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THE THERMAL DESTRUCTION OF DDT-BEARING POWDERS

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THE THERMAL DESTRUCTION OF DDT-BEARING POWDERS

by

G.K. Lee*, F.D. Friedrich*, B.C. Post** and H. Whaley*

SUMMARY

Laboratory research with a pilot-scale incinerator established that DDT powder blended with inorganic carrier dust can be thermally destroyed. HCl, the residual product from complete combustion of DDT, was neutralized and removed from the flue gas by a combined water-alkali scrubber. Any chemically available basic cations in the carrier dust were found to neutralize equivalent amounts of HCl in gas phase.

Based on the experimental work, design criteria are given for converting commercial-scale incinerators for DDT/oil solutions described in Mines Branch Research Report R 225, to burn DDT-bearing powders.

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Direction des mines

Rapport de recherche R 234

LA DESTRUCTION THERMIQUE DE POUDRES CONTENANT DU DDT

par

G.K. Lee*, F.D. Friedrich*, B.C. Post** et H. Whaley*

RÉSUMÉ

Des recherches au laboratoire, avec un incinérateur à l'échelle pilote, ont établi que la poudre DDT, mélangée à de la poussière de support inorganique, peut être détruite par la chaleur.

HCl, produit résiduel de la combustion complète du DDT, a été neutralisé et éliminé du gaz de carneau par un épurateur combiné à eau et alcali. On a trouvé que tout cation basique disponible chimiquement dans la poussière de support neutralisait une quantité équivalente de HCl en phase gazeuse.

En s'appuyant sur le travail expérimental, on donne des critères de conception pour convertir des incinérateurs à l'échelle commerciale pour des solutions DDT/huile, décrites dans le Rapport de recherche R 225 de la Direction des mines, afin de brûler des poudres contenant du DDT.

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INTRODUCTION

The nationwide ban on the use of DDT, except for special applications, has resulted in large quantities of the pesticide being stockpiled pending the development of safe disposal methods. Research on one method, thermal destruction, was undertaken by the Canadian Combustion Research Laboratory (CCRL) at the request of the Federal Interdepartmental Committee on Pesticides, with the incineration of DDT dissolved in oil being the first priority. Pilot-scale experiments with solutions of DDT in oil established that (a) dissolved DDT can be completely destroyed using a blue-flame oil burner, (b) the residual chlorine product, HCl, can be readily removed and neutralized in a scrubber utilizing water and alkaline sprays, and (c) a large-scale incinerator could be assembled using combinations of commercially available equipment.

Having established the design criteria for incinerating DDT in oil, the research program was extended to include studies on the feasibility of thermally destroying powders containing DDT in solid form. This report describes the experimental work which led to the development of a system for incinerating powders containing from 10 to 92% solid DDT by weight.

LABORATORY INCINERATOR TESTS

DDT Incinerator Components

A study of the thermal-physical properties of pure DDT indicated that the development model incinerator for burning solutions of DDT in kerosene [1/] could, with the addition of two components, be utilized for incinerating DDT in powder form. The two components, which were installed as shown in Figure 1, consisted of a baffled refractory furnace containing the blue-flame burner and a feeder system for injecting powdered DDT into the furnace. The exit of the refractory furnace was connected to the development model incinerator which was adopted without change. A photograph of the laboratory apparatus for incinerating powdered DDT is shown in Figure 2.

The refractory furnace provides the time, temperature, and turbulence conditions that are necessary to first vapourize and then burn the solid DDT particles. Effective entrainment of the powdered DDT in the blue flame is obtained by mounting the burner and the injector so that the two jets impinge as shown in Figure 3.

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1/ Whaley, H. et al, The Thermal Destruction of DDT in an Oil Carrier, Mines Branch Research Report R 225, April 1970.

