LATEST DEVELOPMENTS ON PCB DECOMPOSITION IN BSP MULTIPLE HEARTH FURNACES

FOR PRESENTATION AT THE ANNUAL AICHE CONTINUING EDUCATION, WORKSHOP, NOVEMBER 1, 1972 AT MIDLAND, MICHIGAN.

BY: G. F. KRONEBERGER

MONS 069867

THIS PAPER ON PCB IS PRESENTED IN THE FOLLOWING SEQUENCE:

CHARACTERIZATION
DECOMPOSITION BY INCINERATION
IMPACT OF INCINERATION

IT IS CO-AUTHORED BY:

FRANK P. SEBASTIAN: VICE PRESIDENT, ENVIROTECH CORP. GRADUATE OF UNIVERSITY OF TEXAS, 1944. BS MECHANICAL ENGINEERING; MBA STANFORD, 1948; SPECIALIST IN INTERNATIONAL PUBLIC RELATIONS.

GERRY F. KRONEBERGER: PRODUCT MANAGER, ENVIROTECH SYSTEMS INC. REGISTERED PROFESSIONAL ENGINEER, GRADUATE OF ILLINOIS TECH, 1951, BS CHEMICAL ENGINEERING, POST GRADUATE STUDIES IN BUSINESS, MANAGEMENT, COMPUTER GRAPHICS; SPECIALIST IN THERMAL PROCESSES.

LUIS A. LOMBANA: MGR PROCESS ENGINEERING ENVIROTECH SYSTEMS INC. GRADUATE OF GEORGIA TECH, BS MECHANICAL ENGINEERING, 1940. SPECIALIST IN PURIFICATION AND PROCESS CONTROL.

JIM M. NAPOLEON: PROCESS ENGINEER, ENVIROTECH SYSTEMS INC. STANFORD UNIVERSITY, 1969, BS CHEMICAL ENGINEERING; SPECIALIST IN PROCESS AND COMPUTER TECHNIQUES.

MATERIAL SOURCES ARE AS LISTED IN THE BIBLIOGRAPHY.

MONS 069868

THE FOLLOWING DATA & INFORMATION WAS DEVELOPED IN LATE '72 AS PART OF AN ON-GOING R & D PROGRAM AT ENVIROTECH SYSTEMS INC. AND ALSO IN RESPONSE TO AN EPA STUDY REQUEST.

IN THIS STUDY, WE HAVE EVALUATED THE ACTION OF PCBs, BOTH IN THE FURNACE ITSELF AND IN AFTERBURNING CHAMBERS.

PC3 PROPERTIES:

INERT	HEAT RESISTANT
INSOLUBLE	TOXIC
ADHESIVE	STABLE

POLY CHLORINATED BIPHENYLS (PCBs) HAVE BEEN USED IN INDUSTRIAL PROCESSES BECAUSE OF THEIR UNIQUE PROPERTIES. UNFORTUNATELY, SOME OF THESE SAME PROPERTIES PROMULGATE THE TOXIC PROPERTY WHICH HAS CAUSED THE PRESENT CONCERNS ON ENVIRONMENTAL IMPACT. THE TOXICITY EFFECTS ARE SIMILAR TO OTHER CHLORINATED HYDROCARBONS SUCH AS USED IN PESTICIDES. THE MORE HIGHLY CHLORINATED PCBs ARE MORE PERSISTENT AND THE LESS CHLORINATED ONES ARE MORE TOXIC. IN SOME CASES, SMALL TRACES OF PCBs HAVE INCREASED THE TOXICITY OF DDT BY 100%.

