The implementation of RCRA regulations has created business opportunities in the area of hazardous waste treatment and disposal. This has also created employment opportunities reflected in a steady rise in the number of workers who are involved in the treatment and disposal of hazardous wastes.

The Occupational Safety and Health Act of 1970 (PL-91-596) was enacted to "assure safe and healthful working conditions for men and women." The Act established the National Institute for Occupational Safety and Health (NIOSH) in the Department of Health and Human Services. NIOSH was charged by this Act with the duty and responsibility to conduct research and develop guidance for preventing or reducing exposure of workers to harmful chemical and physical agents. In response to this legislative mandate, NIOSH has conducted major programs to document, develop, and disseminate information regarding the health effects of such agents. To complement these ongoing programs, NIOSH has instituted a major effort to prevent occupational health and safety problems through the assessment and application of hazard control technology in the workplace.

This survey was conducted as part of a NIOSH project to assess and document effective controls in the routine disposal of hazardous wastes from chemicals manufacturing.

AUTHORITY

Two of the main policy objectives of the 1970 Occupational Safety and Health Act (PL-91-596) are to:

- Encourage employers and employees in their efforts to reduce the number of occupational safety and health hazards at their places of employment, and to stimulate employers and employees to institute new and to to perfect existing programs for providing safe and healthful working conditions.

- Provide for research in the field of occupational safety and health with a view to developing innovative methods, techniques, and approaches for dealing with occupational safety and health.

Under Section 20 of the Act, the Secretary of Health and Human Services is authorized to conduct special research, experiments, and demonstrations relating to occupational safety and health as are necessary to explore new problems including those created by new technology.

Paragraph (d) requires the dissemination of the information obtained to employers and employees.

The National Institute for Occupational Safety and Health was established to perform the functions of the Secretary of Health and Human Services described in Sections 2 and 20 of the Act. The manner in which investigations of places of employment are conducted by NIOSH and its representatives is outlined in the Code of Federal Regulations (Title 42, Part 85a).

HAZARDOUS WASTES

The Du Pont Chambers Works is a large multi-product chemical manufacturing complex. Products include fluorinated hydrocarbons ("Freon"), petroleum chemicals (tetra-alkyl lead), elastomers ("Viton" and "Hytrel"), specialty chemicals ("Zepel"), and aromatics such as phenylenediamines, toluidine, nitrotoluenes, dinitrobenzene, and substituted anilines. The site also uses nitric and sulfuric acids, alkaline compounds, and other inorganic materials. These products are used in the manufacture of refrigerants, fire extinguishants, paints, polyurethane foams, and as chemical building blocks for other products including dyes and textiles.

The hazardous wastes generated by the various manufacturing processes are mostly treated and disposed of on the premises by one of four methods. These are: 1) incineration, 2) wastewater treatment, 3) thermal treatment, and 4) landfill. Only hazardous wastes that are incinerated will be discussed in this report.

In November 1980, Du Pont submitted a "Part A" application to the EPA Regional Office which included a listing of all wastes and the annual quantities that were being incinerated at that time. The major organic species listed (10 tons per year and above) were halogenated and non-halogenated hydrocarbons, heavy ends from ethyl chloride production, corrosive and ignitable wastes, para-nitroaniline, acetone, benzene, butyl alcohol, ethyl acetate, methanol, methyl ethyl ketone, nitronaphthalene, alpha-naphthylamine, and toluene diisocyanate. There are small amounts (about 1 ton per year) of p-chloroaniline, ethylenediamine, aniline, dinitrotoluene, ethylene oxide, hydrazine, maleic anhydride, paraldehyde, and pyridine. PCB's are not incinerated at the site. OSHA classified or suspected carcinogens are not disposed of in the secure landfill at the site.

The procedures manual for the incinerator contains two listings of materials that may be handled at the site. The first specifies the name of the waste stream, the building where it originated, and the methods of storage and incineration of the waste. The second listing is for wastes in drums and specifies species which are 1) water soluble, 2) water insoluble, 3) Du Pont-classified carcinogens, and 4) those which are not compatible with 1, 2, and 3.

Most of the waste at the incinerator site is received in tank trailers. Some of the waste comes in dumpsters and in 55-gallon drums. All plant waste streams to be incinerated have been characterized including a determination of their Btu content. This information is provided to the incinerator operators. Only Du Pont-generated wastes are handled at the incinerator site.

In-plant waste arriving at the incinerator site must be accompanied by a "Waste Transportation Order" (Figure 1). As can be seen, it contains information on the origin of the waste, its nature, RCRA code, type of container, designation, amount, and hazards. The hazards information includes a concise description of health as well as reactivity and flammability hazards. For every waste, a "Chemical Waste Description Sheet" (Figure 2) must be submitted and reviewed before the waste is handled. This sheet is used to characterize the waste regardless of the treatment or disposal method used.

MU 1756C REV 1/81

WASTE TRANSPORTATION ORDER

No. 010475

	DEPT.	AREA	BLDG		DEPT	AREA	BLDG
FROM:	40	40	25	TO:	20	83	50

REQUESTED BY (NAME) D. L. Mosley PHONE 4101 DATE 5/6/81

BUILDING NAME Chloroamines BUILDING NO. 464

DELIVER TO: CHEMICAL WASTE AREA

NAME OF WASTE: 3,4 DCA tars and 2,3 DCA

EPA HAZARDOUS WASTE NO. ______ NONE [x] CWA NO 464-I-3

FORM (CIRCLE) — (LIQUID) SOLID, PASTE, SLURRY, OTHER

CONTAINER TYPE	NO.	NET LBS.
DRUMS		
DEMPSTER TANK		
DEMPSTER HOPPER		
TANK TRAILER	CW-460	30,000

Hazards (circle)

- corrosive
- (eye irritant)
- (skin irritant)
- respiratory irritant
- ignitable
- carcinogen
- (cyanogen)
- other: Poison

Reactive with: water, acid, amine, nitro, chloro

Figure 1. Waste Transportation Order at Chambers Works

TO:

FROM: ______________________________ Date: ______________ CWA or WWTP No. __________

CHEMICAL WASTE DESCRIPTION SHEET

Name of Waste ____

Principal Ingredients (%) ____

____

Originating Process ____

Bldg. Name __________________ Bldg. No. __________________ Equipment __________________

Amount: Container Type _________________ No./Yr. _______________ lbs./Yr. _______________

Chemical: %, HCL ______, HNO_3 ______, H_2SO_4 ______, Other Acid ______, Alkalinity ______,
TOC ______, Water ______, Solvent ______, S^{--} ______, CN^- ______, S* ______,
Cl* ______, F* ______, NA* ______, K* ______, Pb ______, pH ______, Ash ______,
Other Metals (by name) ____

Physical: (circle) water solution, water dispersion, solid, paste, liquid, gas, odor
M.P., flow pt.°C ____, decomp.pt.°C ____, Flash pt. ____, Sol.in water % ____,
heat of combust.BTU/lb. ________, Corrosion Rate ________

Hazards: (circle) eye and/or skin irritant, respiratory irritant, ignitable, cyanogen,
corrosive, carcinogen, teratogen, mutagen, poison, explosive
Reactive with: acid, water, amines, nitro, chloro, air. Other, comments:
____

Handling
Precautions: (circle) respirator, air mask, chem suit, acid suit, splash goggles, apron,
butyl or neoprene equipment.
Other, comments: ____.

