The Effect of Process Differences on System Removal Efficiencies (SREs) and the Fate of Metals in Cement Kilns

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ABSTRACT

This paper examines cement kiln parameters in relation to metal system removal efficiencies (SREs) and the resulting effect concerning the fate of the BIF metals in cement kilns. Data from the 1992 Boiler and Industrial Furnace Certification of

Compliance (BIF COC) test results are the basis for the report. In particular, the paper examines SREs versus chlorine input, chlorine gas emissions, hydrogen chloride emissions, particulate emissions and air pollution control device inlet temperature. A multi-variant regression analysis is utilized to determine interaction between these various parameters. The paper builds a strong case that additional metals spiking during post COC compliance/trial burn testing is unnecessary. In addition, no statistically significant correlation was found between metals emissions and the various parameters which have historically been presumed to affect metals emissions and the fate of metals in cement kilns.

INTRODUCTION

Metals spiking and metals emissions testing were conducted in 1992 at Holnam's Holly Hill, South Carolina facility as required by the Environmental Protection Agency (EPA) boiler and industrial furnace (BIF) rules 266.103(c). Certification of Compliance (266.103(c)(1) for metals under BIF requires that: "The owner or operator shall establish limits on...(ii) Feed rates of each metal in the following feedstreams (A) Total feedstreams...(B) Total hazardous waste feed...and (C) Total pumpable hazardous waste feed;" Compliance testing for metals was also conducted in accordance with 266.106 Standards to Control Metals Emissions.

Also noted in the BIF rules, under 266.103(d), is the requirement for periodic recertification which must occur "...within three years from submitting the previous certification or recertification."It is of significant interest to note that EPA provides a rationale for requiring recertification in the BIF Preamble on page 7182 (FR 56, 2-21-91) whereby it is stated that "EPA is requiring recertifications <u>primarily to ensure that air pollution control systems do not deteriorate over time</u>." (emphasis added) While this report examines several factors associated with BIF metals compliance, this preamble language clearly indicates that by demonstrating that an air pollution control system has not deteriorated over a three year period, the primary EPA regulatory compliance goal has been met. Recertification is also necessary if "The owner or operator seeks to recertify compliance under new operating conditions..." (266.103(d))"

The Holnam, Holly Hill facility has a history of examining the fate of BIF metals in the cement manufacturing process, as evidenced by participation in a study presented at a 1990 Air & Waste Management Association conference. The paper was entitled <u>The Fate of Trace Metals in the Wet Process Cement Kiln</u>, and the study was undertaken to examine metals under baseline and hazardous waste fuel burning conditions.

A part of the BIF Precompliance Certification (Certification of Precompliance, or COP) was to estimate system removal efficiencies (SREs) for the various BIF metals and then to confirm those estimated SREs later during the Certification of Compliance (COC) testing. SREs were established in accordance with 40 CFR 266 Appendix IX, Section 8.0 Procedures for Determining Default Values for Air Pollution Control System Removal Efficiencies. Part of the SRE determinations involved consideration of the partitioning of the metals in the cement manufacturing process. Metals partitioning was taken into consideration, SREs were established and metal feed rate limits were set to insure that Holnam would be in compliance with the limits established during COC testing. The high quality of the data used to calculate those SREs was evident by the successful metal balance completed for the COC report.

CEMENT MANUFACTURING

The manufacture of cement begins with digging raw materials out of the ground. At Holly Hill, the primary raw materials are marl and clay, which are quarried on site and fly ash from coal fired power plants. These oversized "rocks" are scooped up by industrial size loaders (larger than a one story building), loaded onto trucks big enough to fit several cars into the bed and then dumped into an impact crusher. This impact crusher reduces the size of the mammoth rocks down to less than six inches in size. These reduced raw materials are then fed into a secondary crusher, which reduces them to almost dust size proportions. These thoroughly crushed raw materials are then metered on a conveyor belt scale into a ball mill. Water is also metered into the raw materials to form a thick, mud-like raw material feed called slurry. This slurry is stored in large agitated vessels until it is fed to the kiln for the cement manufacturing process. The Holly Hill facility has six slurry tanks that are used to blend the slurry to desired specifications and two slurry tanks that feed the kilns. The slurry tanks that feed the kilns hold over two-million gallons each. Consistency in the raw feed/slurry mix to the kiln is critical to the production of quality clinker. Feeding the cement manufacturing process from storage tanks containing two-million gallons of blended raw material mix allows for an extraordinarily consistent raw material feed to the kiln. This wet slurry from the two slurry feed tanks is fed to kiln 1 at the rate of approximately 80 tons per hour and kiln 2 at approximately 165 tons per hour. To give this some additional perspective, 80 tons per hour equals 160,000 pounds per hour, or approximately 10,000 gallons of liquid, and 165 tons per hour equals 330,000 pounds per hour, or approximately 20,000 gallons of liquid. Multiplying these values by 24 hours in a given day equates to approximately one quarter of a million gallons of liquid for kiln 1 and approximately a half million gallons in kiln 2, enough material to fill a small lake in just one day. In a given year, a combined total of over two-million tons of slurry are used to manufacture cement at the Holly Hill facility.

It takes a tremendous amount of heat to turn that much raw material into the cement product called clinker. Towards that end, approximately ten tons of coal per hour is fed to kiln 1 and approximately 18 tons per hour to kiln 2. This tonnage would be the approximate amount fed to these kilns without the benefit of hazardous waste fuel. This amount of coal fed to the kiln equals roughly 240 tons per day for kiln 1 and 430 tons per day for kiln 2. One U.S. government estimate is that one ton of coal is equal to approximately 6,500 kilowatt hours of electricity. It is further estimated that an average home in the Midwest uses an average of approximately 800 kilowatt hours per month. The coal used to manufacture cement in a given 30 day period for kiln 1 would satisfy the electrical requirements of approximately four thousand, eight hundred and sixty homes for one year and eight thousand, seven hundred and thirty homes per year for kiln 2. It is pertinent to note at this point that use of waste solvents as hazardous waste fuel can reduce the Holnam Holly Hill facility natural resource (coal) energy consumption by approximately 50%. Through this conservation of natural resources on kiln 1, enough virgin fuel (coal) is conserved in a given 30 day period to potentially satisfy the electrical requirements of nearly five thousand homes for one year and nine thousand homes per year for kiln 2. Quite a feat of natural resource conservation.

Use of waste solvents as fuel not only conserves natural resources but is also considerate of human health and environmental impacts. A recent life cycle analysis has found that the use of hazardous waste as fuel at one cement kiln in Texas "overall appears to result in less health and environmental impacts" than using conventional fuel. (*Comparative Life Cycle Analysis of Cement made with Coal vs. Hazardous Waste as Fuel*; K. Kelly & J. Beech) The life cycle analysis evaluated potential adverse health effects for cement kiln workers, waste transporters, and consumers using the final product. All aspects of the process were included.

METAL FATE RESULTS FROM COC TESTING

Tables 1 thru 12, in Appendix 1, present data for each metal which includes the metal(s) concentration in each feedstream that went into the cement kiln system (System Metal Inputs) during the 1992 COC testing, the concentration of metals that came out of the kiln system in either the wasted dust, the cement manufacturing product known as clinker or the emitted dust (System Metal Outputs) and the partitioning factors for both kilns 1 and 2 at the Holly Hill facility.

In the COC, default values were used for Tier IA metals, which basically assumes all of a given Tier IA metal coming into the cement manufacturing process/kiln system goes through the kiln and out the stack. This would obviously be the absolute worst case scenario. The Tier IA metals are silver (Ag), barium (Ba), mercury (Hg), and thallium (Tl). Default values were also used for nickel (Ni) and selenium (Se), which were included as compliance metals as per EPA Region IV request. None in this group of metals were spiked. The fact that these metals were not spiked is readily discernible in Tables 1 thru 12 in that a zero is entered in the percent in (Pct In) column under the spike heading for kilns 1 and 2.

Arsenic (As), beryllium (Be), cadmium(Ca), chromium (Cr), lead (Pb) and antimony (Sb) were BIF metals that were spiked. Spiking these metals helped reduce potential analytical detections problems and demonstrate BIF metals compliance even at worst case, elevated metals input into the system.

Tier IA Metals (not spiked)

These metals were not spiked into the cement manufacturing/kiln system and consequently, metals concentrations were frequently at or below the analytical detection limit. This limitation is primarily responsible for some of the large differences in input/output percentages between kiln 1 and kiln 2. Nevertheless, some basic trends did emerge. The Tier IA metal results also underscore the conservative nature of assuming that all of a given Tier IA metal that enters the system exits through the stack emissions. Significant percentages of each Tier IA metal were retained in the cement manufacturing product (clinker), and cement kiln dust captured by the air pollution control device (APCD) captured cement kiln dust.

Silver. Up to ninety percent of the Ag concentration input into both kiln 1 and kiln 2 came from the product raw material (slurry). Given that the levels detected approached the analytical detection limit, it is difficult to be more specific. Even though for compliance purposes, all of the Ag input into the system was assumed to exit the system through the stack, the minimum silver SRE for kiln 1 and 2, from the COC test, was 99.89% and 97.7% respectively and at least 48% of the silver input into the system was retained in the product (clinker). On average, 0.11% of the Ag that was input into the system was emitted from the stack.

Barium. At least sixty percent of the Ba concentration input into both kiln 1 and kiln 2 came from the product raw material (slurry). It is significant to note that even though Tier IA default values assume that all of the Ba that enters the kiln system exits through the stack, the minimum Ba SRE for kiln 1 and kiln 2, from the COC test, was 99.86% and 99.98% respectively while at least 70% of the barium input into the system was retained in the product (clinker). On average, 0.01 to 0.08% of the barium that was input into the system was emitted from the stack.

