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JULY 6, 1994

GEORGE MACKEY ******** WARNING THIS DOCUMENT IS 17 PAGES **********
BOB ANDREWS

CC: RON MCCREEDY
BOB ROUSE
********** WARNING THE ENCLOSED DOCUMENT WHEN PRINTED WILL BE AT LEAST 17 PAGES LONG||||||||||

ENCLOSED IS THE ABSTRACTS THAT I MENTIONED IN OUR PHONE CONVERSATION THIS AM. I THOUGH I HAD SENT A COPY TO BOB ANDREWS BUT HE IS NOT ON THE DISTRIBUTION LIST. SORRY BOB, BUT I GUESS IN HIND SIGHT I WAS THINKING THAT ALL OF THE COMBUSTION PROBLEMS WITH PLASTICS WAS OVER, SO I LEFT YOU OFF THE LIST.

GEORGE, I EXPLAINED THE SITUATION WITH MY BEING AUTHORIZED TO PUBLISH THE DATA THAT WE HAVE THAT REFUTES THAT CHLORINE FEEDS TO INCINERATORS WILL RESULT IN A DIRECT RELATIONSHIP WITH PCDD/PCDF EMISSIONS. IT WOULD TAKE ABOUT ONE WEEK TO COMPLETE THE PAPER BUT I AM NOT AUTHORIZED TO SPEND THE TIME AT THIS TIME. ALSO REALIZES THAT THE SAME PAPER THAT DREW THE POSITIVE CONCLUSION NOTED, ALSO DREW THE CONCLUSION THAT MON-CHLOROBENZENES ALSO WOULD CORRELATE DIRECTLY WITH D&F EMISSIONS.

GEORGE AND BOB, RON MCCREEDY JUST CALLED ME ABOUT THIS ABSTRACT LISTING THAT I HAD MARKED FOR INTERNAL USE OF THE DOW CHEMICAL CO. RON ASKED IF WE COULD RELEASE IT TO THE VINYL INSTITUTE. I SUGGESTED THAT HE LOOK AT THE LARGE TECHICAL TREATIES THAT THE AMERICAN PLASTICE COUNCIL IS COMPLETING UNDER THE LEADERSHIP OF BILL CARROL AND THAT THIS DOCUMENT ALSO HAD A LITERATURE LISTING IN IT.
I HAVE NO PROBLEM WITH RELEASING THE ENCLOSED AS LONG AS IT IS CLEANED UP AND CLEARED BY THE TECHNICAL LIBRARY. NOT SURE WHAT LEGAL CLEARANCES ARE NEEDED. THE ONLY CAUTION IS THE FOLLOWING:

R&S 143525

THE COMPILATION BACK TO ABOUT 1990-91 IS FROM ARTICLES THAT I EITHER HAD OR COLLECTED VERY QUICKLY TO BE PREPARED FOR THE REVIEW WITH EPA SCIENTIST. DON TOWSEND AND I HAD NOT BEEN FOLLOWING THIS SUBJECT OR ISSUE FOR ABOUT 5 YEARS AND WE HAD TO HAVE AWAY OF KNOWING WHAT PEOPLE HAD BEEN SAYING AND WRITING, SO THIS DATA BASE WAS USED. IN GENERAL THE LONG ONES ARE FROM THE ACTUAL ARTICLES.
I ALSO USED THE LISTING OF ABSTRACTS THAT WERE IN THE AMERICA PLASTICS COUNCIL TREATIES ON PLASTICS. THESE TENDED TO BE THE SHORTER ONES UNFORTUNATELY I DID NOT AGREED WITH SOME OF THE STATEMENTS THAT HAD BEEN MADE BY EER (THE CONTRACTOR) AND THUS I HARDEN A NUMBER OF THE REFERANCES THAT THEY PRESENDTED,

BOB, I DO NOT WANT ANY PROBLEMS OR NEGATIVE COMMENTS MADE FOR USING THE DATA BASE FROM THE AMERICAL PLASTICS SOCIETY. PLEASE BE SURE WHATEVER YOU DECIDE IS CORRECT.

RON, HAZNEWS, THE SECOND OR THIRD ONE DOWN IS COPYRIGHTED SO THE LIBRARY WILL MOST LIKELY ADVISE TO DROP IT UNLESS THEY HAVE A WAY TO GET CLEARANCE. ALL OF THE LONG ABSTRACTS WAS TYPED DIRECTLY FROM THE ARTICLE. DO NOT KNOW WHAT THE CLEARANCE ISSUES ARE IN RELATION TO THIS POINT.

I HAVE OVER A 100 TECHNICAL ARTICLES PERTAINING TO THIS SUBJECT, WHICH WERE REQUESTED BECAUSE I THOUGH I WOULD BE CONTINUING TO FOLLOW AND STAY UP ON THIS SUBJECT. FOR THE CURRENT TIME I AM NOT REVIEWING THIS TYPE OF MATERIAL OR AT LEAST NOT UNTIL THE NEXT PANIC CRISIS TAKES PLACE. IN ADDITION A NUMBER OF CONFERANCES HAVE JUST BEEN COMPLETED WHICH WOULD HAVE ADDITIONAL ARTICLES, LIE
DR. GREEN'S MOST RECENT PUBLICATION, WHCIH I HAVE NOT INDEXED. JUST WANT YOU TO
REALIZES HOW MUCH INFO IS BEING GENERATED AND HOW QUICKLY THE TECHICAL COMMUNITY CAN FALL BEHIND.

THIS DATA BASE CAN BE DOWN LOADED TO A FLOPPY AND SHOULD BE SPELLED CHECKED AS WELL AS GRAMMAR REVIEWED BEFORE BEING RELEASED.

PLEASE KEEP ME POSTED AND GOOD LUCK TO ALL THREE OF YOU.

REGARDS,

DAVID WILSON
ENV. TECH CENTER

****

JUNE 9, 1994

W. DELANEY
J. LEBEAU
J. MARTIN
R. MCCREEDY
C. PARK
R. PINGEL

R&S 143526

B. ROUSE
J. STEARNS
D. TOWNSEND

WARNING: THIS DOCUMENT IS AT LEAST 17 PAGES IN LENGTH||||

DURING THE PREPARATION FOR THE RESPONSE TO THE EPA REGULATING CHLORINE IN FEEDS, I FOUND MANY ARTICLES ON D&F THAT I WAS NOT AWARE OF OR HAD FORGOTTEN, DURING THE LAST FIVE YEARS. ALSO MANY ARTICLES THAT ATTACK PVC WERE ALSO DISCOVERED. IN THE HOPES OF TRANSFERRING THE KNOWLEDGE THAT WAS GAINED THE FOLLOWING IS A CURRENT SUMMARY OF THE KEY POINTS FROM SOME OF THE ARTICLES FOUND. PLEASE DO NOT ASSUME THAT THIS IS THE UNIVERSE ON THIS SUBJECT. ON WEDNESDAY OF THIS WEEK I WAS GIVEN AN ARTICLE BY A GERMAN CONTRACTOR THAT I HAD NOT SEEN.