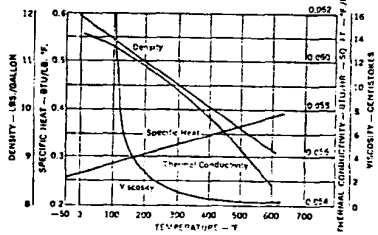
TYPICAL PHYSICAL, CHEMICAL & THERMAL PROPERTIES

	Therminol FR-1	Therminol 55	Therminol 59
Composition	Polychlorinated Biphenyl	Modified Terphenyl	Alkylated Aromatic
Maximum Bulk Temperature Rating (°F.)	600°F.	650°F.	600°F.
Recommended Use Range (°F.)	45 — 575°F.	45 — 625°F.	20 — 575°F.
Pour Point (°F.)	7	—15	—40
Pounds/Gallon (75°F.)	11.55	8.35	7.4
Flash Point (°F.)	350	355	355
Fire Point (°F.)	None to Boiling	374 — 392	410
AIT (°F.)	1250°F.	720	570
Boiling Range (°F.)	527 — 609	644 — 745	535 — 732
Molecular Weight	265	240	340
Expansion Coefficient cc/cc/°F.	0.000331	0.000399	0.000547

THERMINOL FR-1
VARIATION OF PROPERTIES WITH TEMPERATURE

Temperature		Density		Specific Heat		Thermal Conductivity		Viscosity		Vapor Pressure	
°F	°C	lb/gal	Kg/m³	BTU/lb °F	Kcal/Kg °C	BTU ft/hr °F	Kcal m/hr °C	Cs	Cs	mm Hg absolute	Kg/cm²
50	10	11.58	1393.6	0.272	0.272	0.06535	0.0097	303	220	—	—
100	38	11.45	1372.7	0.292	0.292	0.06350	0.0092	23.2	16.9	—	—
150	66	11.32	1343.7	0.291	0.291	0.06181	0.0089	6.5	4.9	—	—
200	93	10.99	1316.7	0.2943	0.2943	0.06026	0.0087	3.4	2.6	—	—
250	121	10.76	1293.1	0.3151	0.3151	0.05887	0.0085	2.3	1.8	—	—
300	149	10.53	1261.3	0.3255	0.3255	0.05765	0.0083	1.4	1.1	—	—
350	177	10.30	1233.5	0.3359	0.3359	0.05659	0.0081	1.0	0.8	10	0.0136
400	204	10.07	1205.8	0.3463	0.3463	0.05563	0.0080	0.8	0.7	27	0.0367
450	232	9.83	1178.5	0.3568	0.3568	0.05469	0.0078	0.6	0.5	65	0.0884
500	260	9.60	1150.2	0.3672	0.3672	0.05393	0.0078	0.5	0.4	133	0.1805
550	288	9.37	1122.5	0.3776	0.3776	0.05320	0.0077	0.4	0.4	251	0.3393
600	316	9.14	1094.7	0.3880	0.3880	0.05247	0.0076	0.4	0.3	450	0.6110
650	343	8.91	1066.9	0.3985	0.3985	0.05182	0.0075	0.3	0.3	18 Psig	1.2670
700	371	8.68	1039.3	0.4089	0.4089	0.05129	0.0074	0.3	0.3	31.5 Psig	2.2429

THERMINOL FR-1
PHYSICAL PROPERTIES



MONS 069869

PCB USES:

ELECTRICAL SYSTEMS	HEAT TRANSFER SYSTEMS
HYDRAULIC FLUID	PLASTICIZERS

PCBs WERE FIRST PRODUCED COMMERCIALLY IN THE U. S. IN 1929. IN 1966, PCBs WERE IDENTIFIED IN SOME FOOD PRODUCTS, AND SINCE THAT TIME HAVE BEEN FOUND THROUGHOUT THE ENVIRONMENT. BECAUSE OF THE FINDINGS, THE SOLE U. S. PRODUCER HAS VOLUNTARILY LIMITED PRODUCTION, AND PCBs ARE NO LONGER USED IN CARBONLESS (NCR) PAPER, PAINTS, AND GLUES. PCB USE HAS BEEN DRASTICALLY REDUCED IN ALL APPLICATIONS EXCEPT ELECTRICAL EQUIPMENT. THIS IS THE ONLY USE CURRENTLY RECOMMENDED BY THE GOVERNMENT AND NO SUITABLE SUBSTITUTES HAVE BEEN FOUND.