Mercury. Up to seventy eight percent of the Hg concentration input into both kiln 1 and kiln 2 came from the product raw material (slurry). Given that the levels detected approached the analytical detection limit, it is difficult to be more specific. Yet even though mercury is widely recognized as a volatile metal and Tier IA default values assume that all of the Hg that enters the kiln system exits through the stack, as much as 40% of the mercury input into the system may have been retained in the product (clinker). At least 50% of the Hg that was input into the system was emitted from the stack.

Thallium. Up to seventy three percent of the Tl concentration input into both kiln 1 and kiln 2 came from the product raw material (slurry). Given that the levels detected approached the analytical detection limit, it is difficult to be more specific. However, even though Tier IA default values assume that all of the Tl that enters the kiln system exits through the stack, up to 70% of the thallium input into the system was retained in the product (clinker). Over ten times as much thallium was retained in the dust as was emitted.

Nickel. Over sixty four percent of the Ni concentration input into both kiln 1 and kiln 2 came from the product raw material (slurry). It is significant to note that even though Tier IA default values assume that all of the Ni that enters the kiln system exits through the stack, the Ni SREs for kiln 1 and kiln 2, from the COC test , were 99.93% and 99.99%

respectively with at least 78% of the nickel input into the system retained in the product (clinker). On average, 0.05% from kiln 1 to 0.01% from kiln 2 of the Ni input into the system was emitted from the stack.

Selenium. Up to ninety percent of the Se concentration input into both kiln 1 and kiln 2 came from the product raw material (slurry). Given that the levels detected approached the analytical detection limit, it is difficult to be more specific. It is significant to note however, that even though Tier IA default values assume that all of the Se that enters the kiln system exits through the stack, the minimum Se SREs for kiln 1 and kiln 2, from the COC test, were 91.44 and 96.76% respectively with up to 30% of the selenium input into the system retained in the product (clinker). At least 68% was retained in the wasted cement kiln dust (CKD). A significantly greater amount of the Se input into the system was retained in the dust than was emitted from the stack.

It becomes quite clear that significant concentrations of the Tier IA metals, silver (Ag), barium (Ba), mercury (Hg), thallium (Tl), nickel (Ni), and selenium (Se) may be retained in the clinker and CKD, even though all Tier IA metals that enter the kiln system are assumed to exit the system through the stack, for regulatory compliance purposes. Again, it underscores the conservative nature of this approach.

Spiked Metals

Arsenic (As), beryllium (Be), cadmium (Cd), chromium (Cr), lead (Pb) and antimony (Sb) were BIF metals that were spiked. The largest percentage concentration for As, Be, Cr and Sb ended up in the cement manufacturing product (clinker) rather than the cement kiln dust (CKD). The exact opposite was the case for Cd and Pb, which both overwhelmingly ended up in the wasted CKD. Overall, for this group of metals, a very low proportion of what was input into the system was actually emitted. The first four metals to be discussed are the carcinogenic metals, which had a limit that added all four metals together.

Arsenic. In the case of arsenic (As), at least 60% of the arsenic input into the cement manufacturing/kiln system entered as spiked material. At least 70% of the arsenic input into the system ended up in the clinker. The minimum arsenic SREs for kiln 1 and kiln 2, from the COC test, was 99.968% and 99.986% respectively while approximately 0.04% or less was emitted.

Beryllium. In the case of beryllium (Be), approximately 70% of the beryllium input into the cement manufacturing/kiln system entered as spiked materials. At least 77% of the beryllium input into the system ended up in the clinker. The minimum beryllium SREs for kiln 1 and kiln 2, from the COC test was 99.92% and 99.99% respectively while approximately 0.08 % or less was emitted.

Cadmium. In the case of cadmium (Cd), approximately 90% of the cadmium input into the cement manufacturing/kiln system entered as spiked material. At least 90% of the cadmium input into the system ended up in the wasted CKD. The minimum cadmium SREs for kiln 1 and kiln 2, from the COC test, was 99.31% and 99.798% respectively while approximately 0.7% or less was emitted.

Chromium. In the case of chromium (Cr), approximately 80% of the chromium input into the cement manufacturing/kiln system entered as spiked material. Approximately 80% of the chromium input into the system ended up in the clinker. The minimum chromium SREs for kiln 1 & 2, from the COC test, was 99.987% and 99.995% respectively while approximately 0.07% or less was emitted.

It is significant to note that all detected chromium was required to be considered as the regulated entity of hexavalent chromium. Although 65% of the allowed total of carcinogenic metals added together was attributable to total chromium being considered as hexavalent chromium, in actuality only 1% of the emitted metals was attributable to hexavalent chromium or 64% less than the highly conservative BIF requirement. Again, this emphasizes the conservative nature of this approach.

Lead. In the case of lead (Pb), at least 86% of the lead input into the cement manufacturing/kiln system entered as spiked material. Approximately 98% of the lead input into the system ended up in the wasted CKD. The minimum lead SREs for kiln 1 & 2, from the COC test, was 99.52% and 99.73% respectively while less than 0.5% actually emitted.

Antimony. In the case of antimony (Sb), at least 95% of the antimony input into the cement manufacturing/kiln system entered as spiked material. Approximately 77% of the antimony input into the system ended up in the clinker. The minimum antimony SREs for kiln 1 & 2, from the COC test, was 99.98% and 99.99% respectively while 0.02% or less was emitted.

It is quite evident, by comparing the metal input percentages, that metals spiking successfully maximized metal input into the cement manufacturing/kiln system and more than adequately achieved a true worst case scenario for COC testing purposes. It is also just as evident that the bulk of the spiked metals, As, Be, Cr, and Sb exited the system in the CKD. It is particularly significant to note that even though these metals were being spiked to achieve a worst case metals input scenario, the compliance limits established during the COC were considerably lower than the limits allowed for by BIF.

CEMENT MANUFACTURING/KILN SYSTEM CONSISTENCY AND COMPLIANCE TESTING

As discussed previously, the raw material mix fed to the cement kilns at the Holnam Holly Hill facility is highly consistent. Feeding the kiln from a two-million gallon slurry storage tank helps to insure the needed consistency. In addition, the quality assurance/quality control activities in the cement manufacturing analytical laboratory are an integral part of insuring the consistency of the slurry. Necessary periodic adjustments are made in the smaller slurry blend tanks as needed before being fed into the mammoth kiln feed tanks. This consistency in raw material feed contributes to the consistency of the clinker product but quality clinker is also the product of a consistent cement manufacturing process. This is a day to day consistency that translates into a consistency from week to week, month to month and ultimately year to year. Compliance testing results achieved/obtained in 1992 would be essentially the same in 1993, 1994, 1995, et cetera. This consistency would seem to preclude the need to repeat identical compliance testing from 1992 again in 1995.

As noted in the introduction of this report, BIF does require periodic recertification"...within three years from submitting the previous certification or recertification." (266.103(d)), but it is of particular significance to note that the rationale for requiring recertification is provided in the BIF Preamble whereby it is stated that "EPA is requiring recertifications <u>primarily to ensure that air pollution control systems do not deteriorate over time"</u> (emphasis added) (FR 56, 2-21-91, page 7182). This preamble language clearly indicates that by demonstrating that an air pollution control system has not deteriorated over a three year period, the primary EPA regulatory compliance goal has been met. Since cement kiln APCDs are solely designed to control PM emissions it would seem that the only compliance test necessary would be periodic particulate testing.

It is also significant to note that there are consistencies within the cement manufacturing process itself. These consistencies are different from other industrial combustion process such as hazardous waste incinerators or municipal waste combustors. Emission differences between cement kilns and incinerators are highlighted in a report entitled *A Comparison of Metal Emissions from Cement Kilns Utilizing Hazardous Waste Fuels with Commercial Hazardous Waste Incinerators* (presented at the Dec. 1993 Rock Products conference). In particular, the concentration of metals in emitted particulate matter are much higher from incinerators than from cement kilns. The report also discusses how cement kilns, by the very nature of their design and operation, employ a highly effective means of metal emission control, namely dry sorbent adsorption. Dry sorbent adsorption is the technique of injecting relatively inert fine particulate to act as a medium for volatile metal condensation and capture.

For this metals fate study, data from 33 cement kilns has been analyzed for five BIF metals that were spiked as part of the 1992 BIF Certification of Compliance testing process. In particular, system removal efficiencies were examined and then compared to various BIF compliance parameters. The consistencies within the cement manufacturing process become evident upon review of the data graphically represented in Appendix 2. Emissions at the Holnam Holly Hill facility were well below the BIF limitations. This was consistent all across the hazardous waste burning cement kiln universe. Lead and cadmium were the metals with the lowest SREs for the Holnam Holly Hill cement kiln. This is consistent with the 33 kilns which spiked both lead and cadmium. Of the 33 that spiked both metals, lead was the metal with the lowest SRE for 14 of the kilns and cadmium was the metal with the lowest SRE for 16 of the kilns. Clearly, if it were necessary to spike metals beyond the 1992 COC testing, Pb and/or Cd would be truly representative of worst case metals.

SYSTEM REMOVAL EFFICIENCIES

A system removal efficiency (SRE) was determined for each metal, as part of the COP, by using best engineering judgement as per 266.103(b). Those SREs were then validated and or modified during the COC testing. SREs were determined for 24 cement manufacturing BIFs during the 1992 COC testing. The SREs determined for each of five BIF metals that were spiked into the cement manufacturing/kiln system at all 24 BIF facilities, As, Be, Cd, Cr, & Pb have been examined in comparison to the chlorine input, Cl_2 emissions, particulate matter (PM) emissions, kiln exit temperature & HCl emissions. These comparisons are graphically demonstrated in Appendix 2. What becomes obvious with a cursory review of the various parameters as compared to SREs is the scatter graph arrangement of the various data points with no apparent direct or inverse relationship.