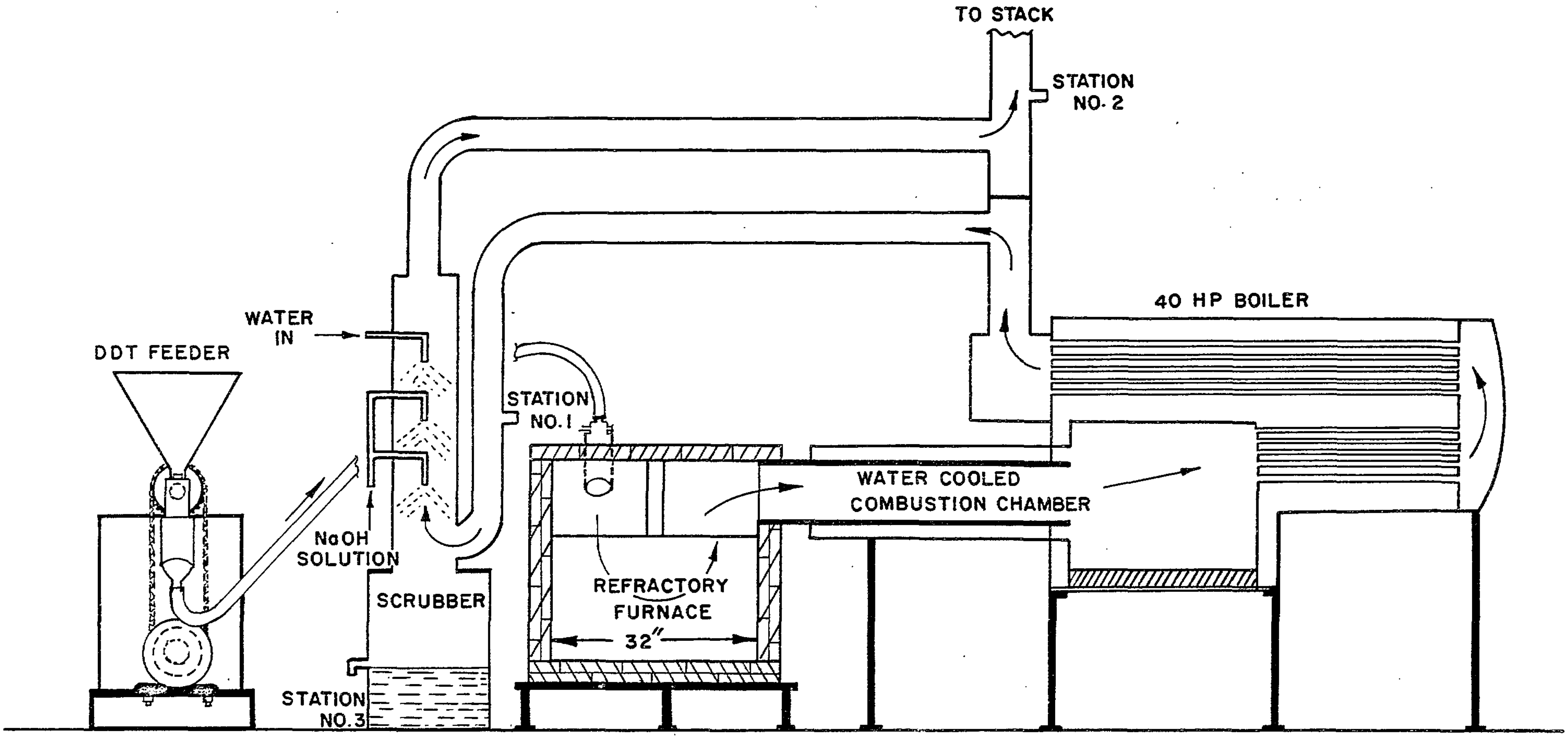
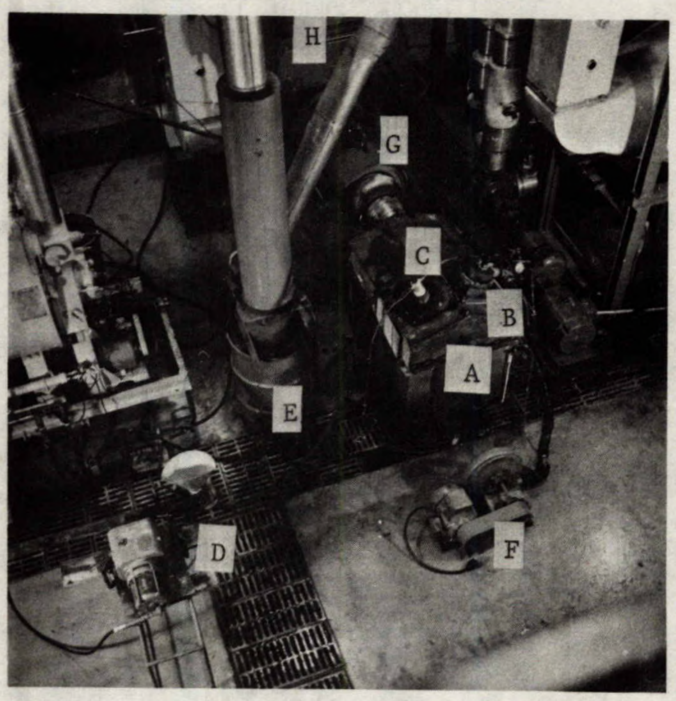


Figure 1. Illustration of pilot-scale incinerator for burning DDT-bearing powders.