DOT**: Name ____________________________ Hazard Class & No. ____________________
Label ____________________________ Placard ____________________
Container Type ____________________ Chemical Name ____________________

EPA: Hazardous Waste Nos. __________ __________ __________ __________ None ___

Info. above was used to determine waste nos. by ______________________ Date __________

Disposal: Incineration; Landfill, Sanitary or Secure; Ditch, Area or CWA;
Off-Plant ________________________ Disposal Letter No. ________________

Approvals	Comments	Date

* For Incineration Only

** For Off-Site Shipments Only

Figure 2. Chemical Waste Description Sheet

INCINERATOR OPERATIONS

The Chambers Works incinerator is a stationary liquid injection type rated at 18 million Btu/hour. It consists of a refractory lined combustion chamber with one liquid burner. A process flow diagram of the entire system appears in Figure 3.

Waste liquids are pumped at the rate of 2 to 4 gallons per minute to an atomizing nozzle located in the furnace head. High pressure steam is used to atomize the waste as it exits the burner nozzle. Combustion air at the rate of 5500 cubic feet per minute is provided by the forced draft fan. A 0.5 in H_2O vacuum in the furnace is achieved by maintaining a higher airflow rate through the induced draft fan (9000 cubic feet per minute) than through the forced draft fan. The temperature in the furnace is automatically maintained between 1800^oF and 2500^oF (the upper limit is the temperature at which the brick lining would start to fail).

The air pollution control system consists of a water scrubber (for quenching and the removal of HCl and most of the particulates), an electrostatic precipitator for removal of fine particulates, and an 85-foot stack.

Figure 4 is a plan view of the incineration facility. Tank trailers and dumpsters are backed into appropriate truck spots. The wastes in these containers may be pumped directly to the incinerator for burning or into one of the storage tanks. Drums arrive in flat bed trailers or truck. They may be temporarily stored at the concrete storage pad. The contents of all drums are pumped to storage tank TS-2. Also drums destined for landfill are temporarily stored at this concrete storage pad. There are four alternatives for empty drums: they may be rinsed, crushed, and sold to the reclaimer; they may be rinsed, crushed, and sold for scrap; they may be crushed and landfilled as in the case of drums with a "heel" in them; or the drums are sent for off-site renovation and/or reclamation.

There are 8 workers at the incinerator site. The incinerator is operated around the clock (3 shifts per day) by four operators. Three additional

