MULTI-POLLUTANT CONTROL TECHNOLOGY FOR THE CEMENT AND LIME INDUSTRY

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EPA's New Limits and The United States Cement Industry

- The EPA issued final rules for mercury, particulate matter and other pollutants resulting from Portland cement manufacturing as of August, 2010 to be effective as of 2013.

- These new rules establish limits on mercury emissions, strengthens limits on new kilns and sets limits to reduce acid gases. The mandate also limits particle emissions from all kilns as well as new limits for nitrogen oxides and sulfur dioxides.

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Final EPA Reduction Rules

- **National Emission Standard for Hazardous Air Pollutants (NESHAP)**
- Mercury- For existing facilities 55 lbs/million tons of clinker and for new facilities 21 lbs/million tons of clinker
- Total Hydrocarbons-24 Total Hydrocarbons ppmv for both existing and new facilities. Facilities have the alternative compliance option, where they would demonstrate compliance with a total organic HAP emission limit of 9 ppmv.
- Hydrochloric Acid- 3 ppmv for existing and new facilities.

- **New Source Performance Standard (NSPS)**
- Particulate Matter- .01 lbs per ton of clinker.
- Sulfur Dioxide- .04 lbs per ton of clinker.
- Nitrogen Dioxide-1.5 lbs per ton of clinker for all facilities.

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Potential Solutions for the Cement Industry Vary Among The Following:

- Activated Charcoal Injection
- Electro Static Precipitators/baghouses (fabric and membrane filters)
- Spray Tower/ Conditioning Tower
- Flue Gas Desulfurization
- Selective Catalytic Reduction
- Selective Non-Catalytic Reduction
- Regenerative Thermal Oxidizer
- FLS Mercury Roaster
- Various approaches relating to producing alternative cements and carbonates

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A Multi Pollutant Control Solution to EPA's Lower Emissions Standards

- CEFCO is an acronym for "Clean Energy Fuel Company"
- CEFCO has developed a complete multiple emission capture solution that will be warranted to allow any cement or lime plant to comply with all targeted emissions mandated by the EPA.
- This multi pollutant control process and technology will meet all lower emission levels but will also provide the user with a potential "Profit Center" based solution.

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The Solution is Based Upon A Combination of Existing Processes and Technology

- This Multi-Pollutant Control approach integrates two established and patented technologies:

- The “Ewan Technology” which has a proven record in the removal of metals, particulates, SOx, NOX, CO2 and acid neutralization from post air stack emissions.

- The “Cooper Process”, which has been proven successful in refining captured compounds producing metal oxides, fertilizers, pure CO2 and other products.

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Thomas K. Ewan (1918 – 2009)
Aerophysics Technology Advisor and Co-Inventor

Thomas Ewan served as a Technology Advisor to CEFCO until his passing in June 2009. Ewan, a Physicist, retired as Chief of Operations and Administration of the National Ordnance Aerophysics Laboratory of the DOD (Combined USAF, USN, USA, NASA: Aerodynamic Designs for Missiles, Air Frames, NASA Shuttles, etc.), and headed the Executive Committee of the Guided Missile Program of the National Research Laboratory, DOD. Ewan received a B.S. in Physics from the College of William & Mary. He co-authored and published "The Glossary of Guided Missile Terms" that was used by the Department of Defense. Ewan held several issued and deployed patents, including that for the "Free Jet" collision scrubbers, which have been in continuous use at Nuclear Regulatory Commission facilities for the handling and treatment of radioactive incineration off-gases, and toxic and acidic gases emissions. His technology has been recognized by the EPA as a standard component of the Hazardous Waste Combustors ("HWC") Maximum Achievable Control Technology ("MACT") for air emissions elimination.