A. Refractory furnace

B. Blue-flame oil burner

C. Dust-injector discharge nozzle

D. Dust feeder

E. Scrubber

F. Combustion air fan

G. Water-cooled combustion chamber

H. Waste heat boiler

Figure 2. Top view of pilot-scale incinerator for burning DDT-bearing powders.

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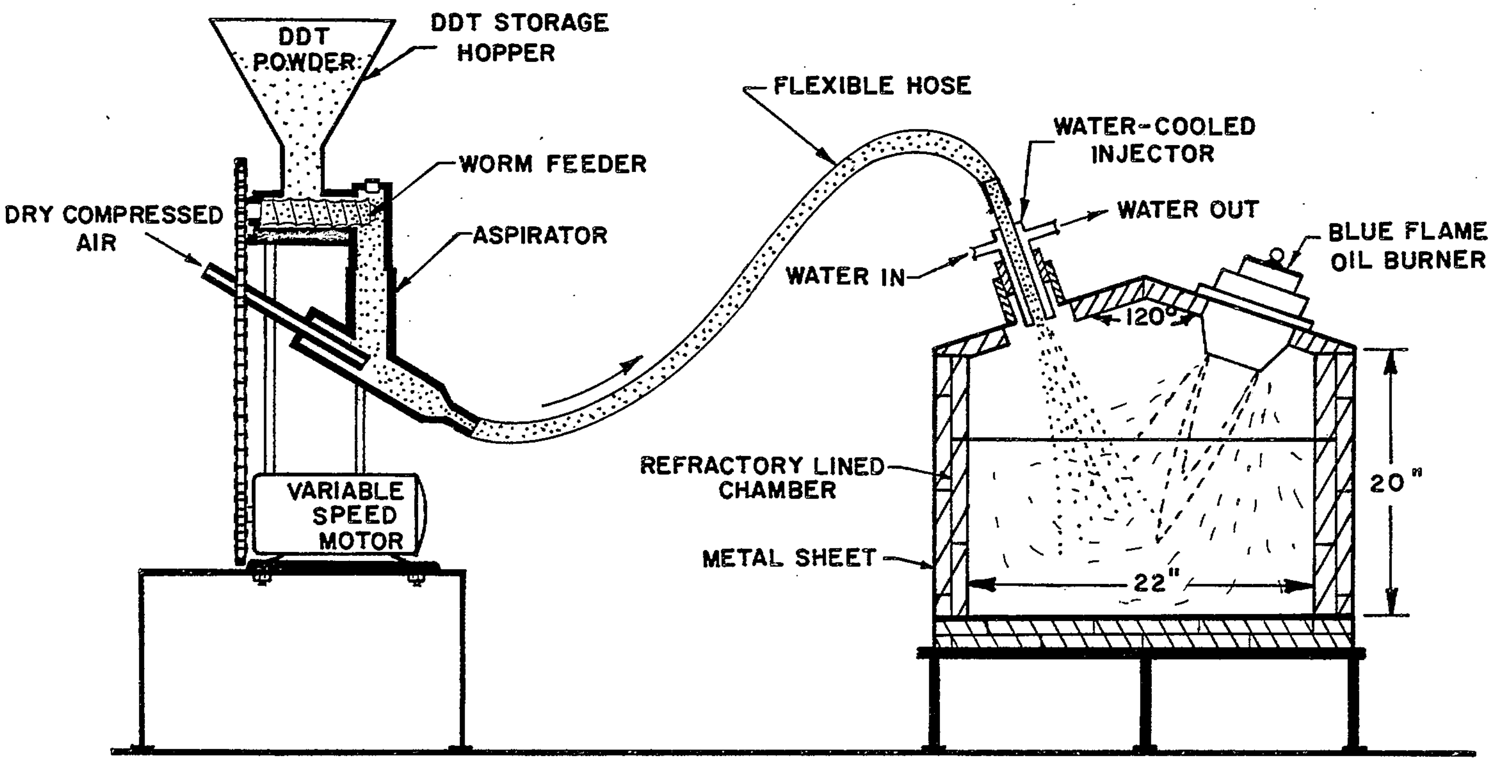


Figure 3. Illustration of powder feeder and combustion system.