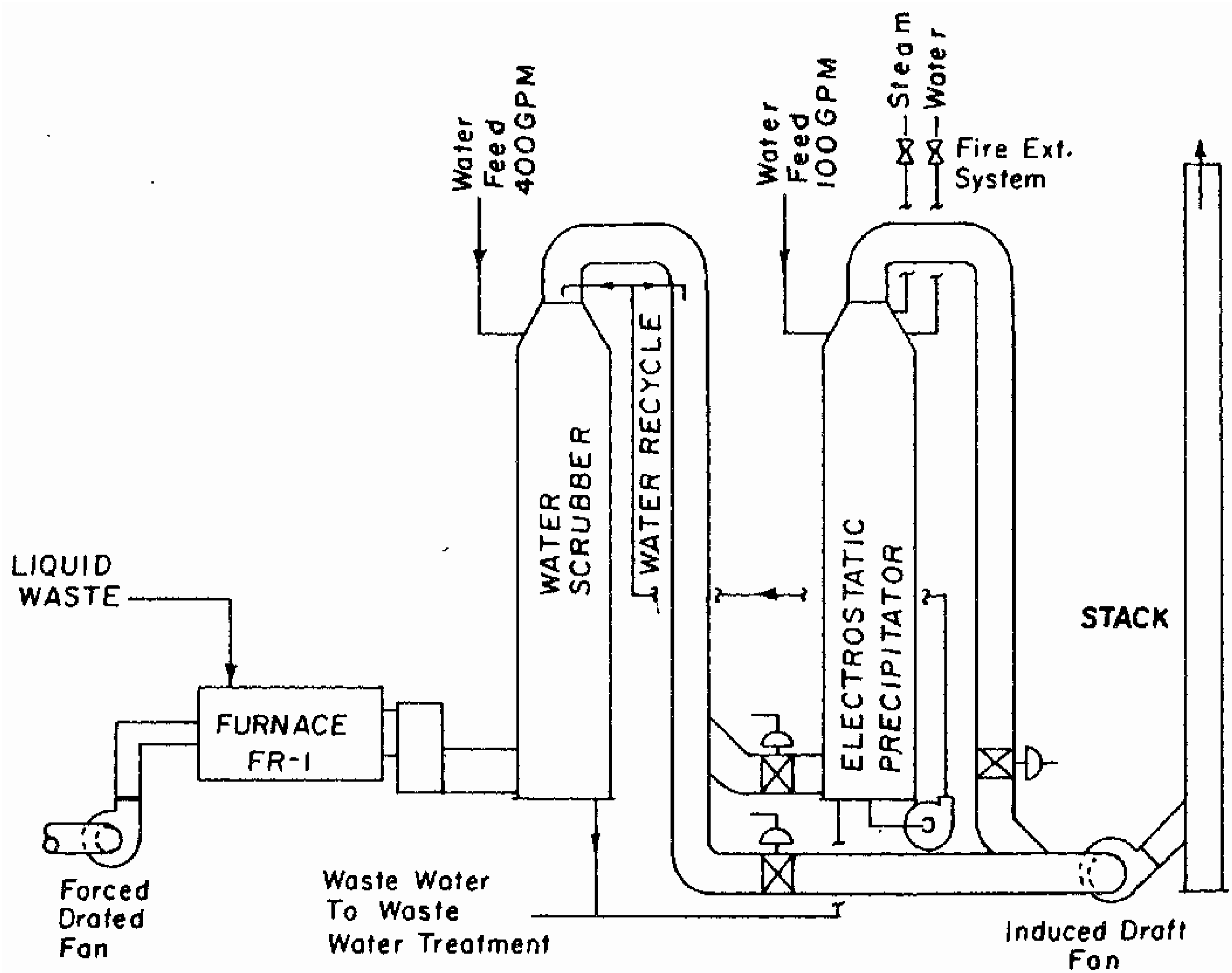

Figure 3. Process flow diagram of chambers works waste incinerator

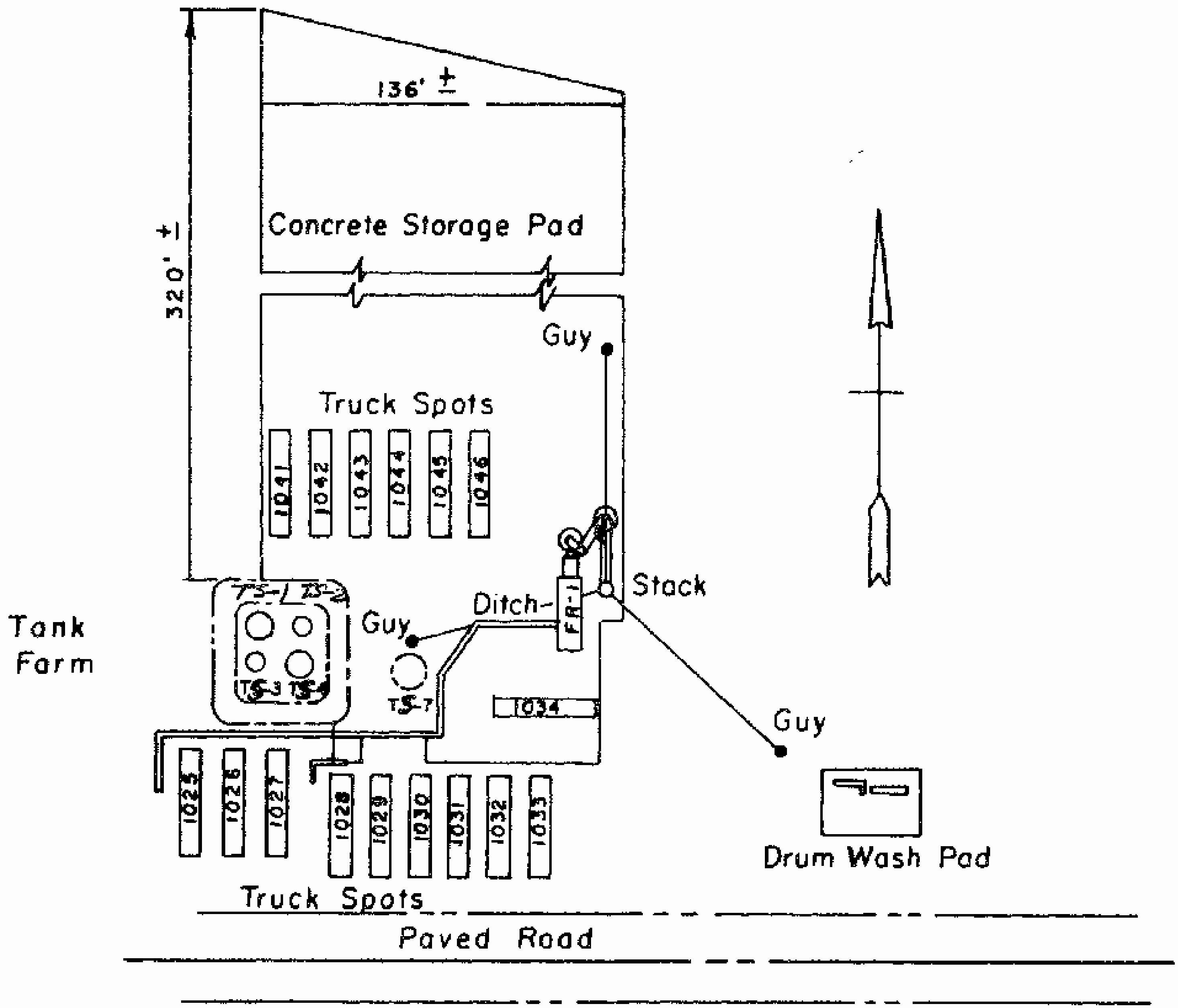

Figure 4. Chambers Works Waste Inicinerator Equipment Arrangement Plan

workers on the day shift are available. Two of them handle drums and one worker prepares the paper work (manifests, records, etc.). If the furnace is down, the operators stack drums, load them on flat bed trucks for landfilling, or rinse and move empty drums.

POTENTIAL HEALTH HAZARDS

A wide variety of chemicals are handled at the incineration site. The adverse health effects of a number of these chemicals are well known. In recognition of these effects, a health hazard control system of engineering controls, work practices, and personal protective equipment has been implemented. In general, the sources of exposure include dedrumming of liquid wastes, connection and disconnection of trailers and dumpsters, accidental spills, drum rinsing and crushing, maintenance operations, and emergencies.

A brief description of the more significant health effects of classes of the chemicals handled at this site will be given in order to provide an appreciation for the high levels of control that are required.

Halogenated and non-halogenated hydrocarbons are central nervous system depressants. Furthermore, some of the chlorinated species are hepatotoxic and others are carcinogenic. The aromatic nitro and amino compounds are methoglobin formers and the consequences of overexposure may be cyanosis and chemical asphyxia.

Alpha-naphthylamine, which may contain beta-naphthylamine as an impurity, is a human bladder carcinogen. Toluene diisocyanate is a respiratory tract irritant and chemically damages lungs. It is also a sensitizer. The phenylene and ethylene diamines are respiratory irritants, sensitizers, and allergenic.

Many of the above species are also strongly absorbed through the skin. It is not known at this time what the health effects of multiple (or simultaneous) exposure to a number of species are. Additive effects have been assumed for species which produce the same effect or affect the same organ.

Many of the liquids handled at the site form explosive mixtures with air. The explosions could result from sparks in improperly isolated or controlled electrical equipment (motors, switches, etc.) or sparks generated when using tools that are not sparkproof. The explosions could also result from sparks produced by high voltages generated by liquids flowing in electrically ungrounded equipment.

CHARACTERIZATION OF HAZARD CONTROLS

An in-depth survey of the Chambers Works incinerator was conducted during the period October 18 to October 21, 1982. The objectives of the survey were to document the engineering controls, observe work practices, and determine levels of exposure to various chemical agents.

Before conducting the survey, it was necessary to determine which species were likely to be present during the survey. This determination was made by inspection of the company's RCRA "part A" application and listing of all species that were reported to be disposed of in quantities of at least 10 tons per year and which were of relatively high toxicity. The listing appears in Table 1.

Because of the diversity in the species handled at this incinerator, it became apparent that air sampling would have to be conducted for specific operations in which the contaminants are known. Such specific operations may be the connection or disconnection of a trailer or dedrumming of liquid wastes. Full shift personal samples are not feasible under such conditions since sampling/desorbing media vary from one species to another.

At the time of the NIOSH survey, the opportunities for air sampling were very few because of the low operating rate at the Chambers Works. Consequently, the number of daily "movements" of waste were very low.

Breathing zone samples were obtained while toluene-containing waste was dedrummed and also while a tank trailer containing ortho- and para-chloronitrobenzene was being connected. Charcoal tubes were used to collect toluene samples. Each charcoal tube was desorbed with 1 ml of carbon disulfide and analyzed by gas chromatography, using a flame ionization detector. The column was a 30 meter DB-1 bonded phase fused silica capillary column (splitless mode). Gas chromatography/mass spectrometry (GC/MS) techniques were used to identify the species. The limit of detection (LOD) for this method is 1.0 micrograms per sample and the limit of quantitation (LOQ) is 3.0 micrograms per sample.

Silica gel tubes were used to sample for ortho- and para-chloronitrobenzene. They were desorbed with 1 ml of methanol and placed in a sonic bath for one hour and were analyzed by gas chromatography as explained for toluene. The LOD for this method is 3 micrograms per sample and the LOQ is 7.