Chlorine input vs. SREs

Chlorine input was normalized to gas flow rates in order to best evaluate the system relative to the chlorine concentrations in the system over a given unit of time. Ideally, the size of the kiln would have been considered but this was not readily available in all cases, stack gas flow rate was available. Chlorine input of zero to 150 g/sec, normalized to cement kiln gas flow rates, clustered in the 99.9 to 100% average SREs for arsenic, near 100% average SREs for beryllium, between 99 to 100% average SREs for cadmium, 99.98 to 100% average SREs for chromium and 99 to 100% average SREs for lead. There appeared to be no direct relationship between chlorine input, normalized for gas flow rates, and cement kiln SREs for any metal.

Cl_2 emissions vs. SREs

Cl_2 emissions ranging from 0.001 to nearly 10 lb/hr clustered in the narrow range of 99.9 to 100% average SREs for arsenic, very nearly 100% average SREs for beryllium, 99 to 100% average SREs for cadmium, 99.94 to 100% SREs for chromium and 98.5 to 100% average SREs for lead. It is quite obvious that over a wide range of Cl_2 output, there was a very narrow range for the SREs . There appears to be no direct relationship between chlorine emissions and cement kiln metal SREs.

Particulate Matter (PM) vs. SREs

PM emission ranging from approximately 0.001 to 0.1 grains per dry standard cubic foot (gr/dscf) clustered between 98.5 to 100% average SREs for lead, between 99.9 to 100% average SREs for arsenic, around 100% average SREs for beryllium, between 98.8 to 100% average SREs for cadmium and 99.97 to approximately 100% average SREs for chromium. There appears to be no direct relationship between particulate matter emissions and cement kiln metal SREs.

Kiln Exit/APCD inlet temperature vs. SREs

The majority of BIF cement kilns have exit temperatures in the 400 to 600^{o} F range. In that kiln exit/APCD inlet temperature range, average SREs for arsenic fell into the narrow band of 99.9 to 100%, approximately 100% for beryllium , 99 to 100% for cadmium, 99.94 to nearly 100% for chromium and 99 to 100% for lead. There appears to be no relationship between kiln exit temperature and cement kiln metal SREs.

HCl vs. SREs

HCl emissions varied from .01 to slightly above 100 lb/hr in the narrow band of 99.9 to 100% average SREs for arsenic, approximately 100% average SREs for beryllium, 98.8 to 100% average SREs for cadmium, 99.4 to 100% average SREs for chromium and clustered in the 99 to 100% average SREs for lead. There appears to be no relationship between HCl emissions and cement kiln metal SREs.

Multi-Variant Regression Analysis

It is clear from the data just presented that there is no correlation between the parameters of normalized chlorine input rate, Cl_2 emissions, particulate emissions, HCl emissions, and kiln exit/APCD inlet temperatures and SREs. To examine the possible interrelationship(s) between these various parameters, a multi-variant regression analysis was conducted. This multi-variant regression analysis of the six independent variables: normalized chlorine input rate, Cl_2 emissions, particulate emissions, HCl emissions, and kiln exit/APCD inlet temperatures against each of the six dependant variables, As, Be, Cd, Cr, and Pb reveals no statistically significant correlations.

The cement manufacturing/kiln system parameters of chlorine input, Cl_2 emissions, PM emissions, kiln exit temperature and HCl emissions addressed in the BIF regulations do <u>not</u> have any direct correlation to metals emissions. The apparent lack of any relationship between these BIF parameters and metals emissions raises the question of the appropriateness of any of these parameters in regards to setting regulatory limits.

DISCUSSION

Consider that the overall cement kiln data presented in the previous section indicates that it is the cement manufacturing process itself that most directly affects SREs in cement kilns. In fact, the single plant with the poorest SREs was a Lepolt grate facility. The Lepolt grate kiln has greatly reduced amounts of dust in the cool end which reduces the opportunity for metals adsorption. The inherent physical/chemical conditions in the cement manufacturing process required to produce cement clinker dictates that the metal SREs will fall within a narrow range. This is demonstrated by the "Pct In" numbers in Tables 1 thru 12, where metals spiking successfully achieved worst case scenarios for Certification of Compliance testing. Yet even under the worst case metals spiking load to the cement manufacturing/kiln system, emissions stayed within the required BIF limits, in some cases several orders of magnitude lower.

The definitive data presented from the 1992 COC testing coupled with the consistencies within the cement manufacturing process itself combine to strongly indicate that there is no need for additional metals testing as part of either a 1995 COC recertification or a Trial Burn. This rationale is firmly supported in 270.22(a)(6) *Data in lieu of trial burn.* "The owner or operator may seek an exemption from the trial burn requirements to demonstrate conformance with 266.104 through 266.107 ...and 270.66 by providing the information required by 270.66 from previous compliance testing of the device in conformance with 266.103 ...or from compliance testing or trial or operational burns of similar (BIFs) burning similar hazardous wastes under similar conditions..." Further along in this same BIF regulatory passage, it is stated that "The Director shall approve a permit without a trial burn if he finds that the hazardous wastes are sufficiently similar, the devices are sufficiently similar, the operating conditions are sufficiently similar, and the data from other compliance tests, trial burns, or operational burns are adequate to specify (under 266.102...) operating conditions that will ensure conformance with 266.102(c)..." (emphasis added). In the case of the Holly Hill kiln(s), the hazardous wastes are more than sufficiently similar, they are essentially identical; the cement kiln(s) are not only sufficiently similar, they are virtually identical being as they are the exact same devices; the operating conditions are not to be significantly altered; and compliance with 266.104 thru 266.107 will be appropriately achieved.

With the promulgation of the BIF rules, EPA sought to "...control emissions of toxic organic compounds, toxic metals, hydrogen chloride, chlorine gas, and particulate matter from (BIFs)." (BIF introductory Summary, FR 56 2-21-91, pg. 7134) In order to achieve these stated goals, EPA relied on the available data at the time, which was almost exclusively hazardous waste incinerator based. That a cement kiln is not operationally similar to an incinerator is still a point of contention today. However, it becomes clear from the data presented in this report that the inherent physical/chemical conditions in the cement manufacturing process required to produce cement clinker dictates the controls that EPA seeks. This is particularly well illustrated by the graphically represented data comparing SREs to the cement manufacturing/kiln system parameters of normalized chlorine input rate, Cl_2 emissions, particulate emissions, HCl emissions, and kiln exit/APCD inlet temperatures. Metal SREs fall within a narrow range across the universe of cement kilns that burn hazardous waste, even though that universe includes 24 different kilns and represents a number of variations in the cement manufacturing process, including different kiln exit temperatures, particulate emission rates, gas flow rates, etc..

This report demonstrates that the metal emissions data from the 1992 BIF COC tests do in fact represent worse case scenarios, yet the required BIF emission limits were met. In addition, the cement manufacturing process is quite consistent from day to day, week to week, month to month and year to year. The consistency in slurry alone is extraordinary. The cement manufacturing process itself dictates the type of control sought by EPA with promulgation of the BIF rules, as evidenced by narrow variation in metals SREs as compared to widely varied and numerous BIF parameters. In short, this report strongly indicates that the COCs metals data collected in 1992 is representative of a worst case scenario from a highly consistent manufacturing process (cement clinker) in which the cement manufacturing process itself dictates metals emission controls and consequently, there is no need to repeat the extensive and complex COC metals testing for either recertification or trial burn. Using previous data and not spiking metals also provides for a significant improvement in risk to human health and the environment by eliminating the need for repeated handling of concentrated metals solution that was necessary to effect the original COC metals spiking.

Holnam - Holly Hill 1992 BIF Compliance Test / Trial Burn

Silver

System Metal Inputs

Kiln 1	Slurry Feed			Coal/Coke Feed			HFL			Spike		Total In (lb/hr)	
	ppm	lb/hr	Pct In	ppm	lb/hr	Pct In	ppm	lb/hr	Pct In	lb/hr	Pct In	min	max
Run 1	1.69	0.430222	95.1	0.305	0.004498	1.0	3.05	0.017785	3.9	0	0	0.452505	0.452505
Run 2	< 1.12	< 0.285118	92.9	< 0.25	< 0.003687	1.2	3.11	0.018135	5.9	0	0	0.018135	0.306939
Run 3	< 1.12	< 0.285118	93.9	< 0.25	< 0.003687	1.2	2.52	0.014695	4.8	0	0	0.014695	0.303499
Average	< 1.31	< 0.333486	94.0	< 0.268333	< 0.003957	1.1	2.893333	0.016872	4.9	0	0	0.016872	0.354314
Range	0.57	0.145104		0.055	0.000811		0.59	0.00344		0			
Std Dev	0.268701	0.068403		0.025927	0.000382		0.265121	0.001546		0			
Composite	1.48	0.376762	95.5	< 0.25	< 0.003687	0.9	2.42	0.014111	3.6	0	0	0.390874	0.394561

Kiln 2	Slurry Feed			Coal/Coke Feed			HFL			Spike		Total In (lb/hr)	
	ppm	lb/hr	Pct In	ppm	lb/hr	Pct In	ppm	lb/hr	Pct In	lb/hr	Pct In	min	max
Run 1	< 1.3	< 0.653614	93.6	< 0.25	< 0.004249	0.6	1.77	0.0404	5.8	0	0	0.0404	0.698263
Run 2	< 1.03	< 0.517864	94.9	< 0.25	< 0.004249	0.8	1.04	0.023738	4.3	0	0	0.023738	0.545851
Run 3	< 1.18	< 0.593281	95.3	< 0.25	< 0.004249	0.7	1.11	0.025336	4.1	0	0	0.025336	0.622865
Average	< 1.17	< 0.588253	94.6	< 0.25	< 0.004249	0.7	1.306667	0.029825	4.7	0	0	0.029825	0.622326
Range	0.27	0.135751		0	0		0.73	0.016662		0			
Std Dev	0.110454	0.055534		0	0		0.32887	0.007506		0			
Composite	< 1.23	< 0.61842	92.8	< 0.25	< 0.004249	0.6	1.91	0.043596	6.5	0	0	0.043596	0.666264