PCB IN ENVIRONMENT:

20,000 TONS	AIR
250,000 TONS	LAND
30,000 TONS	WATER

PCB DISTRIBUTION WAS DETERMINED BY A RECENT INTER-AGENCY TASK FORCE. THE TOTALS REPRESENT A GREAT MAJORITY OF THE PCBs THAT HAVE BEEN PRODUCED IN THE U. S. IN THE LAST 40 YEARS. WORLDWIDE TOTALS WOULD RUN MUCH HIGHER. THESE FIGURES UNDERLINE THE RESISTANCE, STABILITY, AND INERTNESS OF THIS CONFIGURATION. THESE TOTALS ALSO INDICATE THAT EVEN WITH AN UNECONOMICAL DISCONTINUATION OF ALL USE, THERE WILL HAVE TO BE SOME MEANS OF DECREASING THE PERSISTENCE OF THIS TYPE OF MATERIAL.

CYCLE THROUGH ENVIRONMENT:

WASTE STREAMS	RECEIVING WATERS
AQUATIC ORGANISMS	FISH
ANIMALS	MAN

ALTHOUGH PCBs ARE NOT AN IMMEDIATE THREAT TO HUMAN HEALTH, THE GOVERNMENT IS CONCERNED ABOUT THE LONG RANGE THREAT BECAUSE OF THE TENDENCIES FOR PCBs TO CONCENTRATE IN THE FOOD CHAIN. LIKE THEIR PESTICIDE RELATIVES, DDT, DDD, DIELDRIAN-CHLORINATED HYDROCARBONS TEND TO CONCENTRATE IN THE FATTY TISSUES AT THE VARIOUS FOOD CHAIN LEVELS. IN ADDITION, THERE HAVE BEEN CASES REPORTED WHERE EXTERNAL CONTAMINATION HAS TAKEN PLACE.

WATER SURVEY:

SCIENTISTS WERE SURPRISED TO FIND PCBs IN MANY PLACES WHERE PCBs WOULD NOT BE EXPECTED TO EXIST, SUCH AS REMOTE LAKES AND RIVERS. IN A SURVEY OF STREAMS AND LAKES IN 39 STATES, PCBs WERE FOUND IN ALMOST HALF OF THEM. RECOGNIZING THE EXTENT OF THIS PROBLEM, THE EPA ESTABLISHED A TASK FORCE TO INVESTIGATE THE REQUIREMENTS FOR PCB DESTRUCTION. THE FOLLOWING PAGES SUMMARIZE THE FINDINGS OF THAT TASK FORCE AND ALSO INCORPORATE RECENT DATA DEVELOPED AT ENVIROTECH SYSTEMS INC.'S BRISBANE, CALIFORNIA FACILITY.

MONS 069870

SUMMARY OF EFFECTS OF PCB*

*NOTE THAT THERE ARE NOT TOO MANY KNOWN CLINICAL CASES THAT HAVE BEEN DIRECTLY RELATED TO PCBs. THE WORST KNOWN INCIDENCE IS SUSPECTED TO HAVE BEEN AGGRAVATED BY IMPURITIES IN MATERIALS OF FOREIGN MANUFACTURE.

THERE ARE ABOUT 210 POSSIBLE PCB COMPOUNDS. ABOUT 50 OF THESE ARE PRODUCED COMMERCIALLY AND USUALLY EXIST AS MIXTURES. GAS CHROMATOGRAPHY IS USED FOR TOTAL ANALYSIS, & IT IS DIFFICULT TO DIFFERENTIATE BETWEEN THE VARIOUS ISOMERS. SOME GENERALIZATIONS ARE LISTED BELOW, BUT THE EFFECTS ARE FAR FROM SCIENTIFIC AT THIS POINT:

THE LOWER CHLORINATED COMPOUNDS ARE MORE TOXIC. DIBENZO-FURANS ARE SOMETIMES CONTAINED IN PCBs AND THEY ARE SUSPECTED OF BEING A MAJOR CONTRIBUTOR TO THE TOXIC EFFECTS.

CONCENTRATIONS IN FISH:

COMMON - 0.01 TO 1 PPM

ALSO FOUND IN EXCESS OF THE 5 PPM U. S. FDA SEIZURE LIMIT.

CONCENTRATIONS IN FISH (CONTD):

IN MANY AREAS, PCB RESIDUES IN FISH HAVE BEEN FOUND IN EXCESS OF DDT.