I HAVE PLACED A "P" BESIDE THE ARTICLES THAT SPECIFICALLY MENTION PVC. PLEASE DO NOT CONSIDER THIS A FINAL DOCUMENT. MANY PEOPLE HAVE TYPED IN DATA AND I HAVE NOT HAD TIME TO PROOF EVERY LINE AS YET. I AM GOING TO BE GONE FOR TWO WEEKS AND I THOUGH THAT SOME OF THE INFO MAY BE USEFUL WITH THE CURRENT ATTACKS ON PVC.

IF YOU HAVE ARTICLES THAT ARE NOT LISTED THAT YOU BELIEVE SHOULD BE ADDED, PLEASE SEND ME A COPY.

THE ARTICLES BY WAGNER AND GREEN ARE EXTREMELY DAMAGING TOWARDS PVC. A TECHNICAL PUBLISHED RESPONSE IS THE ONLY WAY TO COUNTER MIS INFORMATION.

REGARDS,

DAVID WILSON
ENV. TECH CENTER

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PLEASE DO NOT QUOTE MATERIALS UNLESS YOU HAVE REVIEWED ARTICLE COMPLETELY|

P* SINTEF, SICKEL, et.al. (1994); The purpose of this study was to determine chloroorganic incineration products by combustion of fuel containing inorganic chlorine (NaCl) and organic chlorine (PVC). The chlorine content of the fuel was approximately 1% which is representative for municipal waste. The following combustion series were performed: Biomass (sawdust+starch), used as a reference; Biomass + NaCl; Biomass + PVC; Biomass + NaCl + PVC. No significant differences were found at the 95% confidence level in the identified chloroorganic incineration products of the PVC, NaCl and NaCl+PVC combustions. In the NaCl and NaCl+PVC combustions, the inorganic chlorine was radioactively labeled (36Cl). Liquid scintillation counting (LSC) was used to trace the labeled chlorine in the combustion products. When comparing the ratio of the LSC results to the EOCl

amounts of the two combustions, the results indicated that the chlorine from the inorganic source (NaCl) is present in a significantly higher amount in the chloroorganic compounds, than the chlorine from the organic source (PVC).

P* Haznews No. 74 (May 1994); Dioxins in German PVC production sludge: EVC Deutschland GmbH, in Wilhelmshaven, northern Germany, has found dioxins in the biologial treatment sludge it generates during polyvinylchloride (PVC) production. The dioxin concentration in the biological sludge is up to 7ug/kg (dry weight), and 400ug/kg in the metal sludge, according to the Lower Saxony environment ministry. EVC has been ordered to ensure that future sludge contains lower dioxin levels, to enable landfill disposal to continue. The company plans to minimize the formation of dioxins in the production process, and submitted its proposals to the Ministry at the end of April.

P* Alan Blankenship, et.al. (1994, Chemosphere Vol 28, No. 1); Toxic Combustion By-products from the Incineration of Chlorinated Hydrocarbons and Plastics; Polyvinylidene chloride and polyvinyl chloride were pyrolyzed in a thermal gravimetric analyzer and by-products were collected for chemical analysis and bioassay. Chemical analyses identified polycyclic aromatic hydrocarbons and chlorinated PAHs as the major pyrolysis products. Products generated from the pyrolysis of both polymers yielded definite positive bioassay responses.

* Brian K. Gullett (1994); This research uses experimental data and a statistical approach to determine the effect of combustion- and sorbent-injection-related parameters on the mechanism of polychlorinated dibenzo-p-dioxin and polychlorinated dibenzofuran (PCDD and PCDF, respectively) formation and prevention in waste combustors. The operation of a pilot-scale combustor was varied to effect different regimes of oxygen (O2), hydrogen chloride (HCl), and chlorine (Cl2) concentration; temperature; residence time; quench rate; and sorbent injection. The fly ash loading of a municipal waste combustor was simulated by postcombustion injection of fly ash collected from a full-scale facility. Downstream sampling and analysis indicated significant PCDD and PCDF formation, beyond

concentrations on the preinjected fly ash, at rates conducive to explaining formation in full-scale facilities at particle/gas residence times <5s. Stepwise regression analyses determined the predictive parameters for four models of PCDD, PCDF, the total of PCDD and PCDF yield, and the partitioning between PCDD and total yield. Substantial prevention of PCDD and PCDF formation can be brought about with upstream sorbent injection for HCl and Cl2 reduction, control of excess air, and increased quench rate.

P* Klausbruckner, Bruno; As Environmental Director for the Association of Hospitals in Vienna, Austria, Bruno Klausbruckner is in charge of wast disposal, emission control, environmental impact assessment and environmentally sound purchasing for 25 municipal hospitals. This has

included finding replacements for polyvinyl chloride in nearly all building materials and medical implements in the recently constructed SMZ-Ost hospital. since 1968 he has worked for the City of Vienna in hospital construction and maintenance, occupational safety and, since 1990 in his current position. (Taken from: 1993 Biennial Meeting on Great Lakes Water Quality; Profiles of Commissioners, Speakers and Delegates)

P* (1993); Polyvinyl Chloride Plastics in Municipal Solid Waste Combustion - Impact Upon Dioxin Emissions; National Renewable Energy Laboratory, Solar Energy Research Institute, Golden, Colorado; United Stated Department of Energy, Washington, DC; Solid Waste Association of North American, Silver Spring, Maryland; In summary, consideration of the representative information contained in this report, and drawn from literature that has been referenced, leads to the following indications:

- Reported tests, which compare the PVC plastics wastes content of MSW that is fed to combustors with observed emissions of dioxins, do not convincingly lead to a consensus view that removal of PVC from MSW will cause less dioxins to be emitted during MSW combustion.
- Evidence is available which indicates that regardless whether PVC plastics are present in MSW or not, when MSW is combusted, dioxins can be formed in amounts that presently are of regulatory concern unless control measures to limit dioxin emissions are applied.
- When MSW is combusted, control measures can limit dioxin emissions to levels that are below current regulatory concern, regardless of whether or not PVC is present in MSW. The presence or absence of MSW stream will not reduce the need to employ such control measures.

P* (1993); Heinz Riedelbauch, Gert Kerber, Ferdinand Kleppmann; Mehr PVC, trotadem weniger Dioxin; Umwelt Magazin, September 1993. More PVC without increased dioxin.