System Metal Outputs

Kiln 1	Clinker			Kiln Dust Wasted			Emissions		Total Out (lb/hr)	
	ppm	lb/hr	Pct Out	ppm	lb/hr	Pct Out	lb/hr	Pct Out	min	max
Run 1	1.72	0.1505	66.6	3.04	0.07524	33.3	< 0.000119	0.05	0.22574	0.225859
Run 2	< 1.32	< 0.1155	61.8	2.87	0.071033	38.0	0.000269	0.14	0.071301	0.186801
Run 3	< 1.22	< 0.10675	57.4	3.19	0.078953	42.5	0.000222	0.12	0.079175	0.185925
Average	< 1.42	< 0.12425	62.0	3.033333	0.075075	37.9	< 0.000203	0.11	0.075075	0.199528
Range	0.5	0.04375		0.32	0.00792		0.00015			
Std Dev	0.216025	0.018902		0.130724	0.003235		6.26E-05			
Composite	< 1.41	< 0.123375	48.8	5.22	0.129195	51.1	0.000203	0.08	0.129398	0.252773

Kiln 2	Clinker			Kiln Dust Wasted			Emissions		Total Out (lb/hr)	
	ppm	lb/hr	Pct Out	ppm	lb/hr	Pct Out	lb/hr	Pct Out	min	max
Run 1	< 1.39	< 0.254833	64.8	2.94	0.13818	35.1	0.00033	0.08	0.13851	0.393344
Run 2	< 1.24	< 0.227333	79.2	< 1.26	< 0.05922	20.6	0.000447	0.16	0.000447	0.287
Run 3	< 2.05	< 0.375833	84.7	< 1.43	< 0.06721	15.2	0.000419	0.09	0.000419	0.443462
Average	< 1.56	< 0.286	76.2	< 1.876667	< 0.088203	23.6	0.000399	0.11	0.000399	0.374602
Range	0.81	0.1485		1.68	0.07896		0.000117			
Std Dev	0.351852	0.064506		0.755086	0.035489		4.97E-05			
Composite	< 2.35	< 0.430833	88.8	1.15	0.05405	11.1	0.000399	0.08	0.054449	0.485282

Partitioning

Kiln 1	Ratio In/Out		Adjusted Feed(*)	Dust vs Clinker	Dust vs Feed
	min	max			
Run 1	2.003484	2.00454	2.640625	1.767442	1.151243
Run 2	0.097082	4.304823	< 1.75	2.174242	1.64
Run 3	0.079035	3.833267	< 1.75	2.614754	1.822857
Average	0.726534	3.380877	< 2.046875	2.185479	1.538033
Range			0.890625		
Std Dev			0.419845		
P(Diff)(**)				0.986371618986798	0.914918
Composite	1.546341	3.049193	2.3125	3.702128	2.257297

Kiln 2	Ratio In/Out		Adjusted Feed(*)	Dust vs Clinker	Dust vs Feed
	min	max			
Run 1	0.10271	5.041235	< 2.03125	2.115108	1.447385
Run 2	0.082711	1220.769	< 1.609375	1.016129	0.782913
Run 3	0.057132	1488.32	< 1.84375	0.697561	0.775593
Average	0.080851	904.7103	< 1.828125	1.276266	1.001963
Range			0.421875		
Std Dev			0.172584		
P(Diff)(**)				0.328527039758609	0.079478
Composite	0.089836	12.23656	< 1.921875	0.489362	0.598374

Combined

		Dust vs Clinker	Dust vs Feed
Kiln 1	Run 1	1.767442	1.151243
	Run 2	2.174242	1.64
	Run 3	2.614754	1.822857
Kiln 2	Run 1	2.115108	1.447385
	Run 2	1.016129	0.782913
	Run 3	0.697561	0.775593
Average		1.730873	1.269998
Std Dev		0.671489	0.402039
P(Diff)(**)		0.931276	0.837349

* Slurry feed values are adjusted for moisture and reported in ppm.

** P(Diff) values indicate the probability that Dust and Feed concentrations or Dust and Clinker concentrations are statistically different at a 95% confidence level. Because of rounding, values >0.9999995 (indicating near certainty) are displayed as 1.

Holnam - Holly Hill 1992 BIF Compliance Test / Trial Burn

Arsenic

System Metal Inputs

Kiln 1	Slurry Feed			Coal/Coke Feed			HFL			Spike		Total In (lb/hr)	
	ppm	lb/hr	Pct In	ppm	lb/hr	Pct In	ppm	lb/hr	Pct In	lb/hr	Pct In	min	max
Run 1	5.16	1.313577	31.9	7.6	0.112076	2.7	< 0.758	< 0.00442	0.1	2.69	65.29011	4.115653	4.120073
Run 2	5.4	1.374674	36.0	< 0.815	< 0.012019	0.3	< 0.644	< 0.003755	0.1	2.43	63.60511	3.804674	3.820448
Run 3	6.33	1.611423	37.8	5.7	0.084057	2.0	< 0.392	< 0.002286	0.1	2.56	60.12543	4.25548	4.257766
Average	5.63	1.433225	35.2	< 4.705	< 0.069384	1.7	< 0.598	< 0.003487	0.1	2.56	63.00688	3.993225	4.066095
Range	1.17	0.297846		6.785	0.100057		0.366	0.002134		0.26			
Std Dev	0.504579	0.12845		2.857922	0.042145		0.152918	0.000892		0.106145			
Composite	4.8	1.221932	31.6	5.69	0.083909	2.2	< 0.694	< 0.004047	0.1	2.56	66.15178	3.865842	3.869888

Kiln 2	Slurry Feed			Coal/Coke Feed			HFL			Spike		Total In (lb/hr)	
	ppm	lb/hr	Pct In	ppm	lb/hr	Pct In	ppm	lb/hr	Pct In	lb/hr	Pct In	min	max
Run 1	3.02	1.518396	27.5	4.43	0.075293	1.4	< 0.712	< 0.016251	0.3	3.92	70.88684	5.513689	5.529941
Run 2	3.18	1.598841	29.5	4.91	0.083451	1.5	< 0.749	< 0.017096	0.3	3.72	68.64244	5.402292	5.419388
Run 3	2.88	1.448007	26.9	10.5	0.17846	3.3	< 0.765	< 0.017461	0.3	3.74	69.46601	5.366467	5.383928
Average	3.026667	1.521748	28.0	6.613333	0.112401	2.1	< 0.742	< 0.016936	0.3	3.793333	69.6651	5.427483	5.444419
Range	0.3	0.150834		6.07	0.103167		0.053	0.00121		0.2			
Std Dev	0.122565	0.061623		2.755266	0.046829		0.022196	0.000507		0.089938			
Composite	2.89	1.453035	27.2	4.48	0.076143	1.4	< 0.718	< 0.016388	0.3	3.79	71.03277	5.319178	5.335566

System Metal Outputs

Kiln 1	Clinker			Kiln Dust Wasted			Emissions		Total Out (lb/hr)	
	ppm	lb/hr	Pct Out	ppm	lb/hr	Pct Out	lb/hr	Pct Out	min	max
Run 1	24.4	2.135	79.4	22.4	0.5544	20.6	< 0.000396	0.01	2.6894	2.689796
Run 2	46.2	4.0425	77.8	46.5	1.150875	22.2	0.000839	0.02	5.194214	5.194214
Run 3	56.1	4.90875	80.4	48.2	1.19295	19.5	0.000751	0.01	6.102451	6.102451
Average	42.23333	3.695417	79.2	39.03333	0.966075	20.8	< 0.000662	0.01	4.661492	4.662154
Range	31.7	2.77375		25.8	0.63855		0.000443			
Std Dev	13.24194	1.158669		11.782	0.291605		0.000191			
Composite	33.1	2.89625	77.2	34.6	0.85635	22.8	0.000662	0.02	3.753262	3.753262

Kiln 2	Clinker			Kiln Dust Wasted			Emissions		Total Out (lb/hr)	
	ppm	lb/hr	Pct Out	ppm	lb/hr	Pct Out	lb/hr	Pct Out	min	max
Run 1	22.5	4.125	71.2	35.5	1.6685	28.8	< 0.000482	0.01	5.7935	5.793982
Run 2	23.4	4.29	74.3	31.5	1.4805	25.7	< 0.000504	0.01	5.7705	5.771004
Run 3	33.7	6.178333	73.0	48.6	2.2842	27.0	< 0.000515	0.01	8.462533	8.463049
Average	26.53333	4.864444	72.8	38.53333	1.811067	27.1	< 0.000501	0.01	6.675511	6.676012
Range	11.2	2.053333		17.1	0.8037		3.3E-05			
Std Dev	5.080901	0.931499		7.30312	0.343247		1.37E-05			
Composite	23	4.216667	77.5	26	1.222	22.5	0.000501	0.01	5.439167	5.439167

Partitioning

Kiln 1	Ratio In/Out		Adjusted Feed(*)	Dust vs Clinker	Dust vs Feed
	min	max			
Run 1	1.530098	1.531967	8.0625	0.918033	2.778295
Run 2	0.732483	0.73552	8.4375	1.006494	5.511111
Run 3	0.697339	0.697714	9.890625	0.85918	4.873302
Average	0.98664	0.9884	8.796875	0.927902	4.387569
Range			1.828125		
Std Dev			0.788405		
P(Diff)(**)				0.679672632499235	0.937304
Composite	1.029995	1.031073	7.5	1.045317	4.613333

Kiln 2	Ratio In/Out		Adjusted Feed(*)	Dust vs Clinker	Dust vs Feed
	min	max			
Run 1	0.951623	0.954508	4.71875	1.577778	7.523179
Run 2	0.93611	0.939154	4.96875	1.346154	6.339623
Run 3	0.634106	0.636208	4.5	1.442136	10.8
Average	0.840613	0.84329	4.729167	1.455356	8.220934
Range			0.46875		
Std Dev			0.191508		
P(Diff)(**)				0.972667508141202	0.976357
Composite	0.97794	0.980953	4.515625	1.130435	5.757785

Combined

		Dust vs Clinker	Dust vs Feed
Kiln 1	Run 1	0.918033	2.778295
	Run 2	1.006494	5.511111
	Run 3	0.85918	4.873302
Kiln 2	Run 1	1.577778	7.523179
	Run 2	1.346154	6.339623
	Run 3	1.442136	10.8
Average		1.191629	6.304251
Std Dev		0.275498	2.476821
P(Diff)(**)		0.714199	0.999277

* Slurry feed values are adjusted for moisture and reported in ppm.