Table 1. Organic Species Anticipated at the Chambers Works Incinerator

RCRA Code	Contaminant	TLV, ppm (Ceil/TWA)	Sampling Medium	Desorbing* Medium	Sampling Rate (Lpm)	Mg Substance per 100 mg Sorbent	Total Vol. Liters @ TLV Conc.	Method No. Volume**
F-001	Tetrachloro-ethylene	150/100	CT	CS_2	0.05	58	40	S335-3
	Trichloro-ethylene	150/100	CT	CS_2	0.05	45	50	S336-3
	Methylene chloride	500/100	CT	CS_2	0.05	23.2	3.5	S329-3
	1,1,1-Tri-chloroethane	450/350	CT	CS_2	0.05	36.2	18.7	S328-3
	Carbon tetra-chloride	20/5	CT	CS_2	0.05	15	48	S314-3
F-002	Tetrachloro-ethylene	150/100	CT	CS_2	0.05	58	40	S335-3
	Trichloro-ethylene	150/100	CT	CS_2	0.05	45	50	S336-3
	Methylene chloride	500/100	CT	CS_2	0.05	23	3.5	S329-3
	1,1,1-Tri-chloroethane	450/350	CT	CS_2	0.05	36.2	18.7	S328-3
	Chlorobenzene	75	CT	SC_2	0.05	31	96	S133-2
	1,1,2-Tri-chloro-1,2,2-trifluoroethane	1000	CT	CS_2	0.05	40	5.5	S129-2

(continued)

Table 1 (continued)

RCRA Code	Contaminant	TLV, ppm (Ceil/TWA)	Sampling Medium	Desorbing* Medium	Sampling Rate (Lpm)	Mg Substance per 100 mg Sorbent	Total Vol. Liters @ TLV Conc.	Method No. Volume**
	o-Dichloro-benzene	50	CT	CS_2	0.05	29.9	96	S135-3
	Trichloro-fluoromethane	1250/1000	CT	CS_2	0.05	--	--	--
F-003	Xylene	150/100	CT	CS_2	0.05	30	69	S318-3
	Acetone	1250/1000	CT	CS_2	0.05	18	9	S1-2
	Ethyl acetate	400	CT	CS_2	0.05	25	17	S49-2
	Ethylbenzene	125/100	CT	CS_2	0.05	32	74	S29-2
	Ethyl ether	500/400	CT	Ethyl acetate	0.05	15	12	S80-2
	n-Butyl alcohol	50	CT	CS_2/1% propanol	0.05	21	22	S66-2
	Cyclohexane	300	CT	CS_2	0.05	12.5	12	S28-2
F-004	Cresols and cresylic acid	5	SG	Acetone	0.05	1.87	88	S167-3
	Nitrobenzene	1	SG	Methanol	0.05	2.78	446	S217-3

K-018: Heavy ends from fractionation in ethyl chloride production.

1,2-dichloroethane: listed on 4th page

Trichloroethylene: listed under F-001

(continued)

Table 1 (continued)

RCRA Code	Contaminant	TLV, ppm (Ceil/TWA)	Sampling Medium	Desorbing* Medium	Sampling Rate (Lpm)	Mg Substance per 100 mg Sorbent	Total Vol. Liters @ TLV Conc.	Method No. Volume**
	Hexachlorobutadiene		XAD-2	Hexane	0.05			
	Hexachlorobenzene: no information							
P-077	p-Nitro-aniline	2/1	--	--	--	--	--	--
U-012	Aniline	5/2	SG	95% ETOH	0.05	1.7	89	S310-3
U-019	Benzene	25/10	CT	CS_2	0.05	6.8	48	S311-3
U-092	Dimethylamine	10	SG	0.2 N H_2SO_4 in 10% MeoH	0.2	7.3	96	S139-3
U-223	Toluene diisocynate (TDI)	.02	Glass wool/ reagent	Dichloro-methane	1.0	--	—	326-6
P-024	p-Chloroaniline	--	--	--	--	--	—	--
U-071	1,2-Dichlo-benzene	50	CT	CS_2	0.05	29.9	91	S135-3
U-072	1,3-Dichloro-benzene	--	—	--	--	--	—	--
U-073	1,4-Dichloro-benzene	75	CT	CS_2	0.05	8.4	16.2	S281-3
U-075	Dichlorofluoro-methane	1000	2 CT in series	Methylene chloride	0.05	--	12.5	S111-2

(continued)

Table 1 (continued)

RCRA Code	Contaminant	TLV, ppm (Ceil/TWA)	Sampling Medium	Desorbing* Medium	Sampling Rate (Lpm)	Mg Substance per 100 mg Sorbent	Total Vol. Liters @ TLV Conc.	Method No. Volume**
U-077	1,2-Dichloro-ethane	15/10	CT	CS_2	0.05	23.7	58	S105-4
U-165	Naphthalene	15/10	CT	CS_2	0.05	19.4	240	S292-3
U-168	2-Naphthyl-amine	Carcinogen	HEGFF*** 2 SG	Acetic acid in 2-propanol	0.2	—	100	P&CAM 214-4

* CT charcoal tubes; SG - silica gel tubes.
** NIOSH Manual of Analytical Methods, Vols. 1-7.
*** High efficiency glass fiber filter.

HAZARD CONTROLS

GENERAL CONSIDERATIONS

Important hazard controls in effect at the Chambers Works incinerator fall into four categories:

1. Engineering Controls - These include ventilation, automation, and other system design features that directly or indirectly contribute to lowering occupational exposures to chemical and physical agents or enhance worker safety (fire and explosion hazards).

2. Work Practices - Effective training programs result in work practices which significantly minimize the potential hazards associated with the worker's performance of his job. These programs may include on-the-job training and formal and specialized training inside or outside the company.

3. Monitoring - Includes environmental and medical monitoring and observation of employees in the workplace to assure management that job duties are performed in a safe manner.

4. Personal Protective Equipment - Equipment is provided to the employees and used to either further reduce or completely eliminate exposure to hazards.

ENGINEERING CONTROLS

The engineering controls implemented at the incineration facility are generally aimed at reducing the potential for spills, emissions to the ambient air, and unsafe operating conditions which may lead to partial or total destruction of the equipment and/or injury to the operator. The company performed a "fault tree analysis" of various contingencies and situations. The analysis revealed that incidents with serious consequences may occur at a rate (or probability) of 1 in 18,000 years of operation.

Furnace and Process Controls

Liquid wastes injected into the feed gun (burner nozzle) are atomized using high pressure steam. Combustion air is supplied by a forced draft fan through a windbox to the burner. The combustion air is used also to shape and mix the flame. This is done by swirling the air in the windbox by means of spin vanes and injecting it into the burner through the throat in the center of which is the feed gun. The convergence of the throat and swirling air causes a thorough turbulence between the air and fuel and increases the combustion efficiency.

A diffuser (or burner shield) is mounted on the end of the burner gun to deflect the air away from the gun tip. This is necessary because the combustion air would otherwise tend to push the flame away from the gun tip and blow out the flame.

Temperature is maintained between $1800^{o}F$ and $2500^{o}F$, either manually or automatically. Temperatures above 2500 would melt the brick lining and cause it to fail. Temperatures below $1800^{o}F$ may result in incomplete combustion of wastes. When burning chlorinated species, this may cause the formation of phosgene-a life threatening gas in very low concentrations.

A one-half inch H_2O vacuum inside the furnace is maintained automatically. This tends to keep any harmful products of combustion, such as carbon monoxide, from diffusing into the immediate area outside the incinerator. This vacuum is obtained by maintaining a large difference between the air flows through the forced and induced draft fans. These flows are 5500 and 9000 cfm respectively.