LETHAL DOSES FOR SOME FISH (SEVERAL WEEKS EXPOSURE):

BLUE GILLS AND CATFISH	20 TO 50 PPB
TROUT	8 PPB
SHRIMP	1 PPB

CONCENTRATIONS IN BIRDS:

CONCENTRATIONS OF 300 TO 1000 PPM HAVE BEEN FOUND IN CORMORANTS AND OSPREYS.

CONCENTRATIONS IN HUMANS:

200 OUT OF 600 SAMPLES OF HUMAN ADIPOSE TISSUE CONTAINED AT LEAST 1 PPM. 100 PPM HAS BEEN FOUND IN THE FATTY TISSUES IN ONE CASE.

*IN THE WORSE CASE WHICH OCCURRED TO 1000 PERSONS IN JAPAN IN 1968, RICE OIL CONTAMINATED WITH PCB RESULTED IN IMMEDIATE EXTERNAL SYMPTOMS (DARKENED SKINS, EYE DISCHARGES, SEVERE ACNE) ON PATIENTS THAT CONSUMED .5 TO 2 GRAMS AND MORE. NO TREATMENTS ARE KNOWN AND THE CONDITIONS EXISTED THREE YEARS LATER IN MANY CASES.

THE INTERNAL EFFECTS ARE NOT KNOWN, BUT SEVERAL INFANTS WERE BORN WITH THE SYMPTOMS FROM APPARENTLY UNAFFECTED MOTHERS.

MONS 069871

Treatment of PCB in Incinerator Offgases:

EPA Norms (non-MHF)	1600°F for 2 seconds
BSP MHF	1100°F for 0.1 seconds

Being insolluble, much of the water bourne PCB is concentrated in sludge and sediment layers. The February 1972 EPA sludge incineration task force published a preliminary report NTIS No. PB-211-723 in August of 1972.

As a part of the study, sludges from ten communities around the U. S. were analyzed in great detail, along with the by-products of incineration. PCBs were found to be the most thermally resistant of the chlorinated hydrocarbons. The report presumed that PCBs were destroyed since none was reported in off gases, ash or scrubber water. However, it observed that "direct experimental evidence.... should be obtained." In the meantime, the report used extrapolated data from liquid waste incinerators and rotary kilns and recommended an offgas treatment of 1600°F for two seconds. The BSP tests have shown that a Multiple Hearth Furnace can use considerably less retention time and temperature, but the tests showed that there can also be significant processing variations caused by the type of material in the admix.

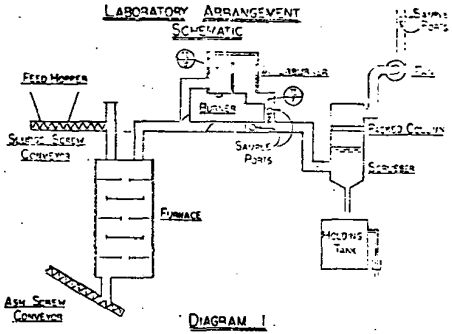
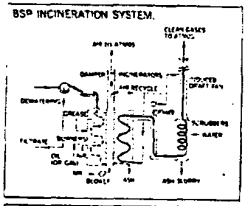
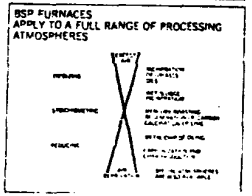
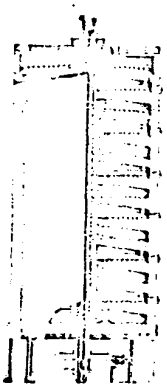