** P(Diff) values indicate the probability that Dust and Feed concentrations or Dust and Clinker concentrations are statistically different at a 95% confidence level. Because of rounding, values >0.9999995 (indicating near certainty) are displayed as 1.

Holnam - Holly Hill 1992 BIF Compliance Test / Trial Burn

Barium

System Metal Inputs

Kiln 1	Slurry Feed			Coal/Coke Feed			HFL			Spike		Total In (lb/hr)	
	ppm	lb/hr	Pct In	ppm	lb/hr	Pct In	ppm	lb/hr	Pct In	lb/hr	Pct In	min	max
Run 1	87.9	22.37663	83.1	107	1.57791	5.9	509	2.968069	11.0	0	0	26.92261	26.92261
Run 2	86.7	22.07115	85.5	25.7	0.378993	1.5	579	3.376252	13.1	0	0	25.82639	25.82639
Run 3	81.5	20.74739	82.7	76	1.120759	4.5	554	3.230472	12.9	0	0	25.09862	25.09862
Average	85.36667	21.73172	83.7	69.56667	1.025887	3.9	547.3333	3.191598	12.3	0	0	25.94921	25.94921
Range	6.4	1.629243		81.3	1.198917		70	0.408182		0			
Std Dev	2.777689	0.707114		33.50088	0.494032		28.96358	0.168892		0			
Composite	86.2	21.94387	82.7	84.4	1.244632	4.7	573	3.341265	12.6	0	0	26.52976	26.52976

Kiln 2	Slurry Feed			Coal/Coke Feed			HFL			Spike		Total In (lb/hr)	
	ppm	lb/hr	Pct In	ppm	lb/hr	Pct In	ppm	lb/hr	Pct In	lb/hr	Pct In	min	max
Run 1	60.6	30.46848	65.4	41.5	0.705342	1.5	675	15.40687	33.1	0	0	46.58069	46.58069
Run 2	61.7	31.02153	70.4	58.4	0.992577	2.3	527	12.02877	27.3	0	0	44.04288	44.04288
Run 3	56.7	28.50763	63.4	78.8	1.3393	3.0	663	15.13297	33.6	0	0	44.9799	44.9799
Average	59.66667	29.99922	66.4	59.56667	1.012406	2.2	621.6667	14.18954	31.3	0	0	45.20116	45.20116
Range	5	2.513901		37.3	0.633958		148	3.378099		0			
Std Dev	2.145279	1.078604		15.24999	0.259192		67.11847	1.531979		0			
Composite	57.8	29.06069	65.3	64.1	1.089456	2.4	628	14.3341	32.2	0	0	44.48424	44.48424

System Metal Outputs

Kiln 1	Clinker			Kiln Dust Wasted			Emissions		Total Out (lb/hr)	
	ppm	lb/hr	Pct Out	ppm	lb/hr	Pct Out	lb/hr	Pct Out	min	max
Run 1	216	18.9	74.7	259	6.41025	25.3	0.00648	0.03	25.31673	25.31673
Run 2	195	17.0625	71.0	281	6.95475	28.9	0.025548	0.11	24.0428	24.0428
Run 3	216	18.9	74.3	264	6.534	25.7	0.012227	0.05	25.44623	25.44623
Average	209	18.2875	73.3	268	6.633	26.6	0.014752	0.06	24.93525	24.93525
Range	21	1.8375		22	0.5445		0.019068			
Std Dev	9.899495	0.866206		9.416298	0.233053		0.007987			
Composite	224	19.6	74.3	274	6.7815	25.7	0.014752	0.06	26.39625	26.39625

Kiln 2	Clinker			Kiln Dust Wasted			Emissions		Total Out (lb/hr)	
	ppm	lb/hr	Pct Out	ppm	lb/hr	Pct Out	lb/hr	Pct Out	min	max
Run 1	225	41.25	80.4	214	10.058	19.6	0.005811	0.01	51.31381	51.31381
Run 2	202	37.03333	78.6	214	10.058	21.4	0.006203	0.01	47.09754	47.09754
Run 3	291	53.35	84.3	212	9.964	15.7	0.004978	0.01	63.31898	63.31898
Average	239.3333	43.87778	81.1	213.3333	10.02667	18.9	0.005664	0.01	53.91011	53.91011
Range	89	16.31667		2	0.094		0.001225			
Std Dev	37.7212	6.915553		0.942809	0.044312		0.000511			
Composite	221	40.51667	80.2	213	10.011	19.8	0.005664	0.01	50.53333	50.53333

Partitioning

Kiln 1	Ratio In/Out		Adjusted Feed(*)	Dust vs Clinker	Dust vs Feed
	min	max			
Run 1	1.063432	1.063432	137.3438	1.199074	1.885779
Run 2	1.074184	1.074184	135.4688	1.441026	2.074279
Run 3	0.98634	0.98634	127.3438	1.222222	2.073129
Average	1.041318	1.041318	133.3854	1.287441	2.011062
Range			10		
Std Dev			4.340139		
P(Diff)(**)				0.950912263486099	0.997332
Composite	1.005058	1.005058	134.6875	1.223214	2.034339

Kiln 2	Ratio In/Out		Adjusted Feed(*)	Dust vs Clinker	Dust vs Feed
	min	max			
Run 1	0.907761	0.907761	94.6875	0.951111	2.260066
Run 2	0.935142	0.935142	96.40625	1.059406	2.219773
Run 3	0.71037	0.71037	88.59375	0.728522	2.392945
Average	0.851091	0.851091	93.22917	0.913013	2.290928
Range			7.8125		
Std Dev			3.351999		
P(Diff)(**)				0.558311978599907	0.999794
Composite	0.880295	0.880295	90.3125	0.963801	2.358478

Combined

		Dust vs Clinker	Dust vs Feed
Kiln 1	Run 1	1.199074	1.885779
	Run 2	1.441026	2.074279
	Run 3	1.222222	2.073129
Kiln 2	Run 1	0.951111	2.260066
	Run 2	1.059406	2.219773
	Run 3	0.728522	2.392945
Average		1.100227	2.150995
Std Dev		0.224671	0.161995
P(Diff)(**)		0.487851	0.999999

* Slurry feed values are adjusted for moisture and reported in ppm.

** P(Diff) values indicate the probability that Dust and Feed concentrations or Dust and Clinker concentrations are statistically different at a 95% confidence level. Because of rounding, values >0.9999995 (indicating near certainty) are displayed as 1.

Holnam - Holly Hill 1992 BIF Compliance Test / Trial Burn

Beryllium

System Metal Inputs

Kiln 1	Slurry Feed			Coal/Coke Feed			HFL			Spike		Total In (lb/hr)	
	ppm	lb/hr	Pct In	ppm	lb/hr	Pct In	ppm	lb/hr	Pct In	lb/hr	Pct In	min	max
Run 1	1.36	0.346214	20.6	4.39	0.064739	3.8	0.568	0.003312	0.2	1.27	75.40382	1.684265	1.684265
Run 2	1.38	0.351305	23.0	0.571	0.00842	0.6	0.928	0.005411	0.4	1.16	76.05873	1.525137	1.525137
Run 3	1.32	0.336031	20.5	5.18	0.076389	4.7	0.842	0.00491	0.3	1.22	74.51156	1.63733	1.63733
Average	1.353333	0.344517	21.4	3.380333	0.049849	3.0	0.779333	0.004544	0.3	1.216667	75.3247	1.615577	1.615577
Range	0.06	0.015274		4.609	0.067968		0.36	0.002099		0.11			
Std Dev	0.024944	0.00635		2.012509	0.029678		0.153504	0.000895		0.044969			
Composite	1.43	0.364034	21.5	7.66	0.112961	6.7	0.79	0.004607	0.3	1.21	71.52986	1.691601	1.691601

Kiln 2	Slurry Feed			Coal/Coke Feed			HFL			Spike		Total In (lb/hr)	
	ppm	lb/hr	Pct In	ppm	lb/hr	Pct In	ppm	lb/hr	Pct In	lb/hr	Pct In	min	max
Run 1	1.27	0.638531	20.8	6.17	0.104866	3.4	0.482	0.011002	0.4	2.31	75.38183	3.064399	3.064399
Run 2	1.26	0.633503	20.8	6.28	0.106736	3.5	0.324	0.007395	0.2	2.3	75.46837	3.047634	3.047634
Run 3	1.22	0.613392	20.8	6.04	0.102657	3.5	0.39	0.008902	0.3	2.22	75.38327	2.94495	2.94495
Average	1.25	0.628475	20.8	6.163333	0.104753	3.5	0.398667	0.0091	0.3	2.276667	75.41116	3.018995	3.018995
Range	0.05	0.025139		0.24	0.004079		0.158	0.003606		0.09			
Std Dev	0.021602	0.010861		0.098093	0.001667		0.064794	0.001479		0.040277			
Composite	1.26	0.633503	20.8	6.85	0.116424	3.8	0.394	0.008993	0.3	2.28	75.02666	3.03892	3.03892