Oxygen levels between 8% and 12% are maintained. If oxygen levels are too low (2 percent or lower), the combustion gas will contain unburned fuel. The furnace is said to be under "reducing" conditions and explosive mixtures with air may result. When the furnace is run under automatic temperature control, adjustment of total air directly affects the amount of fuel incinerated so that the O_2 level remains fairly constant.

Control and safety instrumentation consists of an electrically operated interlock system which senses process disturbances and causes a furnace shutdown. These interlocks are installed such that they are fail-safe. A furnace shutdown will be caused by the following conditions:

- Material does not flow from storage tanks
- Stack temperature is too high
- Vacuum in the furnace is lost
- Low oxygen level. Propane gas is used to fire a pilot burner in the furnace
- Propane pilot fails to ignite when starting up the furnace. Flame sensors called "Bailey eyes" are for this purpose. Propane forms explosive mixtures with air (2-3% lower explosive limit)
- Shutdown of the furnace occurs when the brick lining fails and when water pressure to the scrubbers is low
- Waste flow is too high
- Combustion airflow is too low
- Furnace temperature is too high
- Atomizing steam pressure is too low.

Provisions have been made for purging wastes from the burner feed line using steam when both fans are down due to a power failure. This is a precaution against hazardous waste evaporating or partially combusting in a hot furnace and contaminating the area in the vicinity of the incinerator. A discharge line attached to the line which runs between the pump and the head of the furnace (burner) has been installed for this purpose.

Provisions have been made to purge (or clean) the line between pump and burner with fuel oil after a certain waste is burned. A four-way valve is used to switch from one waste stream to another. This obviously prevents explosions or adverse reactions resulting from mixing with an incompatible waste that is subsequently incinerated.

Provisions have been made also to steam out the line between the burner and storage tank TS-1 which may become plugged with 3,4-dichloroaniline tars. Steam flow is toward the tank.

Tank Trailers and Dempsey Dumpsters

Tank trailers usually contain still residues with organic species such as diamines, alpha-naphthylamine, nitronaphthalene, ortho-toluidine, and nitrotoluenes. These usually require steam heating to maintain a liquid state. Appropriate heat transfer coils have been incorporated into the trailers. Some of these materials may also arrive in 600-gallon dumpsters that are similarly equipped with respect to provisions for steam heating, discharge valves, and vents.

After the tank trailers and dumpsters are properly spotted and the appropriate transfer lines connected, the material may be pumped either directly to the furnace or to storage tanks.

Figure 5 is a schematic process flow diagram representing the operation of direct burning of wastes from trailers. An electrical ground wire is attached to the trailer before the lines are connected. The trailer vent is connected to a spot (local) scrubbing system which prevents the diffusion of vapors into the immediate vicinity. In the absence of such a vent control, this can be a significant source of exposure even though the trailer is located in the outdoors where natural dilution ventilation occurs.

Two flexible hose connections are made; one to the discharge line of the trailer and the other to a recirculation line. A motor-operated, three-way valve is used to vary the recirculation rate from 100 percent to 0. In

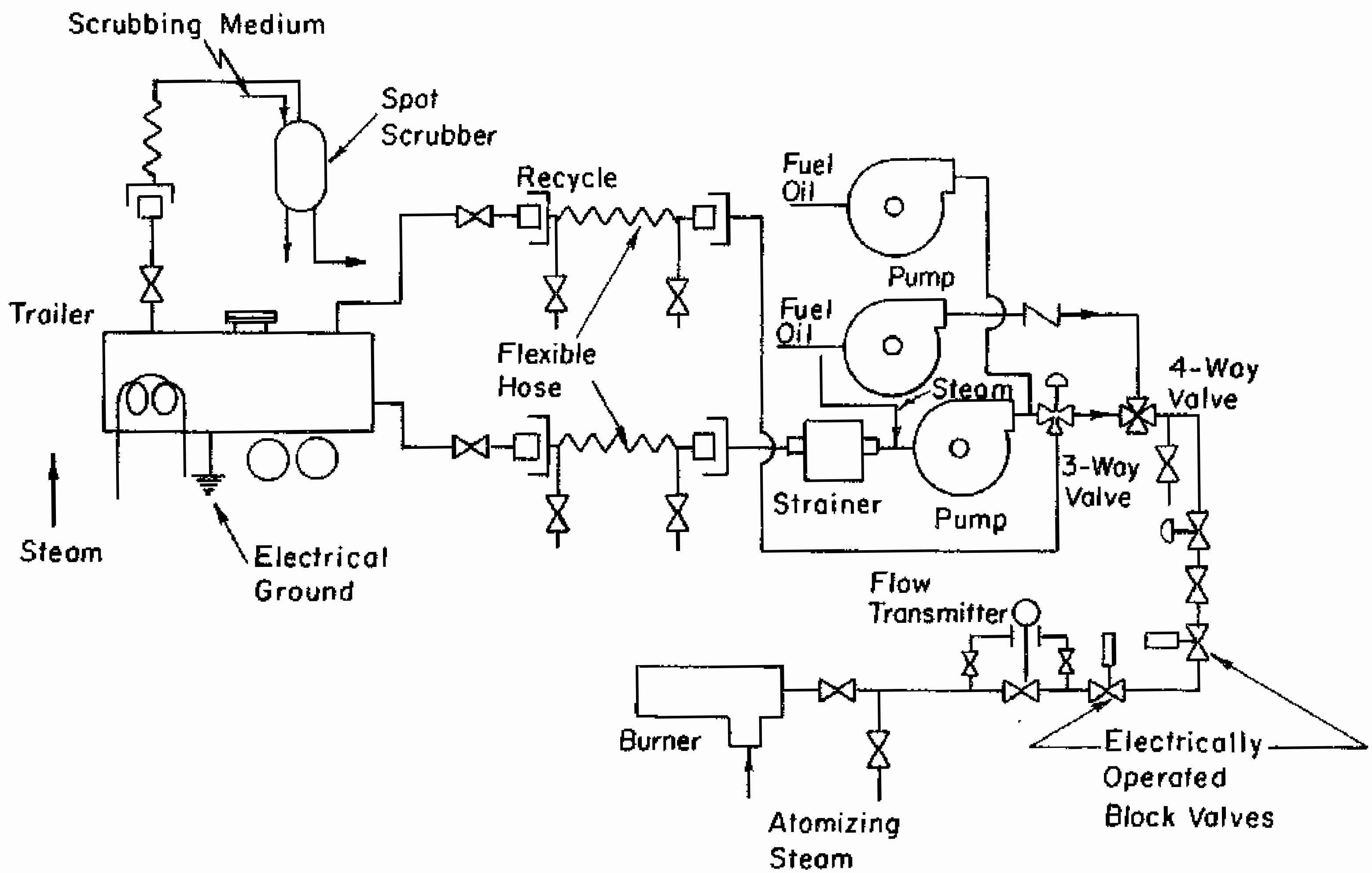

Figure 5. Schematic process flow diagram for burning trailer liquids directly

general, this recirculation prevents the plugging of process lines and the trailer discharge line with grit and dirt particles and, hence, reduces the frequency of maintenance.