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Hal B.H. Cooper
Chemical Engineering Advisor and Co-Inventor

- Hal Cooper serves as the Chief Chemical Science Officer of CEFCO and is a co-inventor. Dr. Cooper was a Professor of Civil Engineering and Environmental Engineering for eight years at the University of Texas at Austin and for two years at Texas A&M University. He taught courses on gaseous and particulate emission control, air quality chemistry and meteorology as well as on energy technologies and systems. He was active in various programs related to air pollution and air emissions control for the power industry and in the study of alternative energy technologies. Cooper received his Ph. D. in Civil Engineering in Environmental Engineering from the University of Washington in 1972, his M.S. in Civil Engineering in Environmental Engineering in 1966 from the University of Washington, and his B.S. in Chemical Engineering in 1963 from the University of California at Berkeley. He is a registered professional engineer. Cooper also worked as Sr. Consulting Engineer at Brown & Caldwell, ICF-Kaiser and Stone & Webster prior to co-founding the Company in 2006. He is an inventor with several issued patents. His motto is: “A pollutant is nothing but a misplaced, very valuable and recoverable resource”.

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Description of the Process

- The CEFCO Process is an integrated multi-pollutant capture system for flue gas for the control of specific pollutants in distinct and separate groupings;
- The Capture and Recovery of metals, particulate matter and acidic gases as an end product group
- The Capture and Recovery of SO2 as an end product group
- The Capture and Recovery of NOx as an end product group

- Steam or Air mixed with reagents such as Hydrogen Peroxide are combined with flue gases (post- bag house or ESP).
- This mixture passes through a combination of supersonic and subsonic nozzles within each of the four reactors in sequence.
- Ewan's Technology creates the sub-atmospheric and adiabatic reaction zone that enhances and enables intimate mixing of reagents and compounds.

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Description of the Process, cont.

- This extreme turbulence under controlled aerodynamic conditions provides near instantaneous chemical reactions facilitating efficient surface chemistry due to the free-jet collisions greater than Mach speed generated by the supersonic nozzles shock waves.

Upon entering the super sonic zone, the selected pollutants/reagents react and become encapsulated in micro water droplets. At this point, the mixture enters a subsonic chamber through a subsonic nozzle subjecting the mix to a drop in pressure. Here the targeted pollutants and reagents condense, collide and grow in size separating or "coalescing" the captured compounds in liquid form, stripping them aerodynamically and mechanically from the gas stream.

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Aerodynamics, Physics and Chemistry

- The CEFCO Process uses aerodynamics, physics along with chemistry to capture over 99% of all particulates, acids and metals, along with SOx, NOx and up to 90% of CO2, pursuant to the Ewan Technology.

- Once captured, the compounds are refined into rare earth metal oxides, potassium sulfate and potassium nitrate based fertilizers, and a pure form of CO2 pursuant to the Cooper Technology.

- Ewan's technology has been recognized by the EPA as HWC MACT for removal of particulate matter, acidic gases and metals.