P* L. Wheatley, Y. Levendis, P. Vouros; (1993); Polynuclear aromatic hydrocarbon (PAH) emissions from the combustion of selected synthetic polymers (plastics), commonly found in municipal solid waste streams, were monitored using bench-scale furnaces. Experiments were conducted burning aerosols of poly(styrene), poly(ethylene), poly(propylene), poly(methyl methacrylate), and poly(vinyl chloride) particles, in size cuts in the range of 150-300um. Most experiments involved dilute

dispersions of polymer particles free-falling in a drop-tube laminar-flow furnace, at gas temperatures of 750-1150 deg C and residence times of .5-2 s in air. Upon melting and pyrolysis, the polymer particles burned with luminous envelope flames, whose temperature and duration were measured pyrometrically in the near infrared. Moreover, the gas temperature and residence time were also measured to investigate the effects of both the flame and the postflame conditions on the PAH emission levels. PAHs were captured in the gas and solid phases using XAD adsorbers and glass fiber filters, respectively, and analysis was conducted with gas chromatography. Results showed that the temperatures and durations of sooting luminous flames, in air, were in

the range of 1700-2900EdegEC and 10-100Ems, respectively, with PVC flame durations being the shortest and those of poly(ethylene) the longest. furthermore, the particle flame temperatures and durations did not change substantially with the gas temperature, in the range of 950-1150EdegEC. Thus, changes in PAH concentrations were mostly attributed to postflame conditions. Effective destruction minimization of toxic hydrocarbon species was found only at the highest postflame gas temperature and longest residence times explored in this study, i.e., 1150 deg C and 2 s.

P* J. Kolenda, et.al. (1993); Determination and Reduction of PCDD/F Emissions From Wood Burning Facilities; Highest dioxin concentrations occurred after addition of halogenated materials (NH4Cl hardened or PVC coated plywood) to the input, but a statistically significant correlation between chlorine input and PCDD/F output cannot be derived. Wurst, et.al. gained similar results after PCV addition to the input of a small wood burning plant (thermal capacity: 50 kW, performance level: 18-23 kW). Very clear relationships were determined between CO and PCDD/F emissions concentrations. This was especially true for production specific wood wastes and when halogenated input materials were added. Therefore, it can be concluded that the addition of halogenated input materials produced a worser combustion quality at the monitored facilities. The dominant influence of combustion quality on PCDD/F emission concentrations can be seen from the increasing CO concentrations and simultaneously decreasing flue gas temperatures.

P* J.C. Wagner, A.E.S. Green (1993); Correlation of Chlorinated Organic Compound Emissions from Incineration with Chlorinated Organic Input (Chemosphere, Vol. 26 No. 11); This paper summarizes the results of stack emission measurements made since 1988 at the University of Florida-Tacahale-Clean Combustion Technology Laboratory. We find several statistically significant relationships between HCl emissions (a surrogate for PVC in the waste) and the emissions of a nubmerof chlorinated organic compounds. These relationships have important implications for clean combustion technology and public policy. The main conclusions from this study of CCRLs VOST, HCl, CO and temperature study are: (1) there is a direct dependence of HCl emission levels on the level of PVC in the waste; (2) there is a strong dependence of ClHC (notably DCB and CB) emissions; (3) there is a strong dependence of DCB and CB on each other and on produts of HCl and nonchlorinated benzene; (4) and there is almost certain evidence of nonlinear relations existing between ClHC emissions and CO and temperature. In nearly all

of the different regression analyses performed here, the relationship between a chlorinated organic emission and HCl emission was positive and well-defined. These results, contrary to the prevailing opinion, lead to the physically reasonable conclusion that decreases in the levels of organically bound chlorine in the input leads to decreases in chlorinated organic emissions. Our best regression equations suggest that compounds with benzene rings, such as polystyrene, should be avoided particularly when chlorine is present. Here it might be noted that the CCTL plastic input (39%) was mostly polystyrene. Many models, including our kinetic models, use benzene as a precursor to chlorinated

benzenes and PCDDs/PCDFs. In final summary the CCRLs experimental, phenomenological, and theoretical studies of toxic emissions from incineration all support the physically intuitive hypothesis that reduction of chlorinated plastics in the input waste stream results in reduction of aromatic chorinated organic emisisons.

* Brinckmann, Glenn A. (1993); The application of dry injection/fabric filtration technology has been shown to be a viable configuration to control the emissions of the pollutants of concern from MWIs. Subsequently, the data presented has shown the operation to be reliable and effective. Furthermore, the application of FORE-TEX membrane filter bags provides benefits which enhance the performance of the incinerator and simplify operation. PM and HCl emissions levels well below the regulatory levels have been achieved. The operators of the particular facilities have realized filter bag life in excess of three years, flexibility in controlling the pressure differential across the filter media, savings in cleaning energy, and the ability to survive system upsets. The DI/FF configuration is gaining more popularity, especially relative to the stricter regulations on the emissions of particulate matter, including heavy metals and dioxins and furans, being proposed and promulgated by the regulatory agencies. It has been shown that the injection of dry reagents, such as lime and sodium bicarbonate, are capable of neutralizing the acid gases, especially HCl, in the flue gas stream and reducing the levels well below the regulatory level.

P* Ishwar K. Puri (1993); A study is performed on turbulent jet flames burning fine PVC particles. The motivation behind the study is to determine the burnability of the particles. Whereas, the bulk of the particles burn, there is some escape of PVC-soot agglomerates into the overfire region of the flame. In addition, dioxin precursors are detected when PVC particles and gas-phase fuel-bonded chlorine (in the form of methyl chloride) are burned together. No precursors are detected when PVC particles are burned in the absence of gas-phase fuel-bonded chlorine.

* Brian K. Gullett (1993); This research uses experimental data and a statistical approach to determine the effect of combustion- and sorbent-injection-related parameters on the mechanism of polychlorinated dibenzo-p- dioxin and polychlorinated dibenzofuran (PCDD and PCDF) formation and prevention in waste combustors. The operation of a pilot-scale combustor was varied to effect different regimes of O2, HCl and Cl2 concentration; temperature; residence time; quench rate; and sorbent injection. The fly ash loading of a municipal waste combustor was simulated by post-

combustion injection of fly ash collected from a full-scale facility. Downstream sampling and analysis indicated significant PCDD and PCDF formation, beyond concentrations on the pre-injected fly ash, at rates conducive to explaining formation in full-scale facilities at particle/gas residence time < 5s. Stepwise regression analyses determined the predictive parameters for three models of PCDD, PCDF and the total of PCDD and PCDF yield. Substantial prevention of PCDD and PCDF formation can be brought about with upstream sorbent injection for

Cl2 reduction, control of excess air, and increased quench rate. These results show how acid gas and operating parameters can be readily altered to prevent conditions conducive to downstream PCDD and PCDF formation.

* J.D. Kilgroe (1993); Mass burn municipal waste combustors (MWCs) equipped with lime spray dryer absorber and electrostatic precipitator (SD/ESP) systems exhibit variable control of mercury (Hg) and polychlorinated dibenzo-p-dioxin and dibenzo-furan (CDD/CDF) emissions. Tests were conducted at the Camden County, New Jersey, MWC Facility to evaluate the effectiveness of injecting powdered activated carbon in the flue gas to improve control of Hg, "other" trace metals, and trace organics in mass burn MWCs with SD/ESP systems. Test variables included carbon type, carbon Injection method (dry and slurry), carbon injection rate, and ESP inlet temperature.