Fuel oil and steam are used to purge the process lines before and after a batch of wastes has been burned. A manually-operated, four-way valve is used to immediately switch from fuel oil to waste burning when starting with a full trailer. After the trailer is unloaded, fuel oil is pumped to the discharge line of the waste pump and flows towards the trailer for a period of 5 minutes through both the recirculation and burner feed lines. The four-way valve is simultaneously turned so that the burner is, at this point, fired with fuel oil. The three-way valve is set so that flow in the recirculation line is reduced. Finally, steam is blown into the suction side of the pump for 60 seconds with flow toward the trailer. This reduces or prevents the safety problems resulting from mixing of incompatible material.

Waste pumps are the positive displacement gear type with explosion-proof motors and double mechanical seals. Where necessary, all lines are steam traced. Provisions for steaming of all lines have been made.

Drums

Drums are brought to the appropriate spot using a forklift. An electrical ground wire is attached to the drum. Bungs are removed using sparkproof tools. A suction leg is inserted into the drum. Drum contents are transferred to a storage tank by a centrifugal pump. A screen is installed at the suction side for the removal of large grit particles.

WORK PRACTICES

Even though state-of-the-art engineering controls have been provided at this site, Du Pont internal policy is such that the work practice component of the hazard controls is emphasized. There are plant-wide or general programs for indoctrination of workers and auditing their on-the-job performance. There are also written procedures that are specific for the operations carried out at the incinerator site.

Plant-Wide Safety and Audit Programs

It was emphasized by Du Pont officials that safety at Chambers Works is a management responsibility that is handled by the Plant Manager, Assistant Plant Manager, and General Department Superintendents. Also, each Department is responsible for developing its own safety program in consultation with the Employee Relations Department. The latter has specific responsibility in the areas of safety and health. The safety program is administered by the Senior Supervisor for Safety who has 5 Safety Engineers working for him.

The plant has maintained a Central Safety and Health Committee headed by the Works Manager. This committee meets every month to discuss the results of observations of work practices. Included in the meeting are the General Superintendents, the five Safety Engineers, and other special consultants as necessary. There are also a number of subcommittees which also meet every month. Among these are:

- Industrial hygiene - headed by the Assistant Works Manager with members from every department. Every department has its own industrial hygiene program.

- Process Hazards Management - their efforts are a primary input into a handbook on Guidelines for Process Hazards Management. The General Superintendent for the Employee Relations Department heads this subcommittee.

- Safety Standards.

- Safety Programs and Publicity - has representatives from every department.

- Serious Incident Investigation - reports of incidents and/or problems are submitted to this committee. Safety people get involved in the investigation of every incident.
- Protective clothing and equipment.
- Emergency and disasters.
- Transportation of Hazardous Materials.
- Disaster Prevention.

Minutes of subcommittee meetings are written and published.

There are number of programs in effect to monitor work practices. A so-called "weekly staff audit" is performed by the Works Manager, the General Department Superintendents, and the 5 Safety Engineers on a weekly basis. They go to a specific section for two hours, split into teams of 3 each, and observe work in that area. A rating is assigned and if problems are found these are reported to the area superintendent who resolves these problems in consultation with the Safety Specialists. Typical questions asked of workers during this inspection are:

- Did you have a physical lately?
- Were you informed of the results of air monitoring?

Answers to these questions must be confirmed. Problems are resolved in meetings of the Central Safety and Health Committee. Appropriate specialists from either Safety or Health may be brought in to help resolve a given situation.

The Safety Specialists conduct observations of workers in every building in the plant twice a month. They assign ratings of excellent to poor for virtually all aspects of a job, including procedures (work practices) used to perform a job, tools, and equipment. About 1000 workers per month are observed. The data are used to compute a monthly Unsafe Acts Index which helps management in monitoring the overall trend in safety at the plant.

Another audit program is called PROJECT 96. The program name is based on a company-developed statistic which shows that 96 percent of all injuries result from unsafe acts. Under this program the supervisory staff (about 800) go out in teams of two once a month and observe workers as they perform their job duties. The workers are asked specific questions about their jobs. The information gathered during these inspections is recorded on cards and sent to the safety group. Results are discussed at the Central Safety and Health Committee meetings.

Wage grade (hourly) workers are also involved in their own safety. Within each department there are joint committees between salaried and hourly workers to handle immediate needs. Mechanics have daily tool box meetings. If there are any problems with operating procedures these are brought to the attention of the appropriate subcommittee chairman and the procedure is reviewed. Some procedures, such as lock-out procedures for pumps and valves, are routinely reviewed every year.

Training for Incinerator Workers

Workers are required to familiarize themselves with Chambers Works General Safety rules. These are reviewed and revised annually. All incinerator operating procedures are written and each includes safety rules and requirements for personal protective equipment. All operators must be trained by supervisors in the handling of OSHA and Du Pont classified carcinogens and in the DOT regulations for transportation of hazardous materials. Workers must be familiar with the location and use of safety and fire-fighting equipment. Training in fire fighting and prevention is provided. Workers are also trained in the proper use of respirators once a year.

Contingency evacuation plans have been developed. Drills are conducted quarterly. An emergency and disaster manual is available. A spill control procedures manual has been developed. It specifies SAF (Safety Action Follow-up) procedures to be followed. The codes for these procedures are specified in the Material Hazards list. The S code specifies the level of protective equipment required while taking remedial actions. The A code specifies actions to be taken in controlling and cleaning up the spill. The F code specifies follow-up actions to be taken in monitoring the "adequacy of personal protective equipment and/or completeness of decontamination." Reporting requirements are also specified.

Furnace Operation and Training Procedures

The training manual includes a technical description of the incineration process. It explains the roles of oxygen, air, and atomizing steam in the incineration process. The functions and settings of alarms and interlocks are explained. The supervisor tests the operator twice a year by setting up an alarm condition and observes the operators reactions as he attempts to return it to normal operating conditions. The alarm that is set up is not a dangerous condition. The operator is warned ahead of time about the test.

Startup and shutdown procedures are also discussed. There are several types of startups that are required. For example, there are startups from long shutdowns; these require heating up the furnace slowly in order not to damage the brick lining. Several types of shutdowns are also required. For example, a special shutdown is necessary when the furnace must be entered to rebuild the lining. This shutdown is conducted in such a way so as to eliminate the possibility of leaving residual organics inside the furnace enclosure.

Trailers and Dumpsters

The procedures for trailers specify that these usually contain still residues and should be considered highly cyanogenic. The operator checks the trailer for proper placement then places an unloading sign in front of it. The wheels are chocked and an additional support is placed in the front as a precaution in case of landing gear collapse. A chain barricade is affixed to block access to the trailer from the front. This is to prevent an attempt to remove the trailer while it is connected. The Waste Identification Tag is removed and checked against waste listings. The operator proceeds with the hookup, if the waste is found on the list. The waste will not be pumped unless it is listed.

The ground cable is attached to the trailer and flexible hose connections are made after checking the conditions of the gasket in the coupling and the in-line strainers (screens) for clean liners. A safety wire is installed around the coupling to prevent it from coming apart. A flexible steam hose is then attached and steam is turned on slowly to detect any leaks. The steam trap is checked to make sure that it is operating. Material is transferred to the appropriate tank or directly to the incinerator by opening the proper valves. The procedure requires the operator to trace the pipeline from starting point to proper storage tank or head of the furnaces. The discharge valve on trailer is not opened until personal protective equipment is donned. The trailer vent is then connected to the spot scrubber system.