System Metal Outputs

Kiln 1	Clinker			Kiln Dust Wasted			Emissions		Total Out (lb/hr)	
	ppm	lb/hr	Pct Out	ppm	lb/hr	Pct Out	lb/hr	Pct Out	min	max
Run 1	13.6	1.19	79.9	12.1	0.299475	20.1	0.000405	0.03	1.48988	1.48988
Run 2	11.8	1.0325	77.2	12.3	0.304425	22.8	0.000905	0.07	1.33783	1.33783
Run 3	13	1.1375	79.7	11.7	0.289575	20.3	0.000963	0.07	1.428038	1.428038
Average	12.8	1.12	78.9	12.03333	0.297825	21.0	0.000758	0.05	1.418583	1.418583
Range	1.8	0.1575		0.6	0.01485		0.000557			
Std Dev	0.748331	0.065479		0.249444	0.006174		0.00025			
Composite	13.7	1.19875	79.6	12.4	0.3069	20.4	0.000758	0.05	1.506408	1.506408

Kiln 2	Clinker			Kiln Dust Wasted			Emissions		Total Out (lb/hr)	
	ppm	lb/hr	Pct Out	ppm	lb/hr	Pct Out	lb/hr	Pct Out	min	max
Run 1	13.5	2.475	81.3	12.1	0.5687	18.7	0.000311	0.01	3.044011	3.044011
Run 2	11.5	2.108333	78.2	12.5	0.5875	21.8	0.000385	0.01	2.696219	2.696219
Run 3	16.3	2.988333	83.6	12.5	0.5875	16.4	0.000333	0.01	3.576166	3.576166
Average	13.76667	2.523889	81.0	12.36667	0.581233	19.0	0.000343	0.01	3.105465	3.105465
Range	4.8	0.88		0.4	0.0188		7.49E-05			
Std Dev	1.968643	0.360918		0.188562	0.008862		3.14E-05			
Composite	11.7	2.145	78.9	12.2	0.5734	21.1	0.000343	0.01	2.718743	2.718743

Partitioning

Kiln 1	Ratio In/Out		Adjusted Feed(*)	Dust vs Clinker	Dust vs Feed
	min	max			
Run 1	1.13047	1.13047	2.125	0.889706	5.694118
Run 2	1.140008	1.140008	2.15625	1.042373	5.704348
Run 3	1.146559	1.146559	2.0625	0.9	5.672727
Average	1.139012	1.139012	2.114583	0.944026	5.690398
Range			0.09375		
Std Dev			0.038976		
P(Diff)(**)				0.648724346266452	0.999775
Composite	1.122937	1.122937	2.234375	0.905109	5.54965

Kiln 2	Ratio In/Out		Adjusted Feed(*)	Dust vs Clinker	Dust vs Feed
	min	max			
Run 1	1.006698	1.006698	1.984375	0.896296	6.097638
Run 2	1.130336	1.130336	1.96875	1.086957	6.349206
Run 3	0.823494	0.823494	1.90625	0.766871	6.557377
Average	0.986843	0.986843	1.953125	0.916708	6.33474
Range			0.078125		
Std Dev			0.033754		
P(Diff)(**)				0.581318358833662	0.999792
Composite	1.117767	1.117767	1.96875	1.042735	6.196825

Combined

		Dust vs Clinker	Dust vs Feed
Kiln 1	Run 1	0.889706	5.694118
	Run 2	1.042373	5.704348
	Run 3	0.9	5.672727
Kiln 2	Run 1	0.896296	6.097638
	Run 2	1.086957	6.349206
	Run 3	0.766871	6.557377
Average		0.930367	6.012569
Std Dev		0.106092	0.348636
P(Diff)(**)		0.819489	1

* Slurry feed values are adjusted for moisture and reported in ppm.

** P(Diff) values indicate the probability that Dust and Feed concentrations or Dust and Clinker concentrations are statistically different at a 95% confidence level. Because of rounding, values >0.9999995 (indicating near certainty) are displayed as 1.

Holnam - Holly Hill 1992 BIF Compliance Test / Trial Burn

Cadmium

System Metal Inputs

Kiln 1	Slurry Feed			Coal/Coke Feed			HFL			Spike		Total In (lb/hr)	
	ppm	lb/hr	Pct In	ppm	lb/hr	Pct In	ppm	lb/hr	Pct In	lb/hr	Pct In	min	max
Run 1	< 1.06	< 0.269843	5.2	0.425	0.006267	0.1	7.77	0.045308	0.9	4.82	93.74844	4.871576	5.141419
Run 2	< 1.12	< 0.285118	6.1	< 0.25	< 0.003687	0.1	8.03	0.046824	1.0	4.35	92.83706	4.396824	4.685629
Run 3	1.83	0.465862	9.1	0.35	0.005161	0.1	7.11	0.04146	0.8	4.6	89.97585	5.112483	5.112483
Average	< 1.336667	< 0.340274	6.8	< 0.341667	< 0.005038	0.1	7.636667	0.044531	0.9	4.59	92.18712	4.634531	4.979843
Range	0.77	0.196018		0.175	0.002581		0.92	0.005365		0.47			
Std Dev	0.349698	0.089022		0.071686	0.001057		0.387241	0.002258		0.192007			
Composite	< 1	< 0.254569	5.2	< 0.25	< 0.003687	0.1	7.27	0.042393	0.9	4.59	93.85258	4.632393	4.890649

Kiln 2	Slurry Feed			Coal/Coke Feed			HFL			Spike		Total In (lb/hr)	
	ppm	lb/hr	Pct In	ppm	lb/hr	Pct In	ppm	lb/hr	Pct In	lb/hr	Pct In	min	max
Run 1	1.51	0.759198	8.0	< 0.25	< 0.004249	0.0	11.2	0.25564	2.7	8.43	89.21497	9.444838	9.449087
Run 2	< 1.03	< 0.517864	5.9	< 0.25	< 0.004249	0.0	9.47	0.216153	2.5	8.02	91.57065	8.236153	8.758265
Run 3	< 1.18	< 0.593281	6.7	< 0.25	< 0.004249	0.0	11.4	0.260205	2.9	8.05	90.3709	8.310205	8.907735
Average	< 1.24	< 0.623447	6.9	< 0.25	< 0.004249	0.0	10.69	0.243999	2.7	8.166667	90.38551	8.410666	9.038362
Range	0.48	0.241334		0	0		1.93	0.044052		0.41			
Std Dev	0.200499	0.100807		0	0		0.866526	0.019778		0.186607			
Composite	< 1.23	< 0.61842	6.8	< 0.25	< 0.004249	0.0	10.5	0.239662	2.7	8.17	90.45284	8.409662	9.032331

System Metal Outputs

Kiln 1	Clinker			Kiln Dust Wasted			Emissions		Total Out (lb/hr)	
	ppm	lb/hr	Pct Out	ppm	lb/hr	Pct Out	lb/hr	Pct Out	min	max
Run 1	1.57	0.137375	3.1	171	4.23225	96.5	0.016974	0.39	4.386599	4.386599
Run 2	< 1.32	< 0.1155	3.0	151	3.73725	95.8	0.048196	1.24	3.785446	3.900946
Run 3	1.71	0.149625	3.8	149	3.68775	94.7	0.057352	1.47	3.894727	3.894727
Average	< 1.533333	< 0.134167	3.3	157	3.88575	95.7	0.040841	1.03	3.926591	4.060757
Range	0.39	0.034125		22	0.5445		0.040379			
Std Dev	0.161314	0.014115		9.93311	0.245844		0.017286			
Composite	1.87	0.163625	3.8	168	4.158	95.3	0.040841	0.94	4.362466	4.362466

Kiln 2	Clinker			Kiln Dust Wasted			Emissions		Total Out (lb/hr)	
	ppm	lb/hr	Pct Out	ppm	lb/hr	Pct Out	lb/hr	Pct Out	min	max
Run 1	< 1.39	< 0.254833	3.8	136	6.392	96.0	0.010101	0.15	6.402101	6.656935
Run 2	< 1.24	< 0.227333	3.6	130	6.11	96.2	0.012176	0.19	6.122176	6.34951
Run 3	< 2.05	< 0.375833	5.6	135	6.345	94.3	0.010317	0.15	6.355317	6.731151
Average	< 1.56	< 0.286	4.3	133.6667	6.282333	95.5	0.010865	0.17	6.293198	6.579198
Range	0.81	0.1485		6	0.282		0.002075			
Std Dev	0.351852	0.064506		2.624669	0.123359		0.000931			
Composite	3.23	0.592167	8.6	134	6.298	91.3	0.010865	0.16	6.901032	6.901032

Partitioning

Kiln 1	Ratio In/Out		Adjusted Feed(*)	Dust vs Clinker	Dust vs Feed
	min	max			
Run 1	1.110559	1.172074	< 1.65625	108.9172	103.2453
Run 2	1.127117	1.237801	< 1.75	114.3939	86.28571
Run 3	1.312668	1.312668	2.859375	87.1345	52.10929
Average	1.183448	1.240848	< 2.088542	103.4819	80.54676
Range			1.203125		
Std Dev			0.546404		
P(Diff)(**)				0.997969794206703	0.997804
Composite	1.061875	1.121074	< 1.5625	89.83957	107.52

Kiln 2	Ratio In/Out		Adjusted Feed(*)	Dust vs Clinker	Dust vs Feed
	min	max			
Run 1	1.418797	1.475935	2.359375	97.84173	57.64238
Run 2	1.297132	1.43058	< 1.609375	104.8387	80.7767
Run 3	1.234589	1.401619	< 1.84375	65.85366	73.22034
Average	1.316839	1.436045	< 1.9375	89.51136	70.54647
Range			0.75		
Std Dev			0.31328		
P(Diff)(**)				0.999826446290461	0.999838
Composite	1.218609	1.308838	< 1.921875	41.48607	69.72358

Combined

		Dust vs Clinker	Dust vs Feed
Kiln 1	Run 1	108.9172	103.2453
	Run 2	114.3939	86.28571
	Run 3	87.1345	52.10929
Kiln 2	Run 1	97.84173	57.64238
	Run 2	104.8387	80.7767
	Run 3	65.85366	73.22034
Average		96.49662	75.54662
Std Dev		16.18963	17.24906
P(Diff)(**)		0.999997	0.999997

* Slurry feed values are adjusted for moisture and reported in ppm.