Diagram 1







MONS 069872

MHF TEST PROCEDURE

SEWAGE SLUDGE + 4500 PPM FR-1
NORMAL 1500/1700°F + 4 AFTERBURNER TEMPERATURES
INDEPENDENT ANALYSIS

THE HIGHEST PCB CONCENTRATION FOUND TO-DATE IN MUNICIPAL SLUDGE HAS BEEN 100 PARTS PER MILLION. IN ORDER TO FULLY TEST THE REFERENCED EQUIPMENT AND PROCESS, THE TEST SLUDGE WAS BOLSTERED TO 45 TIMES THIS CONCENTRATION WITH THERMINOL FR-1 TYPE PCB. THE TEST EQUIPMENT IS ONE OF THE MOST EFFICIENT TYPES OF SLUDGE INCINERATORS IN EXISTENCE AND BECAUSE OF THIS, SLUDGES WITH A TOTAL HEAT CONTENT AS LOW AS 2800 BTU PER WET POUND CAN BE INCINERATED, IN A SELF-SUSTAINING MANNER, WITH NORMAL OUTLET TEMPERATURES. SLUDGES WITH MORE THAN 75% WATER OR HIGHER OUTLET TEMPERATURES CAN REQUIRE SUPPLEMENTARY FUEL. IT WAS FOUND THAT EVEN WITH THE HEAVY DOSE OF PCB THE EXHAUST GASES FROM THE MULTIPLE HEARTH FURNACE REQUIRED ONLY 1100°F AND .1 SECOND. THIS "COMBUSTION EQUIVALENT" FOR THE BSP MULTIPLE HEARTH FURNACE IS VERY CONSERVATIVE SINCE ANY TRACES WERE 1/10 OF GOVERNMENT SUGGESTED RESIDUALS.

AN ITEM OF FURTHER STUDY WILL BE THE CHARACTERIZATION OF THE COMBINED EFFECTS OF PCBs AND THE ENTRAINING MATERIAL.

ADVANTAGES OF LOW-TEMP MHF OPERATIONS:

FUEL SAVINGS
COMPLETE DESTRUCTION
ECONOMICAL SUB-PROCESSES
REDUCED ENVIRONMENTAL IMPACT

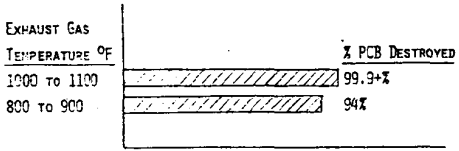
THE ADJACENT CHART SHOWS THE EFFECT OF OUTLET TEMPERATURE ON FUEL ECONOMY, WITH FEED MATERIAL CHARACTERISTICS THAT REQUIRE FUEL AT LOW TEMPERATURES, PROPORTIONATELY MORE FUEL IS REQUIRED FOR HIGHER OUTLET TEMPERATURES. ONLY MULTIPLE CHAMBERED CONTERFLOW UNITS ARE ABLE TO OBTAIN PROPER COMBUSTION WITH LOW OUTLET TEMPERATURES. DEPENDING ON THE TYPE OF APPLICATION, A BSP/MHF CAN HAVE OUTLET TEMPERATURES LESS THAN 1000°F WHILE MAINTAINING COMBUSTION ZONE TEMPERATURES OVER 1600°F.



NORMAL MULTIPLE HEARTH OPERATION HAS A WEEKLY PER CAPITA COST OF 2 1/2¢. THE DAILY EMISSIONS FROM THIS PROCESS ARE LESS THAN THAT PRODUCED BY OPERATING ONES CAR 5 MINUTES, THE FURNACE EMISSIONS BEING FIGURED ON A PER CAPITA BASIS. THE MULTIPLE ZONES OF THE MHF GREATLY ASSIST THE COMPLETE BURN-OUT OF TRACE QUANTITIES OF PCBs BECAUSE TESTS HAVE SHOWN THAT THEY CAN SURVIVE SHORT PERIODS OF RED HOT TEMPERATURES WHEN DEEP WITHIN THE INTERSTICES OF INERT PARTICLES.