The operator starts the pump and checks lines for leaks. If any are found, he is expected to take remedial action, such as tightening flanges and valve glands. Spills are to be cleaned immediately. Storage tank measurements (at the beginning and end) are to be recorded on the tank log sheet if material is transferred to a tank. The operator knows that the trailer is empty when pump noise changes. Purging of lines with oil and steam is performed for certain materials as discussed under Engineering Controls. Steam tracing of the process line to the storage tank is halted and steam pressure is bled off. All valves used in this operation are closed. Steam supplied to heat the trailer is shut off and the hoses disconnected. The discharge and vent lines of the trailer are disconnected. The end of the flexible hose to the discharge line is placed in a small bucket to catch the drippings. The grounding cable is disconnected and the chain and sign in front of the trailer are removed.

If material does not flow from the trailer, the pump is isolated and the trailer vent is opened. Steam is introduced to the process line. If puffs of steam issue from the vent, steam is turned off. This means that the line to the trailer is free from obstructions. Otherwise, the trailer is disconnected and returned to plant area where it came from.

There are separate operating procedures for each special material with a low permissible limit of exposure. These procedures specify sources of exposure. These are usually the connection and disconnection of trailers, maintenance operations such as cleaning of plugged lines, and spill cleanup. The procedures specify plans to control exposures. These include 1) restricting access to the area except for authorized personnel, until lines are flushed with oil; 2) prohibition of the consumption of food, tobacco, and beverages; 3) signing a roster upon entry and exit from restricted area; and 4) washing of hands, forearms, face, and neck with soap and water upon each exit from the restricted area. The procedures also specify personal protective equipment required for routine operations, maintenance, and spill control. There are emergency procedures to be followed when the special materials are accidentally released, producing a potential for exposure of personnel. These procedures call for 1) evacuation of the affected area; 2) removal of contaminated clothing, washing exposed areas with cold water and reporting to medical personnel; 3) roping of the affected area with yellow chains and posting signs such as "AUTHORIZED PERSONNEL ONLY;" 4) calling a member of supervision; 5) consulting the Material Hazards List for the appropriate SAF codes; and 6) executing the appropriate material cleanup and area decontamination procedures.

Drums

Drums are brought from the storage pad to the dedrumming spot using a forklift truck. The information on the drum label is checked against information in the Chemical Waste Description File to ensure that the waste can be pumped and disposed of at this facility.

Drum emptying into the appropriate storage tank proceeds as follows. A ground wire is attached to the rim. The bung is opened slowly and the suction leg is inserted. All necessary valves are set to facilitate material transfer to the tank. The operator is required to trace the line from one end to the other to assure that the proper line has been used.

The storage tank level is recorded on the tank log sheet and the pump is started. The procedures specify tank capacity in terms of gallons per inch. If material does not flow, the screen is to be checked and cleaned if necessary. When drum is about to be emptied, the worker tilts the drum so suction leg is in the lowest side of the drum to remove all material. The bung is replaced as soon as the drum has been emptied.

A drum of spent oil is pumped through the the line to flush it when all drums have been emptied. A valve at end of the suction leg is closed and the suction leg and hose are left to drain into a 5-gallon container. The pump is shut off and all valves are closed. Empty drums are transferred to the empty container storage spot. Final tank level is recorded.

The procedure for dedrumming of wastes contains specification of personal protective equipment for both carcinogens and non-carcinogens. The sources of exposure while dedrumming carcinogens are outlined and methods to control these are written, as in the case of trailers. Similarly, emergency and disaster procedures are also provided.

Empty drums which previously contained carcinogens are triple rinsed with water, crushed, and sold as scrap.

Occasionally, the labels on the drums become illegible. If such a drum is discovered, the supervisor is to be notified. If the drum is not bulged, it is transported to a designated area adjacent to one of the truck spots and a grounding cable is attached. This is done on the presumption that the material may be flammable. The drum bung is opened slowly in case it is pressurized. A dry glass pipette is used to withdraw an 8-ounce sample of the waste if it is a liquid, or a "thief" is used to sample the contents if it is solid. The bung is replaced and tightened. Samples are sent for analysis. Drums that are bulged are placed in a barricaded area and the bungs are removed with a long handle wrench. The supervisor specifies additional personal protective equipment that may be required.

Cleaning of Screens

Screens have been installed at the suction side of all pumps in hazardous waste lines to remove grit and large particulates that may be present in wastes. All screens are to be checked before pumping any material through them.

Cleaning of the screens can be a significant source of exposure if improperly performed. With the pump off, the worker isolates the pump by closing the hand valves upstream and downstream, then opens the bleed valve (located in the screen housing). Any liquids that may come out are collected in a bucket. In case the drain valve is clogged, the worker removes the screen lid slowly so as to minimize splashing as a result of slight overpressure in the line.

The contents of the screen are also dumped into the bucket. The worker replaces the screen and tightens the lid after checking to make sure the gasket in the lid is not worn or torn.

There is a two-stage procedure to be followed by the worker in checking for leaks. First, the screen is checked for leaks when only the hand valves are opened. If no leaks are observed, the pump is started and when the line is under pressure, the screen assembly is again checked for leaks.

When the above procedure is not sufficient, the worker cleans the screen by first placing it in hot water bath for one hour, then in a bucket of soap and water, and finally washes it with hot water or 50 psi steam. If the screen was contaminated with highly toxic materials, the worker is required to wash his face and hands with a decontamination solution.

The drainings from screen housings and wastes collected on the screens are collected in small buckets. These buckets are placed in open-head 55-gallon steel drums and buried in the secure landfill. Flyash is used to fill the voids inside the drum.

Housekeeping and Spill Cleanup

Good housekeeping was evident at the incinerator site during the NIOSH survey. All procedures require that spills be cleaned up immediately. When such spills occur, the worker is required to locate the source and take appropriate action to eliminate the source. After reporting the spill to the supervisor, the worker is required to take actions to combat the spill.

The worker assesses the situation for potential hazards before cleanup begins. He then consults the Material Hazards List for the appropriate S.A.F. codes for handling the chemical that has been spilled. The S code specifies the level of protective equipment required. A code of S-3 specifies an air purifying respirator, for example. The A code specifies the actions to be taken to both control and cleanup a spill. For example, the code A-2 specifies that the spilled material be absorbed on Oil-Dri (oil sorbent) or sand and shovelled into a container. The F code specifies follow-up actions to be reported. For example, F-2 specifies that air samples be obtained and F-3 specifies that wipe samples be taken and submitted to the appropriate laboratory for analysis.

The worker then returns to the site of the spill and erects barricades to keep non-essential personnel away from the affected areas and areas downwind of these. He dons appropriate PPE and proceeds to stop or contain the spill. He cleans the affected area as specified in the A code and takes follow-up actions as specified in the F code.

The spill reporting requirements include instructions on who to report to and what type of information is required. A Spill Incident Reporting Form must be filled out.

A Mark I VIC-JET scrubber is used to clean floors and other surfaces. The unit mixes steam and water to produce a hydraulic scrubbing action. Cleaning agents may be added to the unit.