Experimental Results

Initially, tests were conducted with the feeder system injecting powders containing 10% DDT and 90% talc directly into the inlet of the combustion air fan. However, after about two hours of operation, the burner air tube was so fouled with semi-fused powder that the flow of combustion air was severely restricted. Accordingly, this method of feeding was discontinued in favour of injecting powdered DDT formulations directly into the furnace by a water-cooled discharge nozzle as shown in Figure 3.

In one series of tests, the injector discharge nozzle was operated with no cooling and then with air cooling, but in both cases sustained incinerator operation was prevented by a rapid, progressive build-up of fused powder at the nozzle exit. The importance of water cooling the injector discharge nozzle is evident from Table 1 which describes the solid to liquid transformations that occur when powders, containing 92 and 75% DDT respectively, are heated from 70° to 1100°F in a muffle oven.

Typical operating data obtained while burning powders containing 10, 50, and 92% DDT are given in Table 2. During all experiments, samples of both gaseous and aqueous effluents were analyzed for HCl, Cl_2, DDT, and DDT derivatives as reported previously[1/]. Quantitative data on the chlorinated effluents from the incinerator are given in Table 3, and it is noteworthy that only trace quantities of DDT or its derivatives were detected.

TABLE 1

Effect of Heat on DDT-Bearing Powders

Oven Temperature °F	Description and Composition by Weight	
	75% DDT + 25% MgO	92% DDT + 8% inert dust
200	Dry powder*	Dry powder*
250	Dry powder*	Surface melting
300	Surface melting	Centre portion molten
320	Surface melting	About 50% liquid
340	Muddy grey with surface entirely liquid	About 75% liquid
380	"	All liquid, brown in colour
400	"	"
440	"	Light fuming
480	Surface crater-like, ruptured by blowholes.	Heavy fuming
500	"	Boiling
535	"	Slow evaporation with liquid turning darker brown
560	About 50% of surface changed from grey to black. Slight fuming.	Evaporation continues
610	All of surface now blackened with solidification starting. Slight fuming.	Over 50% of sample evaporated. Residue turning black.
640	"	"
660	Surface area beginning to decrease with cracks and edges turning from black to grey. Slight fuming.	Over 80% of sample evaporated. Black residue.
700	"	Fuming stopped. Black residue.
740	"	Black residue resembling a thin, hard layer of paint.
800	"	"
900	"	"
1015	"	"
1025	Burning starts. Light-grey ash visible.	"
1050	All ashed except for outer edges.	"
1080	Fuming stops.	"
1100	Light-grey powder. No combustible matter in ash residue	Grey-tan powder. No combustible matter in ash residue.

*1/4-in. thick layer of powder on a watch glass.

TABLE 2

Typical Operating Data on Incinerator for DDT-Bearing Powder

Powder		Burner Conditions		Combustion Conditions				Gas Scrubber Flows	
					Stack			1.8N NaOH	H_2O
% DDT	Feed Rate lb/hr	No. 2 oil Igph.	Atomizing Air Pressure psig	Combustion Air Pressure in. W.G.	Draft in. W.G.	Temperature °F	O_2 %	Igph	Igph
10	33	5.0	50	3.7	0.08	330	7.0	-	-
50	8	4.2	39	5.0	0.06	332	6.2	4	4
50	12	4.4	38	3.8	0.04	385	4.6	6	4
100	12	4.5	40	6.0	0.06	410	4.8	8	4