MONS 069873

TEST RESULTS

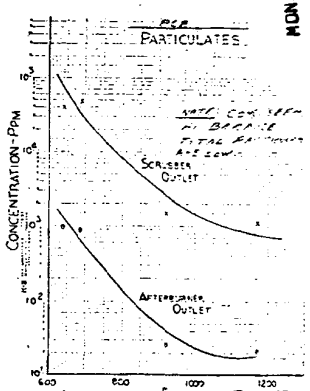


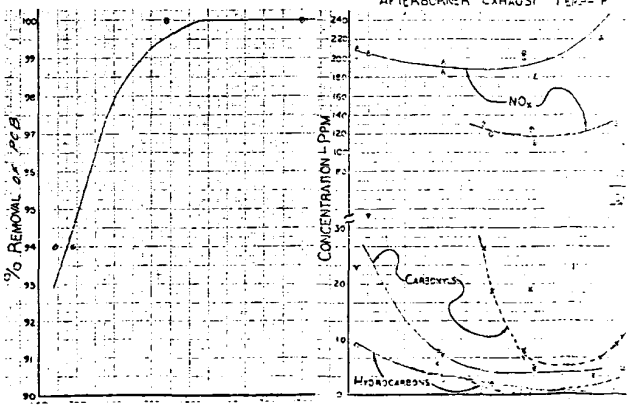
Basis: 0.1 second exhaust gas retention time

In the above tests, no PCB was found in the furnace ash. The upper bar represents low temperature after burner operation and shows that the PCB is satsifactorily destroyed, even at the lower retention times and temperatures.

The lower bar shows normal furnace operation without separate afterburning. In these runs, 94% of the PCB was destroyed which indicate that the reduced afterburning requirements of the furnace is due to the fact that most of the PCB is destroyed within the hearth chambers due to the multiple processing zones. Subsequent tests have shown that in some instances more PCB has been found in scrubber influent water than in the exhaust gases from the multiple hearth furnace. If desired, activated carbon systems can be used for removing PCB from water streams. The adsorbed PCBs can be destroyed during the thermal reactivation of the carbon in multiple hearth furnaces.

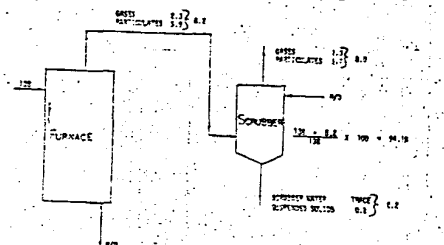
GRAPHS SHOWING THE TEMPERATURE DEPENDENCY OF EXHAUST GAS PRODUCTS





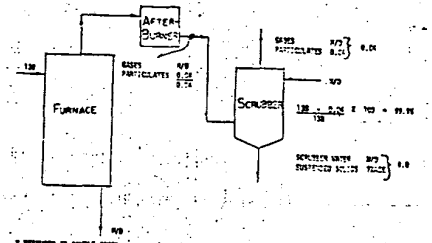
MDNS 069874

LAB FURNACE TEST* – 640°F



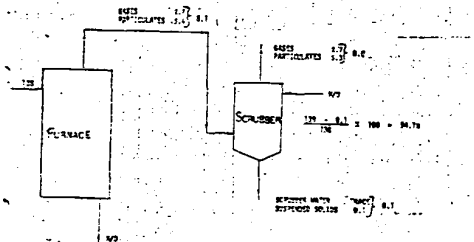
THERMINOL FR-1 (PCB)
MATERIAL BALANCE

LAB FURNACE TEST* – 920°F



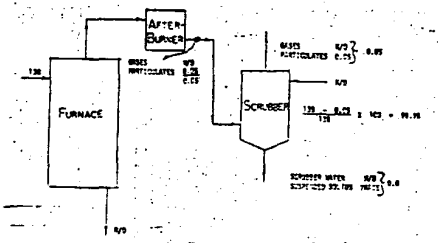
THERMINOL FR-1 (PCB)
MATERIAL BALANCE

LAB FURNACE TEST* – 690°F



THERMINOL FR-1 (PCB)
MATERIAL BALANCE

LAB FURNACE TEST* – 1170°F



THERMINOL FR-1 (PCB)
MATERIAL BALANCE

MONS 069875

MHF SLUDGE INCINERATION

Destroys PCBs	(Reduces Environmental Impact)
Low Air Emissions	(1/300 of Auto)
Low Cost	(2 1/2¢/capita/week)
Solves Problem	(Sludge Disposal)