* Hans-Ulrich Hartenstein (1993); The application of activated carbon for flue gas polishing has led to emission levels well below previous expectations. Especially the use of HOC in adsorption filters has proven its unmatched potential in reducing a wide variety of harmful and toxic pollutants simultaneously to concentrations around the detection limit. This ability as well as the large buffering capacity make this technology superior to other approaches such as the injection of calcium hydroxide mixed with small amounts of pulverized activated carbon and its collection in a baghouse. In a comparison of activated carbon filters with other techniques of flue gas polishing, it has been proven that the activated carbon filters provide the most extensive removal of the greatest number of different pollutants and can be applied most universally ¢11,12!.

* Rick Gleiser (1993); The spray dryer absorption system has been successfully applied to flue gas cleaning for municipal solid waste incinerators for the last ten years. Not only can acid gas emissions and particulate emissions be controlled to very low levels, but heavy metals and trace organics can also be controlled. For enhanced removal of vapor phase emissions such as mercury and dioxins, the addition of an activated carbon system has been shown to be particularly advantageous. Data acquired over a 2-1/2 year period shows no measurable revolatization of mercury from spray dried product, with or without activated carbon addition.

* Ismo Halonen, et.al. (1993); Incineration tests of biosludge and refuse derived fuel (RDF) were performed in a pilot scale circulating fluidized bed plant. Samples of chlorinated organic compounds were collected simultaneously at three different locations in the incinerator (temperatures 850, 250, and 140 deg C). Polychlorinated dibenzo-p-dioxin

(PCDD) and polychlorinated dibenzofuran (PCDF) concentrations formed in the furnace were higher in incineration tests of RDF than in incineration tests of biosludge mixtures. PCDD/PCDF formation at 850 deg C was observed to depend on chlorine content in the fuel. Post-formation of PCDD/PCDF compounds beyond the furnace was only observed in test of RDF.

It is obvious that variables other than the chlorine and PCDD/PCDF input contents in the fuel have an influence on formed PCDD/PCDF levels.

P* Mattila, et al. (1993);The influence of mixed chlorinated plastics on PCDD/PCDF formation during the combustion of coal and bark in a full scale MWC was investigated. Chlorinated plastics addition caused an increase PCDD/PCDF stack emission for all of the cases studied. The PCDD/PCDF levels were below 0.1 ng/m3 TEQ for all cases.

* Kenneth R. Durkee (1993); The Office of Air Quality Planning and Standards (OAQPS) of the U.S. Environmental Protection Agency (EPA) is conducting a regulatory development program for air emissions from medical waste incinerators (MWIs) under Section 129 of the Clean Air Act (CAA) of 1990. The regulatory program includes the development of new source performance standards (NSPS) based on maximum achievable control technology (MACT), and the development of emission guidelines for existing sources. The development program involves three principal phases of activity: 1) information gathering, 2) analysis of the information, and 3) development of the standards for new sources and emission guidelines for existing sources. In developing the standards, the EPA has conducted studies to develop emissions data, information on control equipment performance for removal of various pollutants; and to determine costs, economic environmental, and energy impacts of various regulatory alternatives. The control techniques investigated include both combustion control (i.e., residence time and combustion temperatures) and add-on controls, such as wet scrubbers, dry injection/fabric filter systems, and dry scrubbers. Pollutants for which the EPA has gathered data are particulate matter, carbon monoxide, hydrogen chloride, sulfur dioxide, nitrogen oxides, trace metals, dioxins/furnaces and testing with spores in the feed to assess destruction of pathogens by the incinerator (both in air emissions and in ash). As part of this data gathering effort, the EPA has tested seven incinerators with varied emissions control techniques and at varied combustion and feed conditions. Test results were presented at the 1992 Incineration Conference in a paper by the authors. This paper will discuss the performance and costs of the control options being considered as the basis for the NSPS and emission guidelines. The control options being considered are various levels of combustion controls, wet scrubbers, dry lime injection/fabric filter systems, and carbon injection systems. Also, a summary of the corresponding impact analyses conducted for this regulatory program will be presented.

P* Frankenhaeuser et al. 1993 NTIS. The influence of mixed plastics on PCDD/PCDF formation during the combustion of coal in a 7 MW fluidized bed boiler was investigated. The PCDD/PCDF flue gas emissions of the plastic/coal mixtures were below 0.1 ng/Nm3 TEQ. The emissions of PCDD/PCDFs generated by the incineration of 100% plastics were 0.8 and 0.2 ng/Nm3, with and without limestone, respelcively. The reason for

these values was the incomplete combustion conditions. PCDD/PCDF emissions were independent of the plastic and chlorine content of the feed.

* David Avina (1993); This paper investigates an operational process that reduces pollutant emission below that considered normal by most regulators and air pollution control device (APCD) manufacturers. This process involves the application and maintenance of a sodium bicarbonate precoat injection onto the fabric filter bags during the entire burn cycle. By precoating the fabric filter with sorbent and maintaining the bed between 154 deg C and 176 deg C, optimal pollutant collection efficiency results. The original goal of this procedure was to provide a consistent air emission sample during test burns. The result showed gas emissions of HCl, metals, particulates, and CDD/CDF that were lower than those characteristically observed from medical waste incinerators using dry sorbent injection/fabric filter APCD technology.

P* Alex E.S. Green, John C. Wagner (1992); Book-"Medical Waste Incineration and Pollutioin Prevention", edited by Alex E. S. Green; Chapter 1. Toxic Products of Medical Waste Incineration; Many of the disposables in the medical waste stream, upon combustion, produce toxic chlorinated hydrocarbon emissions and metals (from plasticizers and pigments). Polyvinyl chloride is a prime example of such mateiral although this issue has been obfuscated by the present day focus on air pollution control devices and by some overly stated conclusions in the literature. In this chapter we have particularly focused on the PVC issue and have assembled studies that contradict the conventional wisdom that there is no correlation between PVC input and CHC output. Perhaps the most convincing evidence of the efficacy of PVC reduction in lowering PCDD/PCDF emissions are measurements in Hamilton, New Zealand, reported by Bulley (1990). His comparison showed that the Hamilton PCDF and PCDD emissions were much lower than the corresponding emissions at Sutter, St. Agnes, and Cedars Sinai hopsitals reported by CARB. To reduce corrosive HCl emissions, New Zealand control authorities have attempted to limit the amount of PVCs used by hospitals. Bulley originally attributed Hamilton's low PCDF/PCDD emissions to the high destruction efficiency achieved by their New Zealand-designed four-stage controlled air incinerator. However, the importance of PVC reduction measures is strongly emphasized in more recent work (Bulley, 1991). The correlation of low PCDF/PCDD with low HCl is clearly shown in measurement of waste with low plastic content at Shelly Bay in Wellington (see Chapter 3). Neverthless, most evidence points to the physically and chemically reasonable rule that reducing the input sources of HCl will generally reduce the output of CHCs.