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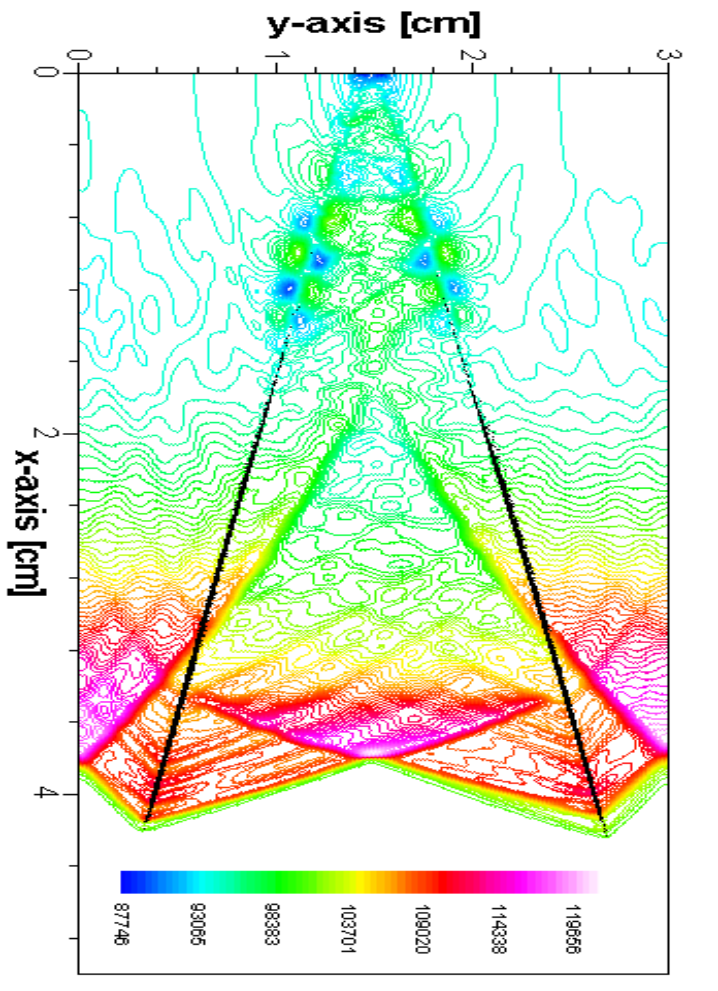
CEFCO Process in the Supersonic Shock Wave

Flue Gases move rapidly through the System

Reaction zones are governed by the speed of gas through the responsive distances of the sequential modules.

Time, Velocity, Temperature, Pressure and pH parameters determine the Targeted Reactions.

In each module steam is propelled at supersonic speeds generating multiple intense shock waves in terms of pressure and energy.



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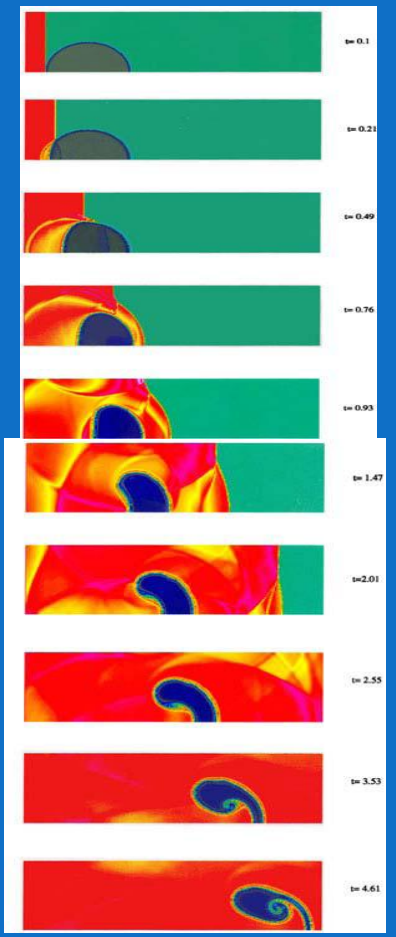
In the Supersonic Shock Wave

- Specific Reagents enter the shock wave as droplets and become shaped as “ribbons” or “strings” initially.
- These droplets contact the targeted molecules and reform into spherical shapes.
- The small size of the droplets enhances surface chemistry leading to outstanding reaction efficiencies.
- These droplets in combination with the treated gas exit via a sub-sonic nozzle and rapidly expand into a sub-atmospheric zone.