** P(Diff) values indicate the probability that Dust and Feed concentrations or Dust and Clinker concentrations are statistically different at a 95% confidence level. Because of rounding, values >0.9999995 (indicating near certainty) are displayed as 1.

Holnam - Holly Hill 1992 BIF Compliance Test / Trial Burn

Chromium

System Metal Inputs

Kiln 1	Slurry Feed			Coal/Coke Feed			HFL			Spike		Total In (lb/hr)	
	ppm	lb/hr	Pct In	ppm	lb/hr	Pct In	ppm	lb/hr	Pct In	lb/hr	Pct In	min	max
Run 1	37.4	9.520888	19.4	22.1	0.325905	0.7	106	0.618105	1.3	38.5	78.62776	48.9649	48.9649
Run 2	36.6	9.317233	18.3	1.02	0.015042	0.0	114	0.664754	1.3	40.9	80.35833	50.89703	50.89703
Run 3	35.4	9.01175	16.5	13.5	0.199082	0.4	104	0.606442	1.1	44.9	82.05818	54.71727	54.71727
Average	36.46667	9.28329	18.1	12.20667	0.18001	0.4	108	0.629767	1.2	41.43333	80.34809	51.5264	51.5264
Range	2	0.509138		21.08	0.310863		10	0.058312		6.4			
Std Dev	0.821922	0.209236		8.65433	0.127624		4.320494	0.025194		2.639865			
Composite	37.3	9.495431	18.4	14.6	0.215304	0.4	101	0.588949	1.1	41.4	80.07786	51.69968	51.69968

Kiln 2	Slurry Feed			Coal/Coke Feed			HFL			Spike		Total In (lb/hr)	
	ppm	lb/hr	Pct In	ppm	lb/hr	Pct In	ppm	lb/hr	Pct In	lb/hr	Pct In	min	max
Run 1	36.3	18.25092	19.3	7.17	0.121863	0.1	94.4	2.154679	2.3	74.17	78.32311	94.69746	94.69746
Run 2	33.6	16.89341	17.5	9.98	0.169622	0.2	73.9	1.686767	1.8	77.56	80.53178	96.3098	96.3098
Run 3	32.2	16.18952	17.4	11.9	0.202255	0.2	91.7	2.093052	2.2	74.67	80.15688	93.15483	93.15483
Average	34.03333	17.11128	18.1	9.683333	0.16458	0.2	86.66667	1.978166	2.1	75.46667	79.67059	94.7207	94.7207
Range	4.1	2.061399		4.73	0.080392		20.5	0.467912		3.39			
Std Dev	1.701633	0.855547		1.942375	0.033013		9.094443	0.207581		1.494218			
Composite	32.9	16.54147	17.6	10.7	0.181859	0.2	90	2.054249	2.2	75.47	80.07633	94.24758	94.24758

System Metal Outputs

Kiln 1	Clinker			Kiln Dust Wasted			Emissions		Total Out (lb/hr)	
	ppm	lb/hr	Pct Out	ppm	lb/hr	Pct Out	lb/hr	Pct Out	min	max
Run 1	405	35.4375	81.5	324	8.019	18.5	0.001978	0.00	43.45848	43.45848
Run 2	368	32.2	77.7	374	9.2565	22.3	0.004645	0.01	41.46115	41.46115
Run 3	439	38.4125	80.2	382	9.4545	19.8	0.003797	0.01	47.8708	47.8708
Average	404	35.35	79.8	360	8.91	20.2	0.003474	0.01	44.26347	44.26347
Range	71	6.2125		58	1.4355		0.002667			
Std Dev	28.99425	2.536997		25.6645	0.635196		0.001113			
Composite	436	38.15	80.9	364	9.009	19.1	0.003474	0.01	47.16247	47.16247

Kiln 2	Clinker			Kiln Dust Wasted			Emissions		Total Out (lb/hr)	
	ppm	lb/hr	Pct Out	ppm	lb/hr	Pct Out	lb/hr	Pct Out	min	max
Run 1	551	101.0167	86.9	325	15.275	13.1	0.0027	0.00	116.2944	116.2944
Run 2	395	72.41667	82.3	332	15.604	17.7	0.002949	0.00	88.02362	88.02362
Run 3	469	85.98333	84.3	341	16.027	15.7	0.002786	0.00	102.0131	102.0131
Average	471.6667	86.47222	84.5	332.6667	15.63533	15.5	0.002812	0.00	102.1104	102.1104
Range	156	28.6		16	0.752		0.000249			
Std Dev	63.71464	11.68102		6.548961	0.307801		0.000103			
Composite	403	73.88333	82.4	336	15.792	17.6	0.002812	0.00	89.67815	89.67815

Partitioning

Kiln 1	Ratio In/Out min	Ratio In/Out max	Adjusted Feed(*)	Dust vs Clinker	Dust vs Feed
Run 1	1.126705	1.126705	58.4375	0.8	5.544385
Run 2	1.227584	1.227584	57.1875	1.016304	6.539891
Run 3	1.14302	1.14302	55.3125	0.870159	6.906215
Average	1.16577	1.16577	56.97917	0.895488	6.330163
Range			3.125		
Std Dev			1.284253		
P(Diff)(**)				0.768039202800694	0.996114
Composite	1.096204	1.096204	58.28125	0.834862	6.245576

Kiln 2	Ratio In/Out min	Ratio In/Out max	Adjusted Feed(*)	Dust vs Clinker	Dust vs Feed
Run 1	0.814291	0.814291	56.71875	0.589837	5.730028
Run 2	1.094136	1.094136	52.5	0.840506	6.32381
Run 3	0.913165	0.913165	50.3125	0.727079	6.77764
Average	0.940531	0.940531	53.17708	0.719141	6.277159
Range			6.40625		
Std Dev			2.658802		
P(Diff)(**)				0.900820254652031	0.999465
Composite	1.050954	1.050954	51.40625	0.833747	6.53617

Combined

		Dust vs Clinker	Dust vs Feed
Kiln 1	Run 1	0.8	5.544385
	Run 2	1.016304	6.539891
	Run 3	0.870159	6.906215
Kiln 2	Run 1	0.589837	5.730028
	Run 2	0.840506	6.32381
	Run 3	0.727079	6.77764
Average		0.807314	6.303661
Std Dev		0.130713	0.508182
P(Diff)(**)		0.963946	0.999999

* Slurry feed values are adjusted for moisture and reported in ppm.

** P(Diff) values indicate the probability that Dust and Feed concentrations or Dust and Clinker concentrations are statistically different at a 95% confidence level. Because of rounding, values >0.9999995 (indicating near certainty) are displayed as 1.

Holnam - Holly Hill 1992 BIF Compliance Test / Trial Burn

Mercury

System Metal Inputs

Kiln 1	Slurry Feed			Coal/Coke Feed			HFL			Spike		Total In (lb/hr)	
	ppm	lb/hr	Pct In	ppm	lb/hr	Pct In	ppm	lb/hr	Pct In	lb/hr	Pct In	min	max
Run 1	< 0.1	< 0.025457	90.8	< 0.1	< 0.001475	5.3	0.19	0.001108	4.0	0	0	0.001108	0.02804
Run 2	< 0.1	< 0.025457	89.7	< 0.1	< 0.001475	5.2	0.25	0.001458	5.1	0	0	0.001458	0.028389
Run 3	< 0.1	< 0.025457	89.7	< 0.1	< 0.001475	5.2	0.25	0.001458	5.1	0	0	0.001458	0.028389
Average	< 0.1	< 0.025457	90.0	< 0.1	< 0.001475	5.2	0.23	0.001341	4.7	0	0	0.001341	0.028273
Range	0	0		0	0		0.06	0.00035		0			
Std Dev	2.38E-11	5.94E-12		2.38E-11	0		0.028284	0.000165		0			
Composite	< 0.1	< 0.025457	89.9	< 0.1	< 0.001475	5.2	0.238	0.001388	4.9	0	0	0.001388	0.028319

Kiln 2	Slurry Feed			Coal/Coke Feed			HFL			Spike		Total In (lb/hr)	
	ppm	lb/hr	Pct In	ppm	lb/hr	Pct In	ppm	lb/hr	Pct In	lb/hr	Pct In	min	max
Run 1	< 0.1	< 0.050278	78.5	< 0.1	< 0.0017	2.7	0.53	0.012097	18.9	0	0	0.012097	0.064075
Run 2	< 0.1	< 0.050278	80.3	< 0.1	< 0.0017	2.7	0.467	0.010659	17.0	0	0	0.010659	0.062637
Run 3	< 100	< 50.27801	100.0	< 0.1	< 0.0017	0.0	0.326	0.007441	0.0	0	0	0.007441	50.28715
Average	< 33.4	< 16.79286	86.2	< 0.1	< 0.0017	1.8	0.441	0.010066	12.0	0	0	0.010066	16.80462
Range	99.9	50.22774		0	0		0.204	0.004656		0			
Std Dev	47.09331	23.67758		2.38E-11	0		0.085288	0.001947		0			
Composite	< 0.1	< 0.050278	78.8	< 0.1	< 0.0017	2.7	0.519	0.011846	18.6	0	0	0.011846	0.063824