P* A.E.S. Green, J.C. Wagner, S. Mahadevan (ASME 1992); Chlorinated Toxics from Incineration; The Clean Combustion Technology Laboratory (CCTL) has conducted pilot scale experiments since 1988 on measuring and minimizing toxics emissions from an institutional incinerator. Our HCl and volatile organic compound (VOC) sampling results indicate that avoidance and source separation of chlorinated plastics, burning slightly above stoichimetric, and stoking the waste bed are effective

methods of minimizing toxic emissions. We have achieved reductions o

HCl and VOCs equivalent to 90% scrubbing and believe we can do better with more stringent pollution prevention protocols. Phenomenological modeling of our data and data in the literature also generally supports these approaches to toxic minimization although noisiness of stack concentrations and variations of the composition of input waste make it difficult to draw sharp conclusions. Numerical experiments with kinetic models of chlorobenzene and chlorophenol formation also support the intuitively obvious conclusion that, all other things held the same, the more chlorinated plastics in the output. Thus experiment, phenomenological modeling, and simple theoretical models all indicate that simple pollution prevention and optimum combustion techniques are effective in toxic minimization.

* Brian K. Gullett (1992); Research has shown that synthesis of polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) during municipal waste combustion can proceed through a three step mechanism including 1) production of Cl2 from a metal-catalyzed reaction of HCl and O2, 2) Cl2 chlorination of aromatic rings through substitution reactions, and 3) formation of dual ring structures by a second metal-catalyzed reaction. Formation of the dual ring PCDD structure, likely through condensation reactions of chlorophenols, is enhanced up to three orders of magnitude in the presence of metal catalysts, such as Cu(II), reaching a maximum around 400 deg C.

* Theodore G. Brna (1992); In early 1989, a joint Environment Canada/U.S. Environmental Protection Agency program investigated the effect of changing combustion and flue gas cleaning system variables on the performance of these systems. The removal of polychlorinated dibenzo-p-dioxins and dibenzofurans, other organics, and particulate matter from flue gas is reported. The transfer of organics to ash/residue is detailed, and the close relationship between particulate removal and organics removal is noted. The results of input/output analyses of the organics across the flue gas cleaning system are discussed.

* Dennis D. Wallace (1992); The EPA testing program conducted to support development of standards of performance and guidance for medical waste incinerators (MWIs) has generated a substantial body of emission data. These data provide information on the performance of both combustion control measures and add-on air pollution control systems for a wide variety of pollutants. This paper summarizes the results from data analyses that examined the effedts of incinerator operating parameters on emissions of particulate matter (PM), carbon monoxide (CO), chlorinated dibenzo-p-dioxins and chlorinated dibenzofurans (CDD/CDF), and total hydrocarbons (THC). Specifically, the paper examines the relationships among CO, PM, and CDD/CDF emissions; the effects of combustion temperatures, residence time, excess air levels, waste type, and operating rate on OC, PM, and CDD/CDF emissions, and the variation in CO and THC emissions across phases of the operating cycle.

* Kenneth R. Durkee (1992); The Office of Air Quality Planning and Standards (OAQPS) of the U.S. Environmental Protection Agency (EPA) is

conducting a regulatory development program for air emissions from medical waste incinerators (MWIs) under Section 129 of the Clean Air Act (CAA) of 1990. The regulatory program includes the development of new source performance standards (NSPS) based on maximum achievable control technology (MACT), and the development of emission guidelines for existing sources. The development program involves three principal phases of activity: 1) information gathering, 2) analysis of the information, and 3) development of the standards for new sources and emission guidelines for existing sources. In developing the standards, the EPA has conducted studies to develop emissions data, information on control equipment performance for removal of various pollutants; and to determine costs, economic environmental, and energy impacts of various regulatory alternatives. The incinerator design types investigated are controlled-air, rotary kiln, and pathological. The control techniques investigated include both combustion controls (i.e., residence time and combustion temperatures) and add-on controls, such as wet scrubbers, dry injection/fabric filter systems, and dry scrubbers. Pollutants for which teh EPA has gathered data are particulate matter, carbon monoxide, hydrogen chloride, sulfur dioxide, nitrogen oxides, trace metals, dioxins/furans and pathogens present in the air emissions and ash. As part of this data gathering effort, the PEA has tested seven incinerators with varied emission control equipment and at varied combustion and feed conditions. Preliminary test results for test at 5 of the incinerators were presented at the 1991 Incineration Conference in a paper by the Authors. This paper will discuss further conclusions from the original five tests, additional testing performed with carbon injection at one of the five original sites and test data from two additional incinerators and associated control equipment. Also, a quick summary of the status of this regulatory development program will be presented.

* Brian K. Gullett (1992); The effect of sulfur dioxide on the formation mechanism of polychorinated dibenzodioxin (PCDD) and polychlorinated dibenzofuran (PCDF) in the postcombustion, downstream region (500-300 deg D) of a municipal waste combustor (MWC) was investigated. Laboratory experiments simulating the flue gases and particle environmental of an MWC examined PCDD production under varying conditions. Effects on the concentration of an organic-chlorinating constituent, Cl2, through both homogeneous reaction with SO2 and deactivation of a Cl2-formation catalyst ¢Cu(II)! were examined. Experimental results suggest that the reaction of Cu(II) with SO2 to form CuSO4 renders the catalyst less active, decreasing PCDD formation. However, this inactivity is not a result of decreased Cl2 formation, but rather of reduced ability of Cu(II) to promote a second catalytic step of biaryl synthesis. These findings suggest that the apparent lack of PCDD and PCDF in the emissions from coal-fired combustors may be due to the relatively high concentrations of SO2.

* W. S. Lanier (1992); In developing medical waste incinerator (MWI) emission standards and guidelines for dioxin and furans (CDD/CDF), the U.S. Environmental Protection Agency (EPA) observed that CDD/CDF stack emission concentrations were greater than those observed from municipal waste combustors (MWCs) equipped with similar air pollution control devices (APCDs). The cause of this observed trend was evaluated by

examining emissions data from 5 MWIs and 10 MWCs. Two important considerations in the evaluation included the fact that substantial concentrations of CDD/CDF may be formed in the APCD and that there are two possible routes for CDD/CDF to exit from the APCD system. The Total CDD/CDF release from the APCD can be calculated by first normalizing the mass of CDD/CDF released with captured fly ash by the flue gas flow rate and then adding the result to the CDD/CDF concentration in the stack gas. When the data base is evaluated in this manner, it is seen that the Total CDD/CDF exiting the APCD (ash & gas), as well as the inlet CDD/CDF concentrations are roughly equivalent between similar MWI and MWC systems. This observation indicates that the trend observed by EPA is not due to increased CDD/CDF formation in the APCD but is rather the result of a major difference in partitioning of CDD/CDF between collected fly ash and stack gases. In MWIs, a smaller fraction of the Total CDD/CDF is retained by the fly ash and thus higher stack gas emissions are observed in MWIs than in MWCs. A number of potential process and system parameters were evaluated in an attempt to evaluate the reason for the different partitioning. That analysis suggested that an important parameter might be differences in the concentration of solid carbon in the combustor exhaust from MWCs and MWIs. For MWIs the total particulate concentration (and thus the solid carbon available in the APCD) is about an order of magnitude activated charcoal into the inlet of an MWI APCD. CDD/CDF stack gas concentration was significantly reduced.