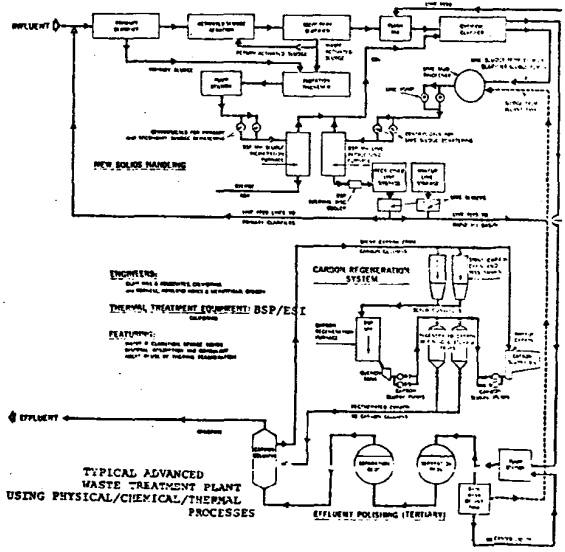
PCB Incineration by BSP Furnaces:

Economical	Efficient Destruction
Favorable E. I.	Expected Improvement

Increasingly, sludge incineration has been recognized as the safest and most efficient method for ultimate sludge disposal. In 1971, the Council on Environmental Quality recommended a policy of ending pollution dumping in the United States. Just this past summer, California instituted a plan which would outlaw ocean dumping by 1977. A recent report prepared for the United Nations by representatives from Western Germany, identified sludge incineration as the disposal method with the brightest future. In Japan, secondary benefits of incineration are achieved by taking phosphate laden ash from the furnaces and selling it as a quasi-fertilizer containing up to 6% phosphates. The ash from our BSP furnaces at the South Lake Tahoe Water Reclamation plant has been found to contain twice that amount, (12%).

SIMPLIFIED FLOWSHEET

SOUTH TAHOE PUBLIC UTILITY DISTRICT
WATER RECLAMATION PLANT
SOUTH LAKE TAHOE, CALIFORNIA



TYPICAL ADVANCED
WASTE TREATMENT PLANT
USING PHYSICAL/CHEMICAL/THERMAL
PROCESSES

MONS 069876

CONCLUSIONS:

DATA FROM THE RECENTLY COMPLETED TESTS AND EXPERIMENTS SHOW THAT THE ESI INCINERATION SYSTEM DESTROYS PCB TO THE DEGREE DESIRED BY THE EPA. THE TESTS ALSO INDICATED THAT THIS WAS ACCOMPLISHED AT TEMPERATURES LESS THAN 1100°F AND LESS THAN 0.2 SECONDS, SO THE SUGGESTED COMBUSTION EQUIVALENT OF 0.5 SECONDS AND 1100°F IS CONSERVATIVE.

1. WITH AN AFTERBURNER TEMPERATURE OF 1100°F AND A RETENTION TIME OF 0.5 SECOND, A SMALLER AFTERBURNER CAN BE USED.
2. WITH THE LOWER TEMPERATURE OF 1100°F, A SUBSTANTIAL SAVINGS IN FUEL CAN BE REALIZED.
3. THE LOWER TEMPERATURE OF 1100°F ALSO REDUCES THE NOx CONCENTRATION WHICH ACCOMPANIES HIGH TEMPERATURES.

THE CONCERN EXPRESSED BY MANY AGENCIES ABOUT PCB ENTERING THE ECO-SYSTEM IS A VERY REAL ONE. BUT AS FAR AS INCINERATION OF WASTE SLUDGES ARE CONCERNED, PCB REMOVAL BY PROPER INCINERATION PROCESSES SHOULD NOT POSE A PROBLEM. THE PCB CONCENTRATION LEVELS NOW FOUND IN MUNICIPAL SLUDGES ARE WELL BELOW THOSE USED IN THE TESTS. SPECIFIC INDUSTRIAL SLUDGES WILL HAVE TO BE EVALUATED ON A CASE BY CASE BASIS.

NOTE: MORE SPECIFIC DATA IS AVAILABLE FROM:

ESI/GFK
BOX 8158
SAN FRANCISCO, CA 94128

BIBLIOGRAPHY

SCIENCE JAN. '72, VOL. 175, A. I. HAMMOND EPA PCB TASK FORCE REPORT 8/72

PCB TEST REPORT, ESI, 9/72

PCB REPORT, EVT, 10/72

THERMINOL CONVERSION BULL, SP/TC-1, MONSANTO

THERMAL SYSTEMS BULL. 711, ESI.