TABLE 3

Chlorinated Effluents from Incineration of DDT-Bearing Powders

Feed Mixture		Effluent Samples			HCl in Effluent ppm	Removal of HCl From Flue Gas, %	
% DDT	Feed Rate lb/hr	Station No.	Location	Type		Boiler*	Scrubber**
10	33	-	Flame	Gas	1512		
		1	Scrubber Inlet	Gas	0	100	
		2	Scrubber Outlet	Gas	0		0
		3	Scrubber Sump	-	-	-	-
50	8	-	Flame	Gas	2270		
		1	Scrubber Inlet	Gas	2120	6.6	
		2	Scrubber Outlet	Gas	27		98.7
		3	Scrubber Sump	Liquid	0		
50	12	-	Flame	Gas	3518		
		1	Scrubber Inlet	Gas	2790	20.7	
		2	Scrubber Outlet	Gas	21		99.3
		3	Scrubber Sump	Liquid	0		
92	12	-	Flame	Gas	6205		
		1	Scrubber Inlet	Gas	6140	1.0	
		2	Scrubber Outlet	Gas	37		99.4
		3	Scrubber Sump	Liquid	0		

*Boiler removal efficiency based on theoretical HCl generated in flame.

**Scrubber removal efficiency based on actual HCl entering scrubber.

Note: DDE is an incomplete breakdown product of DDT.

Remarks

(a) No residual (free) chlorine detected in gas samples.

(b) NaCl solution in scrubber sump maintained at pH value < 7 during all tests.

(c) DDT in NaCl solutions < 0.01 ppm during normal operating conditions.

(d) DDE in NaCl solutions < 0.001 ppm during normal operating conditions.

(e) DDT in deposits in the waste heat boiler < 0.1 ppm when burning powder containing 92% DDT.

(f) DDE in deposits in the waste heat boiler < 0.03 ppm when burning powder containing 92% DDT.

While powder containing 10% DDT was burnt, neither HCl nor Cl_2 were detected in the flue gas entering the scrubber. However, the presence of $MgCl_2$ in powdery deposits removed from the waste heat boiler indicate that any HCl produced during combustion was neutralized completely by a large surplus of chemically available magnesium cations in the carrier dust which comprised 90% of this formulation.

During the tests on powders containing 50 and 92% DDT, the flue gas entering the scrubber always contained large amounts of HCl because the carrier dusts contained relatively small quantities of chemically available basic cations.

DESIGN CRITERIA FOR A PROTOTYPE INCINERATOR FOR DDT-BEARING POWDER

The prototype incinerator for oil solutions containing DDT[1/], if adapted without change, can be readily converted to burn DDT in powder by adding a refractory furnace, upstream from the heat exchanger, and a powder feeder. General design specifications for the refractory furnace and powder feeder are detailed below.

Refractory Furnace

The refractory furnace must provide the time, temperature, and turbulence conditions necessary for complete decomposition and combustion of the DDT before the hot combustion products enter the heat exchanger. A refractory furnace, based on the design shown in Figures 1 and 3, was found to perform as required.