* Michael G. Dennis (1992); Medical waste incineration has been the subject of increasing scrutiny by regulatory agencies, the media, and the public in the last few years. Some of this scrutiny is due to concern about emissions of heavy metals and dioxins, and the associated potential health risks. In response to this concern, the Clean Air Act Amendments of 1990 provide in Section 129 for the U.S. Environmental Protection Agency (EPA) to develop New Source Performance Standards (NSPS) under Section 111(b) of the Clean Air Act for new medical waste incinerators (MWIs) and emissions guidelines for existing MWIs under Section 111(d). The NSPS is to reflect the maximum achievable control technology (MACT) whereas the emissions guidelines may be equal to or less stringent than the NSPS. Section 129 requires EPA to develop numerical emission limits for particulate matter (PM), opacity, sulfur dioxide, hydrogen chloride, oxides of nitrogen, carbon monoxide, lead, cadmium, mercury, and dioxins and furans. In addition to new federal requirements, many states already require that new MWIs meet strict emissions limits on several of the foregoing pollutants. The trend in new state regulations is to set the PM emission limit to either 0.03gr/dscf or 0.015gr/dscf. Some states also require a quantification of trace metals and performance of a health risk assessment as part of the permitting process for new medical waste incinerators. This paper examines the factors affecting trace metal emissions from MWIs and the effect of alternative air pollution controls. A comparison of emission factors for various types of MWIs and controls is presented. Health risk assessments for three facilities with different air pollution control systems are reviewed.

P* G. R. Hassel et al. (1992); The effects of different plastics including polyethylene (PE), polypropylene (PP), ethyl vinyl acetate (EVA) and poly vinyl chloride (PVC) on products of incomplete

combustion (PICs) generated during incineration on a stationary grate were determined. Small quantities of PCDDs/PCDFs (2-60 ng/dscm) and polyaromatic hydrocarbons (PAH) (1-2 ug/dscm) were produced. PVC did not produce appreciatively higher levels of PCDDs/PCDFs than the PE/PP or EVA resin materials. The chlorine feed level was determined to not be a major reason for PCDD/PCDF formation. None of the tests produced measurable PCBs.

* Takeshita et al. (1992); Carbon monoxide (CO) was determined to have direct influence on PCDDs/PCDFs in the flue gas and ash, not HCl. The control of polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDDs/Fs) formation was investigated in a municipal waste incinerator equipped with an electrostatic precipitator (EP). PCDD/F levels in the gas at the high CO level were much higher than those at the low CO levels. At the low (carbon monoxide) levels (exps. 1-9), there were no great differences in the PCDD/F concentration levels in the gas among three concentration levels of HCl at any gas temperature. This indicates that HCl in the flue gas did not contribute to PCDD/F formation during the process of the flow of gas from the furnace to the EP inlet.

P* A German study by Johnke and Stelzner (1992); Stelzner and Greiner (1989) evaluated PCDDs/PCDFs from 15 MSW incineration units. Major points of this study were:
- Significant decreases in PCDDs/PCDFs emissions cannot be achieved by changes to the composition of the waste.
- Increased HCl levels resulted from a one percent by weight PVC increase in the feeds. PCDD/PCDF values for the electrostatic precipitators (ESP) obtained from burning municipal ash, waste, and gas with low levels of in PVC, high levels of PVC, or only waste paper.
- Levels of chlorobenzenes and PCBs increased slightly in response to the addition of PVC.
- PCDDs/PCDFs, PIC and HCl emissions were reduced when lime was added to the waste.
- Changes in operating parameters, excess oxygen, start-up and shutdown periods resulted in PCDD/PCDF concentration sings.

P* Lenoir et al. (1991); Tests were conducted on a fluidized bed combustor with waste blends containing varying amounts of NaCl, PE, and PVC added to cellulose fibers. The increase of PCDD/PCDF levels could not be measured at significant levels. In one case, the addition of three percent PVC to PE increased PCDD/PCDF levels by a factor of three times when compared to PE by itself. The additives and HCl combustion gas valves did not cause PCDD/PCDF formation levels to increase significantly. A negative effect on CO and oxygen (O2) was observed. Moisture values did not impact on total PCDD/PCDF levels. Moisture did seem to reduce the ratio of PCDF to PCDD which led to a shift to lower chlorinated cogener groups. The chlorine content of ash did not correlate with PCDD/PCDF concentration values.

P* Von Bernt Johnke and Eckhard Stelzner (1991); Auswertung des bundesweiten Dioxinmebprogramms an Hausmullverbrennungsanlagen; Dioxi aus MVA; Mull und Abfall 11/91. German EPA study of a number of

incineration test with and without PVC. Water waste, ashes, and emissions were studied extensively.

P* Fangmark et al. (1991); The effect of PVC and resource derived fuel (RDF) on PCDDs/PCDFs in a lab scale combustion reactor was studied. The PVC content was increased from one percent to three percent with no difference in PCDD/PCDF outlet gas emissions. Although a fairly constant amount of PVC was being burned, a broad range of PCDD/PCDF levels was detected, in some cases by 100 percent. This was believed to be caused by cooling condition differences of the flue gas.

P* Kenneth R. Durkee (1991); Preliminary conclusions which can be drawn from these test data are:
- CO emissions from well designed and operated MWIs are generally less than 25 ppm at 7% O2.
- There appears to be little difference in uncontrolled emissions between general hospital waste and segregated red bag waste.
- Medical waste incinerators cannot generally be operated properly at the manufacturer's design rate when fired with the types of waste typically generated by today's hospitals.
- Secondary chamber gas residence times between 1 second and 2 seconds reduce the variability in uncontrolled emissions caused by other operating factors.
- At secondary chamber gas residence times of less than 1 to 2 seconds, incinerator operation significantly affects uncontrolled emissions.
- The overall pathogen "kill" of the incinerators tested was generally greater than 99.99%.