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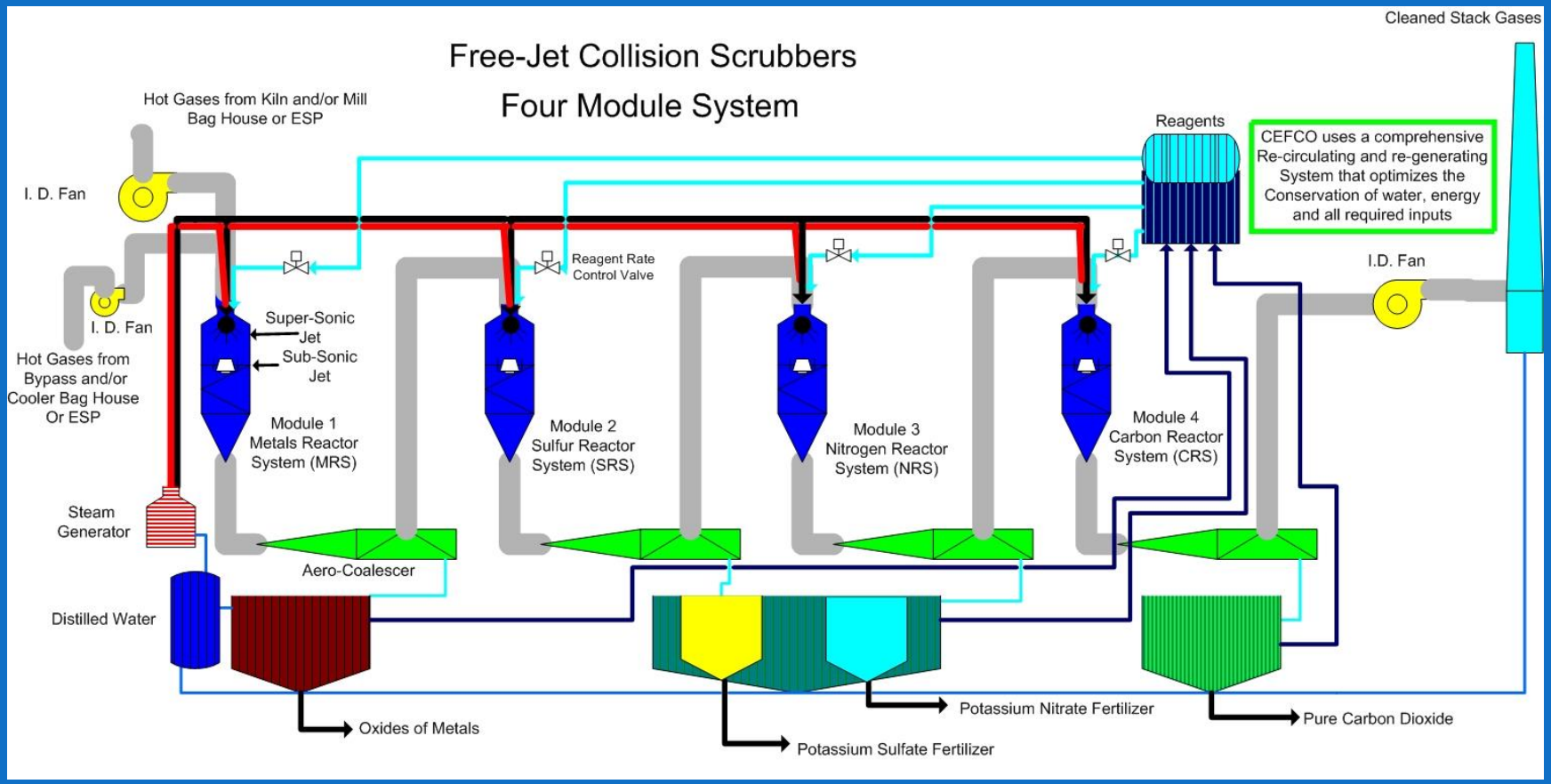
The CEFCO Process



Historical Evaluation of the Technology Preceding the CEFCO Process

- In 1977, Lone Star Steel's scientific advisors, Thomas Ewan and Jay Master, presented their paper titled, "Fine Particle Scrubbing with Lone Star Steel Hydro-Sonic Cleaners, The Coalescer" at The Second Fine Particle Scrubber Symposium sponsored by the EPA.
- This paper reports on Lone Star Steel's results from using the Free-Jet Collision Scrubbers which were developed by Thomas Ewan for fine particulate control which could also control SO2, and H2S.
- Lone Star Steel reported that they achieved "removal of hydrophobic fumed silica having a near uniform particle diameter of .007 microns"