Powder Feeder

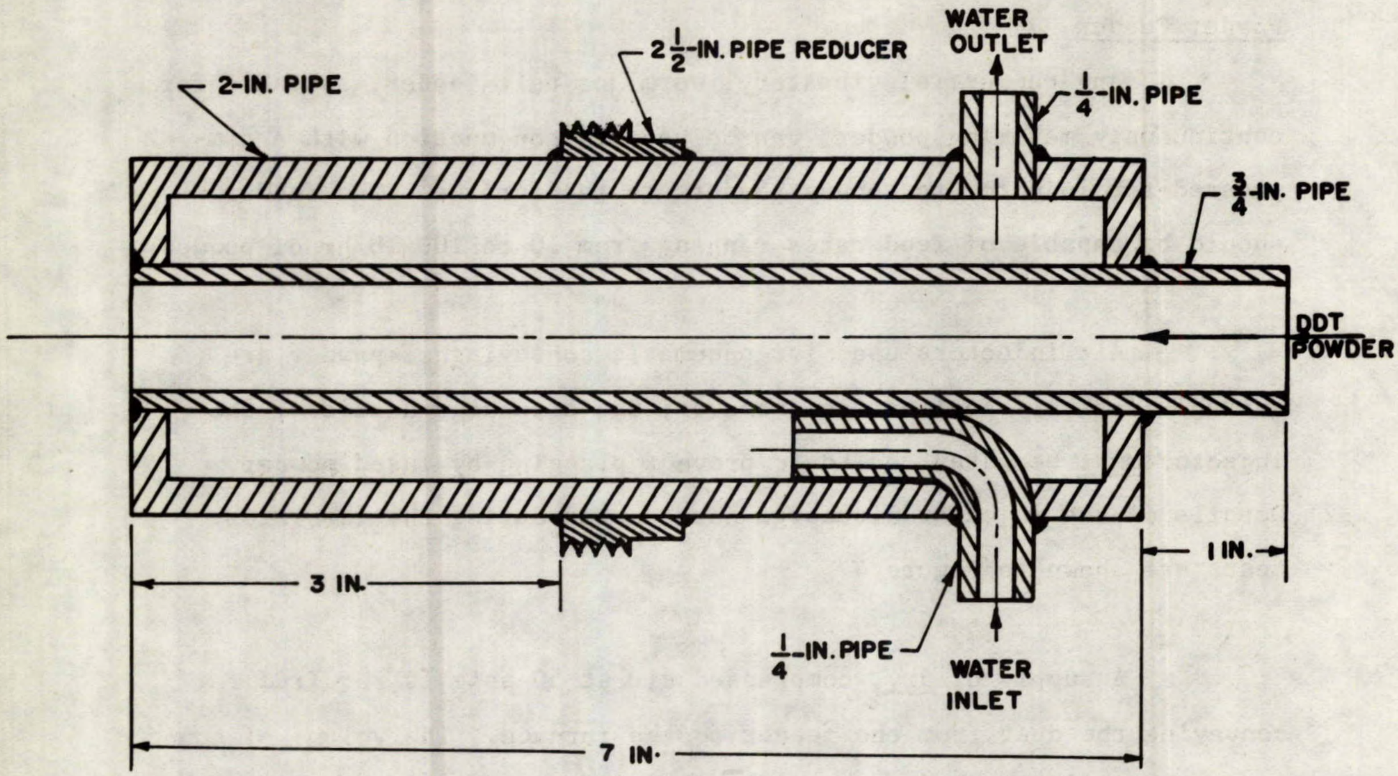
Any commercial vibratory, worm, or belt feeder, suitable for continuously metering powder, can be used in conjunction with a compressed-air injector to convey powders to the furnace. The feeder should be capable of feed rates ranging from 10 to 100 lb/hr of powder.

Air injectors used for pneumatic conveying of powder are suitable for this application; however, the discharge nozzle of the injector must be water cooled to prevent plugging by fused powder. Details of the injector discharge nozzle used during the laboratory tests are shown in Figure 4.

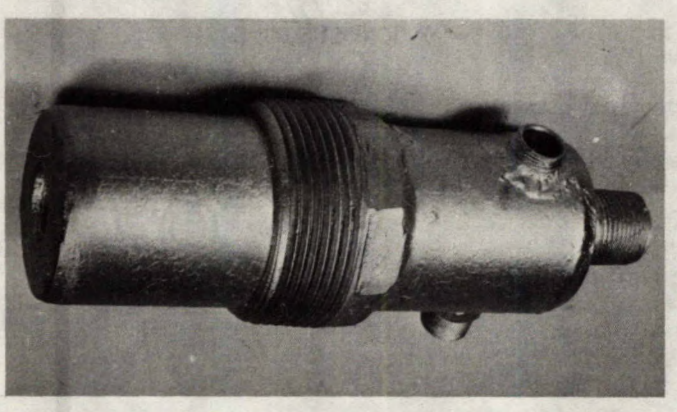
A supply of dry, compressed air at 50 psig is required for conveying the dust from the feeder to the furnace. The volume of compressed air required will vary with the feed rate, but 10 scfm should be sufficient to transport up to 100 lb/hr of powder.

CONCLUSIONS

DDT powder mixed with MgO or inert dust can be safely and completely destroyed by incineration as described.



(a) Section View.



(b) Exterior View.

Figure 4. Water-cooled discharge nozzle of powder injector.

HCl generated during combustion is neutralized in gas phase by the chemically basic dust of the DDT powder formulations. The degree of gas phase neutralization is related directly to the amount of cations in the formulation and influences the quantity of NaOH solution required for gas scrubbing. Generally, formulations containing 10% or less of DDT and 90% or more of talc or magnesia dust will require no alkali scrubbing because little or no free HCl will be present in the flue gas; however, water scrubbing is necessary to prevent dense emissions of inert dust to atmosphere. Conversely, powders containing 90% DDT and 10% talc or magnesia will require alkali scrubbing of the flue gas.

ACKNOWLEDGEMENTS

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