P* R. E. Hall (1991); The U.S. Environmental Protection Agency sponsors a variety of fundamental and applied combustion research at the Air and Energy Engineering Research Laboratory (AEERL) in Research Triangle Park, NC. AEERL's Combustion Research Branch operates a Resource Conservation and Recovery Act-permitted facility with five combustors ranging from bench- to full-scale. Research is conducted to examine the effect of operating parameters such as residence time, temperature, turbulence, and waste characteristics on incineration of principal organic hazardous constituents, the formation of products of incomplete combustion, and transformation of trace metals. This paper describes the five combustors, results of some completed research, and plans for future studies. Experiments were performed to examine transient emissions resulting from batch charging of surrogate solid plastic wastes (1). A series of plastic materials were burned, including polyethylene (PE) and polyvinylchloride (PVC) both separately and together. The results showed that PE created large amounts of PIC material when puffs were formed. PVC, being a refractory plastic, did not produce large puffs. However, when a mixture of PE and PVC was burned, the extremely fuel-rich zones produced by the PE, combined with the chlorine supplied from the PVC, produced many chlorinated PICs, including polychlorinated dibenzo dioxins and dibenzo furans. These results indicate that ring structures in the parent waste were not necessary to form chlorinated cyclic organics. CRB's fundamental

combustion research has shown the importance of PICs when incinerators are not operated properly; e.g., when too much waste is fired, the

temperature is too high or too low, or good mixing is not achieved. For example, this research has shown that rotary kiln rotation speed and temperature can be important for minimizing PICs, especially when incinerating highly volatile liquid wastes. Improved packaging may be another way to minimize PICs from such wastes. Oxygen enrichment and acoustically enhanced mixing also offer hope for ways to improve incineration.

* U. Duwel (1991); During several test-runs before and after the design modernization of a Municipal Solid Waste Incineration (MSWI) plant a reduction of the PCDD/PCDF-levels in the flue gas and in the electrostatic precipitator (ESP)dust was determined. Possible reasons for the reduction were found due to measuring data and design modifications. In the old plant abrupt cooling via the quench reactor from approx. 800 deg C to 270 deg C was meant to avoid the PCDD/PCDF-formation, but this process feature does not seem to have a relevant influence. If a PCDD/PCDF-reduction takes place, it is in any case neutralized by PCDD/PCDF-formation in other parts of the plant - as the values indicate. Furthermore, the old plant emitted higher concentrations despite the boiler with the critical temperature are from 800 deg C to 230 deg C ¢10, 11, 12!. The new plant can be operated under good operating conditions due to the modificated grate design, whereas only poor operating conditions were realized in the old plant. The new plant is operated with a considerably lower oxygen excess than the old plant, as measurements data show. Furthermore it is of interest that the temperatures in the ESP of the old plant amounted to 270 deg C, while the new plant only shows 180 deg C. All in all it can be stated that via consequent process optimizations of combustion, boiler and flue gas cleaning a reduction of PCDD/PCDF-emissions can be achieved.

* H. Hagenmaier (1991); In order to ensure reliable adherence to the dioxin emission limit of 0.1 ng TE/m3, an integrated dioxin reduction concept is necessary. In this paper, modern technologies are presented with which this limit can be reached. The techniques and technical developments listed show that the aim of lowering PCDD/PCDF emissions from RIP to less than 0.1 ng TE/m3 is achievable. It is most likely achievable by various approaches or combinations of approaches. We believe that the approach employing catalytic oxidation with DeNOx-type catalysts is most readily applicable. Since it is a destructive approach rather than a removal/concentration approach, it turns RIP into sinks for PCDD/PCDF if at the same time filter ash is decontaminated as well by low temperature treatment under oxygen deficiency conditions. Most probably the solution can, however, also be adapted to other dioxin emission sources.

* Kevin R. Bruce (1991); The emissions of polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) from municipal and hazardous waste incinerators are undesirable due to the reported extreme toxicity of some of the isomeric forms. Research has shown that these compounds can be formed in the incineration process through heterogeneous

reactions catalyzed by fly ash in a temperature range around 300 deg C. Other tests have shown that Cu compounds, particularly Cu (II), may be the active catalysts in PCDD and PCDF formation. Tests have shown that these Cu compounds participate in the Deacon process, converting HCl

present in the flue gas to Cl2, Cu compounds are suspected of participating in further roles as catalysts in the organic reactions producing the dual ring PCDD and PCDF structures. This paper investigates this hypothesized catalytic activity through laboratory experiments simulating PCDD and PCDF production in an incinerator flue gas.

* G. C. England (1991); Medical waste incinerators (MWI's) are known to emit pollutants which may contribute to the endangerment of public health and welfare (1-5). Therefore, NewSource Performance Standards (NSPS) are now being developed by the U.S. EPA which will limit pollutant emissions from new MWI's. In addition, many state and local agencies with permit responsibility are being pressured to issue permits for incinerator facilities, without the benefit of a validated technical data base. The wide variety of practices used to incinerate medical wastes has presented a considerable challenge to the regulation and permit writers in establishing what levels of emissions control are achievable with state-of-the-art systems. Therefore, Energy and Environmental Research Corporation (EER) conducted a comprehensive emissions characterization and analysis program to establish emissions characteristics of two modern incinerator systems. The program was co-funded by the U.S. Environmental Protection Agency. This paper describes the technical approach taken to conduct a multi-pollutant, parametric environmental characterization of emissions from the two facilities. Tests were conducted with four categories of waste. Incinerator operating conditions were also varied. EPA Category 1 quality assurance/quality control procedures were used for all measurements. Characterization of emissions under representative conditions required the simultaneous operation of up to 11 manual and continuous sampling trains. In order to understand the impact of incinerator and air pollution control device (APCD) operation on emissions, careful documentation of operating condition was required. This presented a considerable challenge in all aspects of the test, including selection of suitable sampling locations, collection and recovery of samples, operation of continuous monitoring equipment, and coordination of waste segregation and incinerator operation. An analysis of the test results was performed to determine the impact of incinerator and APCD operating conditions on emissions and to identify potential surrogate monitoring parameters for trace correlation between emissions of total CDD/CDF with CO, primary or secondary temperature, HCl, or total hydrocarbons was found for the two facilities tested. The trace metals control efficiency was in general superior for the dry injection/fabric filter system than for the venturi scrubber. However, control of mercury emissions was poor for both designs. The results also indicated that the dry injection/fabric filter system did not provide effective control of CDD/CDF emissions. The results of the field test are currently under evaluation. Significant observations relative to the test results thus far are:
  - HCl control efficiency greater than 95% was generally achievable with the dry injection fabric filter system. Greater than 99% HCl removal

was measured with the venturi scrubber system.
- Particulate and non-volatile metals emissions control efficiency was higher for the dry injection/fabric filter system. However, mercury emissions were not effectively controlled with either system.

- There was no significant reduction in CDD/CDF emissions across the dry injection/fabric filter system, in contrast to results obtained from similar systems for municipal solid waste incinerators. This may be due to the intermittent lime injection characteristic of the specific system tested.
- Varying final incinerator outlet temperature from 1600 deg F to 2000 deg F did not significantly affect metals or trace organics emissions. Further analysis of the test results is currently in progress (16).