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EPA's 1986 Evaluation of the Technology Preceding the CEFCO Process

- July 1986, the EPA publishes its, " Control of Air Emissions from Hazardous Waste Combustion Sources: Field Evaluations of Pilot-Scale Air Pollution Control Devices"
- The purpose of EPA's Project was, " to evaluate innovative air pollution control devices and to test their performances on commercial scale facilities."
- The host site was in El Dorado, Arkansas at ENSCO's hazardous waste incinerator, which primarily incinerates polychlorinated biphenyl (pcb) contaminated oils and capacitors.
- A pilot unit was installed to take off a slip stream of particulate-laden gas from the emergency bypass to be drawn through the unit.
- The EPA sampled inlet and outlet gas streams which were continuously monitored from the unit.

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EPA's 1986 Evaluation of the Technology Preceding the CEFCO Process, cont'd

- Three types of systems were evaluated;
- Three (3) different versions of the Free-Jet Collision nozzles and systems developed by Thomas Ewan, i.e. The Steam Hydro, the Tandem and the SuperSub versions of nozzles.
- ETS Inc. — which used a dry lime injection for particulate capture.
- Vulcan Engineering — using a high temperature metallic weave filtration system.

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EPA's 1986 Findings of the Technology Preceding the CEFCO Process, cont'd

- Of the three ACPD's tested the tandem SuperSub nozzles as developed by Thomas Ewan gave the best overall performance in terms of HCl, particulate matter and to accommodate variability in gas streams. However according to the EPA all three of the Free-Jet collision units tested, "achieved excellent HCL control"
- "Ninety-nine percent of HCL was obtained without adding additional alkalinity,"
- "with additional alkalinity any of these units should be capable of well over 99% HCL removal."
- The EPA reported that the wet scrubber system has been used to control emissions from iron and steel making operations, it has been used on electric arc furnaces, coke oven emissions, open hearth steel furnaces and sintering plants.
- The EPA also reported that "the scrubbers have also been used on exhaust streams containing uranium hexafluoride and its hydrolysis products with particulate removal efficiency consistently exceeding 99%."

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EPA's 1997 (Region 7) — Times Beach, Missouri Findings

- In Times Beach, Missouri — a rotary kiln incinerator was operated from March 1996-June 1997 as part of an EPA mandated "Superfund" remedial action to treat dioxin-contaminated soils, rocks, asphalt and other materials with a removal efficiency requirement of 99.9999%.
- The incineration system comprised of a solid waste feed system; a rotary kiln with an oxygen- enhanced burner, a secondary combustion chamber and a wet gas cleaning system.
- Resulting ash from the incinerator was removed, cooled and placed into a land fill with off-gases drawn into the secondary combustion chamber.
- The exit gases from the secondary combustion chamber were drawn into the gas cleaning system which used two Thomas Ewan's Free-Jet Collision Scrubbers "designed to remove gases, particulate matter, and acid gases before discharge into the atmosphere."
- According to the EPA report, "During its 16 months of operation, the incinerator processed approximately 265,000 tons of contaminated material. Treatment performance and emissions collected during this application indicate that all performance standards were achieved."

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1981 DOE Report, "Hazardous and Radioactive Waste Incineration Studies at Los Alamos"

- April 2, 2009 DOE declassifies a 1981 Los Alamos National Laboratory Report which relates to only one aspect of the CEFCO Process, i.e. the Ewan Free-Jet Collision Technology.

1981 DOE Report, “Hazardous and Radioactive Waste Incineration Studies at Los Alamos

- The Abstract of the Report says, “A production scale controlled air incinerator using commercially available equipment and technology has been modified for solid radioactive waste service. This unit successfully demonstrated the volume reduction of transuranic (TRU) waste with an average TRU content of about 20 nCi/g. The same incinerator and off gas treatment system is being modified to further evaluate the destruction of hazardous liquid wastes such as polychlorinated biphenyls (PCB) and hazardous solid wastes such as pentachlorophenol (PCP)- treated wood.”