MONITORING

Company Programs

Air monitoring activities at the Chambers Works are the responsibility of the various manufacturing units. The methods used are developed internally by the Senior Supervisor for Health and his staff of four professionals and 5 technicians. The professional staff consists of two chemists, one industrial hygienist, and a systems engineer. In general, the group advises and consults with the various manufacturing units on all matters of occupational health.

The systems engineer has the responsibility of developing and maintaining computer-based data banks that are used to store and analyze various data. In buildings where carcinogens are handled, sign-in/sign-out procedures are enforced. Data collected are entered into the industrial hygiene system. A program to estimate total exposure has been written. Air monitoring data are entered into a system called AMIS. Data on how long (hours per week) a worker spends in an area where a given chemical (or chemicals) is handled are entered in the Personal Environmental Record System (PERS). Data on the health effects of these chemicals are also entered. This system was developed for epidemiological purposes and identifies exposure levels to various chemicals.

Breathing zone and area sample results obtained by the company for selected wastes appear in Table 2. These are 8-hour TWA levels. The area samples represented source samples at locations where tank trailers were connected or disconnected by the workers. The personal samples represented breathing zone samples outside of respiratory protective equipment. Nondetectable levels are explained for these by the fact that the workers spend only a portion of their time at the sources.

Survey Monitoring Results

As mentioned earlier, there were very few opportunities for monitoring of workers during the NIOSH survey. Monitoring, however, was conducted on two occasions. On the first occasion, wastes were pumped from eighteen 55-gallon drums to the storage tank (TS-2) for about one hour and 25 minutes. The labels indicated that nine drums contained 97% hexane and 3% water, six drums contained 95% toluene and 5% polymer residue, two drums contained diesel fuel oil, and one drum contained lube oil. While performing the pumping operation, the workers donned Tyvek[R] coveralls, a butyl rubber apron, rubber gloves, a hard hat, and a face shield. An air purifying respirator was worn when, on one occasion, the screen at the suction side of the pump was cleaned. Two charcoal tubes were used to obtain simultaneous breathing zone samples while the worker pumped the drums. One of the tubes was to be used for qualitation purposes while the other was to be used for purposes of quantitation. However, because the number of species present was relatively small, qualitation and quantitation was possible for both samples. The results are presented in Table 3.

Table 2. Du Pont-Generated Data on Environmental Levels of Selected Contaminants, mg per cu.m.

	Personal Samples		Simultaneous Area Samples		
Wastes Disposed	Average Breathing Zone Levels	No. of Samples	Average Level	Range	No. of Samples
3,4-dichloroaniline[a]	ND[b]	5	ND	--	3
			0.02	-	1
O-toluidine[c]	ND	1	ND	--	2
			0.04	0.02-0.07	4
phenylenediamines[d]	ND	1	0.12	0.01-0.28	4

[a] There are no standards for this material.
[b] Nondetectable.
[c] OSHA standard is 22 mg per cu.m.
[d] OSHA PEL for p-phenylene diamine is 0.1 mg per cu.m.

Table 3. Breathing Zone Exposures of Worker Dedrumming Liquid Wastes (October 20, 1981)

Sample No.	Air Volume, Liters	Concentrations, mg per cu.m. 2-Methyl Pentane	3-Methyl Pentane	Hexane	Toluene	Methyl Cyclopentane	Total Exposure[a] as Percent of Allowable Standards
1	3.39	1.7	1.0	2.0	3.4	1.0	0.8
2	2.96	1.9	1.1	2.3	3.9	1.2	0.8
Blank	0	ND	ND	ND	ND	ND	
Blank	0	ND	ND	ND	ND	ND	
OSHA Standards/ TLV's mg/cu.m.		1800[b]	1800[b]	1800	765	1600[c]	

a. The additive effect was assumed.
b. Hexane standard was assumed.
c. Methyl cyclohexane TLV was assumed.

Weather conditions, while dedrumming of wastes was performed were: wind, mostly from the southwest at a velocity between 3 and 9 mph; temperature, about 60°F.

On October 21, 1982, personal and area samples were collected on silica gel while a tank trailer containing ortho- and para-chloronitrobenzene was being hooked up. The duration of the personal sample was 12 minutes and the air volume was 2.4 liters. The corresponding parameters for the area sample were 30 minutes and 7.6 liters respectively. The area sample was taken at 6 feet above ground level and about 8 feet away from the potential source. No chloronitrobenzenes were detected in either the personal or area sample. The OSHA standard for these materials is 1 mg per cu.m. Weather conditions during the period of sampling were such that wind velocity was between 11-12 mph coming from the northwest and the temperature was 55 to 60°F. Protective equipment included a half-facepiece air purifying respirator, rubber gloves, and a butyl jacket and apron.

PERSONAL PROTECTIVE EQUIPMENT

Minimum protective equipment required for working in the incinerator area are a Nomex® uniform, rubber gloves, a hard hat, safety glasses, safety shoes, and butyl rubber overshoes.

When handling carcinogens in drums the worker must don a full acid suit and a full-facepiece air line continuous flow respirator. Similar protective equipment is required when connecting and disconnecting wastes containing alpha-naphthylamine, o-toluidine, nitronaphthalene, diamines, dichloro-anilines, and nitrotoluenes in tank trailers. The respirator used is the air purifying type, however. The same protective equipment are used when screens are cleaned or lines are steamed and drainings are collected into buckets.

CONCLUSIONS

A system of health hazard controls is in place at the Du Pont Chambers Works incineration facility where hazardous wastes in drums, tank trailers, and dumpsters are disposed of.

A number of important engineering controls have been implemented. There are alarms and interlocks which, among other things, reduce the potential for explosions. Provisions have been made for cleaning the lines by purging with fuel oil and steaming. In-line strainers (screens) have been installed at the suction side of pumps and, for certain materials, recirculation is practiced. This reduces the frequency with which process lines must be maintained. A spot scrubbing system is used to control emissions from trailer vents. Hazardous wastes may be transferred directly to the incinerator burner. This feature results in 1) the reduction of exposures, since the number of transfer operations is reduced, and 2) enhanced protection from explosions that may result from inadvertent mixing of incompatible materials. All routine hazardous wastes handling operations occur out-of-doors. This may be considered a form of dilution ventilation.

Work practices are emphasized at this site. Procedures have been written for every operation. They specify the personal protective equipment required and identify sources of exposures. There are procedures for the containment and cleanup of spills. Excellent housekeeping was evident throughout the facility during the survey. There are a number of plant-wide programs in place to monitor and improve upon the safety and health aspects of each job.

Air monitoring activities during the survey were limited because manufacturing operations were at a reduced level. Breathing zone samples were obtained while wastes containing common solvents were being dedrummed. Exposures were less than one percent of applicable standards. Exposure measurements were also obtained while a tank trailer containing ortho- and para-nitrochlorobenzene was being connected. The analysis of these samples revealed non-detectable values.

Personal protective equipment consisting of Nomex[R] clothing, safety glasses, hard hats, safety shoes, butyl rubber overshoes, and rubber gloves are required as a minimum. Air line respirators are used when handling carcinogens and air purifying respirators are used when handling less hazardous materials.