* J.D. Kilgroe (1990); A cursory analysis of the performance test results support the following tentative conclusions:
- Combustor emissions of CO and PCDD/PCDF as measured at the SDA inlet were sensitive to the amount of distribution of overfire air. Combustion air distributions which result in poor mixing and low excess air margins are believed to be the primary causes of increased CO emissions.
- PCDD/PCDF stack emissions of less than 0.40 ng/Sm3 were achieve at the Mid-Conn Facility when good operating conditions were maintained on both the combustion and FGC processes.
- FF outlet concentrations of PCDD/PCDF are dependent on SDA/FF operating conditions. The lowest emissions were associated with medium to low gas temperatures at the SDA outlet, while the SDA lime slurry flow rate was set to provide medium to low SO2 concentrations at the FF outlet.

* Nielsen, 1989; Manscher et al., 1990, reported that excess oxygen reductions while still maintaining oxygen, resulted in the lowest measured PCDD/PCDF concentrations for the stack gas, bottom and fly ash.
- PCDD/PCDF emissions were not correlatable with HCl, SO2, HF, NOx, or CO2 concentrations.

P* Nielsen (1989) and Manscher et al. (1990) performed a Danish study on the emissions of PCDDs/PCDFs from MSW and hospital waste incinerators with the following reported.
- Thirteen different incinerators were evaluated with two hundred samples being taken.
- An average of 20 micrograms of 2,3,7,8-TCDD TEQ nordic, per ton of waste was emitted in the stack gas.
- Extensive statistical analyses was performed on the following:
- Excess oxygen levels and thermal load were correlated to PCDD/PCDF levels.
- Low load and low excess oxygen resulted in low PCDD/PCDF levels.
- Hydrogen chloride (HCl) concentration had a very minor significant influence on PCDD/PCDF levels reported.
- Addition of both PVC and sodium chloride (NaCl) as chlorine sources was found to result in slightly higher PCDD/PCDF stack emissions.
- Doubling of the chlorine source increased PCDD/PCDF emissions by fourteen percent.

- QA/QC problems were encountered during the study, which may impact the conclusions.
- Analysis error was estimated to be 100%; and replicate experiments differed in results by 600% in some cases.

* Barton et al. (1990); A statistical evaluation of stack gas PCDD/PCDF data from a Quebec City, Canada incinerator was perform. The study determined a relationship between entrained particulate and volatile hydrocarbons related to PCDD/PCDF levels. The influence of HCl was on PCDD/PCDF could not be found.

* Gullet, Bruce, and Beach, (1990); An evaluation determined that HCl at temperatures above 650oC are not likely responsible for PCDD/PCDF formation. HCl may promote the formation of precursors, which may form chlorine for subsequent chlorination reactions.

* Nottrodt et al. (1990); It was determined that high excess oxygen, high CO, and low temperatures have the most dramatic effects on increasing PCDD/PCDF levels.

* T.G. Brna (1990); The EPA-supported tests reported here indicated that:
  - PCDD/PCDF emissions varied with combustor type, with higher emissions from RDF than mass burn combustors,
  - Lime SDA/FF systems reduced PCDD/PCDF emissions to less than 5 ng/Nm3
  - Lime SDA/ESP system reduced PCDD/PCDF emissions to 62 ng/Nm3, and
  - PCDD/PCDF emissions increased across the ESP of a mass burn refractory unit, with the outlet PCDD/PCDF emissions decreasing with decreasing ESP inlet temperature and with duct injection of hydrated lime upstream of the ESP.

  Data from these and other tests support the use of good combustion practice (GCP) to minimize PCDD/PCDF emissions from MWCs. The CO emission corresponding to CP varies with combustor type.

P* W. Christmann (1989); Report is given on the combustion and pyrolysis conditions. In a final survey we would like to point out again the main results:
  - The isomer distribution pattern and congener profile of the soot samples from our combustion experiments are very similar to those obtained with soot samples collected in public buildings after a fire.
  - In our pyrolysis experiments we got patterns resembling those normally observed with samples from incineration plants.
  - Obviously, in many incineration and pyrolysis processes as well as fires, PVC can be considered a mainsource for the formation of dioxins and furans.
  - And finally in all fields, where wire soldering is used, the wide spread habit of removing wire sheathings with the hot soldering iron should strictly be avoided.

* De Fre and Rymen,(1989); HCl was injected into a hydrocarbon flame and

found to have an exponential relationship between the HCl and PCDD/PCDF concentrations (i.e., an increase in HCl caused an increase in PCDDs/PCDFs).

P* Theisen et al. (1989) and Christmann et al. (1989) Studies have shown that PCDDs/PCDFs are formed during the combustion of PVC and PVC-cable coatings.

P* Guigliano et al. (1989); PVC loading was increased in raw MSW from 0.5% to 10% by weight in a rotary kiln incinerator. PCDDs/PCDFs were not observed to increase in the combustion upstream of the APCD or in the bottom ash. The PVC feed composition did not have any effect on the formation of PAHs, or PCBs.

P* Under sponsorship of the New York State Energy Research and Development Authority (NYSERDA) (Visalli, 1987), a series of test burns was conducted at a Vicon modular excess air facility located in Pittsfield, MA. The effects of operating temperature, feed conditions, MSW with and without PVC, were evaluated for PCDD/PCDF levels in the flue gas and ash. A statistically significant correlation between PVC fed and levels of PCDD/PCDF at various locations in the incinerator could not be obtained. A slight increase in PCDFs was detected with PVC feed but no increase in PCDDs. The correlation was negative between PCDDs/PCDFs and incinerator temperature, and a positive correlation between PCDDs/PCDFs and CO levels was reported.

P* Linak et al. (1987): Test burns were conducted with 100% PVC in a rotary kiln incinerator. Many PICs were detected in the flue gas including dichlorobenzene, a PCDD/PCDF precursor, and OCDF. Test burns of 50% PE and 50% PVC produced additional precursors such as chlorobenzene and chlorophenols and four PCDD/PCDF congeners in high quantities. It was noted that the combustion of two different plastic resins (PE and PVC) shows that PCDD/PCDF intermediates can form during combustion.

* Data from MSW incinerator test programs at Pittsfield, NY as well as Prince Dwarf Island and Peeksill facilities were reviewed (Visalli 1987). No correlation between HCl and PCDD/PCDF levels was determined. It was concluded that because the chlorine available from all MSW sources is thousands of times greater that that required to account for PCDD/PCDF levels, it is extremely unlikely that PCDD/PCDF formation can be correlated with any single chlorine source. If chlorinated plastics were successfully removed from mixed MSW, the concentration of chlorine from other sources is many times greater than that required to account for all PCDDs/PCDFs present in MWC emissions was concluded from the study.