- The Summary provides, “ Modification of commercially available equipment and technology for radioactive service and production scale incineration of TRU-contaminated wastes were successfully demonstrated. Further modifications are presently underway to incorporate incineration studies of hazardous solid and liquid wastes into the Los Alamos CAI development program. Additional current efforts include documentation of the CAI design, operating procedures, and process data generated during the experimental campaigns. Technology transfer has and will remain an important object of the program.”

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Recent History

- April 26, 2010 – CEFCO designates Box International as the exclusive representative to distribute the CEFCO Process to the North American cement and lime industries.
- May 26, 2010 – Box International presents a technical paper to the Global Fuels Conference for the Cement and Lime Industries in Washington D.C.
- June 20, 2010 – edition of Global Cement Magazine references the presentation such that, if the commercial viability of the CEFCO Process is established, the technology has the potential to change the world.
- July 12, 2010 – Peerless Manufacturing (Stock Symbol: PMFG) enters into agreement with CEFCO to become its exclusive manufacturer of the CEFCO System for the U.S.
- August 30, 2010 – Peerless commences to build a Lab Scale Protocol of the CEFCO Process, leading to a Production Prototype in the Spring of 2011.

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Future Plans for CEFCO

- A production prototype is being developed in Wichita Falls, Texas which will demonstrate the degree and extent of CEFCO's Multi-Pollutant Capture System to capture PM, Acidic Gases and Metals, along with SOx, NOx and CO2 which will allow any U.S. based cement or lime plant to be compliant with NSPS and NESHAP and Cement MACT.

- The prototype will also demonstrate the System's ability to refine the above captured compounds into rare earth metal oxides, potassium sulfate and potassium nitrate fertilizers, and CO2 related products.

- Once the production prototype is developed, demonstrations will be arranged.

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Design, Installation and Operations

- Stack emissions and mass weight values from each plant are determined in order to size and scale the CEFCO System modules and to determine budgetary costs, operating margins and reagents usage.
- Based upon the various captured compounds and quantities of end-products captured and converted, the superior economic advantages of the CEFCO System will be shown.
- Once specific requirements and site conditions are resolved the system and process equipment are designed, fabricated and installed at the plant.

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Conclusion

- Progress continues with the development of the Lab Scale Protocol and Production Prototype.
- Other solutions offer partial compliance which represent only cost-center based partial solutions as compared to the CEFCO Process.
- While there are a wide range of other industrial applications, the Cement and Lime Industry need a total, complete and final solution for EPA's new compliance mandates.
- The CEFCO System is a multi-pollutant capture system that will be warranted to allow any cement or lime plant to comply with all of the EPA's new emission levels while providing a potential revenue stream for its users and this solution may represent a paradigm shift for the cement industry regarding total air emissions compliance and management.

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Links to Resources

- CEFCO's website
- www.cefcoglobal.com

Peerless Manufacturing
www.peerlessmfg.com

- BOX's website
- www.boxinternational.com

- US EPA sources
- http://nepis.epa.gov/Exe/ZyNET.exe?ZyActionL=Register&User=anonymous&Password=anonymous&Client=EPA&Init=1
- *When searching for EPA publications by number, remove "EPA" and special characters (spaces, "-"s, etc.); for example,* ***EPA-833-R-08-001*** *becomes* ***833R08001***

- ***1977 report - search directory for 600277193 paper #16 page 319***
- ***1986 report – search directory for 600286011***
- ***1997 Times Beach incineration http://www.clu-in.org/products/costperf/incinrtn/default.htm#14***
- ***then look for Times Beach on list***
- ***US DOE source***
- ***1981 report on Los Alamos released (declassified 2009)***
  http://www.osti.gov/bridge/purl.cover.jsp?purl=/6489558-W71tjd/

- ***Please call should you have questions or need further assistance with the above***

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