System Metal Outputs

Kiln 1	Clinker			Kiln Dust Wasted			Emissions		Total Out (lb/hr)	
	ppm	lb/hr	Pct Out	ppm	lb/hr	Pct Out	lb/hr	Pct Out	min	max
Run 1	< 0.1	< 0.00875	41.0	< 0.1	< 0.002475	11.6	0.01013	47.44	0.01013	0.021355
Run 2	< 0.1	< 0.00875	35.2	< 0.1	< 0.002475	9.9	0.013667	54.91	0.013667	0.024892
Run 3	< 0.1	< 0.00875	45.2	< 0.1	< 0.002475	12.8	0.008112	41.95	0.008112	0.019337
Average	< 0.1	< 0.00875	40.5	< 0.1	< 0.002475	11.4	0.010637	48.10	0.010637	0.021862
Range	0	0		0	0		0.005555			
Std Dev	2.38E-11	0		2.38E-11	0		0.002296			
Composite	< 0.1	< 0.00875	40.0	< 0.1	< 0.002475	11.3	0.010637	48.65	0.010637	0.021862

Kiln 2	Clinker			Kiln Dust Wasted			Emissions		Total Out (lb/hr)	
	ppm	lb/hr	Pct Out	ppm	lb/hr	Pct Out	lb/hr	Pct Out	min	max
Run 1	< 0.1	< 0.018333	61.3	< 0.1	< 0.0047	15.7	0.006872	22.98	0.006872	0.029906
Run 2	< 0.1	< 0.018333	52.3	< 0.1	< 0.0047	13.4	0.012048	34.34	0.012048	0.035082
Run 3	< 0.1	< 0.018333	58.0	< 0.1	< 0.0047	14.9	0.008564	27.10	0.008564	0.031597
Average	< 0.1	< 0.018333	57.2	< 0.1	< 0.0047	14.7	0.009162	28.14	0.009162	0.032195
Range	0	0		0	0		0.005176			
Std Dev	2.38E-11	0		2.38E-11	0		0.002155			
Composite	< 0.1	< 0.018333	56.9	< 0.1	< 0.0047	14.6	0.009162	28.46	0.009162	0.032195

Partitioning

Kiln 1	Ratio In/Out		Adjusted Feed(*)	Dust vs Clinker	Dust vs Feed
	min	max			
Run 1	0.051881	2.767981	< 0.15625	1	0.64
Run 2	0.058564	2.077161	< 0.15625	1	0.64
Run 3	0.075388	3.499535	< 0.15625	1	0.64
Average	0.061944	2.781559	< 0.15625	1	0.64
Range			0		
Std Dev			0		
P(Diff)(**)				ERR	1
Composite	0.063482	2.66246	< 0.15625	1	0.64

Kiln 2	Ratio In/Out		Adjusted Feed(*)	Dust vs Clinker	Dust vs Feed
	min	max			
Run 1	0.404515	9.323716	< 0.15625	1	0.64
Run 2	0.303841	5.198749	< 0.15625	1	0.64
Run 3	0.235494	5872.008	< 156.25	1	0.00064
Average	0.314616	1962.177	< 52.1875	1	0.42688
Range			156.0938		
Std Dev			73.5833		
P(Diff)(**)				ERR	0.577766
Composite	0.367952	6.966503	< 0.15625	1	0.64

Combined

		Dust vs Clinker	Dust vs Feed
Kiln 1	Run 1	1	0.64
	Run 2	1	0.64
	Run 3	1	0.64
Kiln 2	Run 1	1	0.64
	Run 2	1	0.64
	Run 3	1	0.00064
Average		1	0.53344
Std Dev		0	0.238275
P(Diff)(**)		ERR	0.637731

* Slurry feed values are adjusted for moisture and reported in ppm.

** P(Diff) values indicate the probability that Dust and Feed concentrations or Dust and Clinker concentrations are statistically different at a 95% confidence level. Because of rounding, values >0.9999995 (indicating near certainty) are displayed as 1.

Holnam - Holly Hill 1992 BIF Compliance Test / Trial Burn

Nickel

System Metal Inputs

Kiln 1	Slurry Feed			Coal/Coke Feed			HFL			Spike		Total In (lb/hr)	
	ppm	lb/hr	Pct In	ppm	lb/hr	Pct In	ppm	lb/hr	Pct In	lb/hr	Pct In	min	max
Run 1	19.3	4.913186	71.5	124	1.828606	26.6	22.6	0.131785	1.9	0	0	6.873577	6.873577
Run 2	23.3	5.931462	93.9	16	0.235949	3.7	25.4	0.148112	2.3	0	0	6.315524	6.315524
Run 3	21.5	5.473238	68.3	164	2.418479	30.2	21.3	0.124204	1.5	0	0	8.015921	8.015921
Average	21.36667	5.439295	77.9	101.3333	1.494345	20.2	23.1	0.1347	1.9	0	0	7.06834	7.06834
Range	4	1.018277		148	2.18253		4.1	0.023908		0			
Std Dev	1.635713	0.416402		62.51044	0.921831		1.71075	0.009976		0			
Composite	20.4	5.193212	64.1	188	2.772403	34.2	23.3	0.135866	1.7	0	0	8.101481	8.101481

Kiln 2	Slurry Feed			Coal/Coke Feed			HFL			Spike		Total In (lb/hr)	
	ppm	lb/hr	Pct In	ppm	lb/hr	Pct In	ppm	lb/hr	Pct In	lb/hr	Pct In	min	max
Run 1	20.9	10.5081	68.2	231	3.926119	25.5	43.1	0.983757	6.4	0	0	15.41798	15.41798
Run 2	10.3	5.178635	57.2	178	3.025321	33.4	37.2	0.84909	9.4	0	0	9.053047	9.053047
Run 3	16.2	8.145038	69.9	150	2.549428	21.9	41.8	0.954085	8.2	0	0	11.64855	11.64855
Average	15.8	7.943926	65.1	186.3333	3.166956	26.9	40.7	0.928977	8.0	0	0	12.03986	12.03986
Range	10.6	5.329469		81	1.376691		5.9	0.134667		0			
Std Dev	4.336665	2.180389		33.58902	0.570885		2.531139	0.057773		0			
Composite	19.6	9.854491	70.1	194	3.29726	23.5	39.5	0.901587	6.4	0	0	14.05334	14.05334

System Metal Outputs

Kiln 1	Clinker			Kiln Dust Wasted			Emissions		Total Out (lb/hr)	
	ppm	lb/hr	Pct Out	ppm	lb/hr	Pct Out	lb/hr	Pct Out	min	max
Run 1	39.9	3.49125	80.2	34.7	0.858825	19.7	0.00159	0.04	4.351665	4.351665
Run 2	36.8	3.22	78.6	35.3	0.873675	21.3	0.002786	0.07	4.096461	4.096461
Run 3	37.8	3.3075	79.8	33.8	0.83655	20.2	0.001795	0.04	4.145845	4.145845
Average	38.16667	3.339583	79.5	34.6	0.85635	20.4	0.002057	0.05	4.197991	4.197991
Range	3.1	0.27125		1.5	0.037125		0.001196			
Std Dev	1.291855	0.113037		0.616441	0.015257		0.000522			
Composite	40.1	3.50875	80.3	34.8	0.8613	19.7	0.002057	0.05	4.372107	4.372107

Kiln 2	Clinker			Kiln Dust Wasted			Emissions		Total Out (lb/hr)	
	ppm	lb/hr	Pct Out	ppm	lb/hr	Pct Out	lb/hr	Pct Out	min	max
Run 1	84.4	15.47333	91.4	30.8	1.4476	8.6	0.001504	0.01	16.92244	16.92244
Run 2	53.9	9.881667	84.4	38.9	1.8283	15.6	0.000559	0.00	11.71053	11.71053
Run 3	59.8	10.96333	87.9	32.1	1.5087	12.1	0.001311	0.01	12.47334	12.47334
Average	66.03333	12.10611	87.9	33.93333	1.594867	12.1	0.001125	0.01	13.7021	13.7021
Range	30.5	5.591667		8.1	0.3807		0.000945			
Std Dev	13.20867	2.421589		3.551838	0.166936		0.000408			
Composite	56.5	10.35833	86.2	35.2	1.6544	13.8	0.001125	0.01	12.01386	12.01386

Partitioning

Kiln 1	Ratio In/Out		Adjusted Feed(*)	Dust vs Clinker	Dust vs Feed
	min	max			
Run 1	1.579528	1.579528	30.15625	0.869674	1.150674
Run 2	1.541702	1.541702	36.40625	0.959239	0.969614
Run 3	1.933483	1.933483	33.59375	0.89418	1.00614
Average	1.684904	1.684904	33.38542	0.907698	1.042142
Range			6.25		
Std Dev			2.555801		
P(Diff)(**)				0.91795626452399	0.449414
Composite	1.852992	1.852992	31.875	0.86783	1.091765

Kiln 2	Ratio In/Out		Adjusted Feed(*)	Dust vs Clinker	Dust vs Feed
	min	max			
Run 1	0.911097	0.911097	32.65625	0.364929	0.943158
Run 2	0.773069	0.773069	16.09375	0.721707	2.417087
Run 3	0.933876	0.933876	25.3125	0.536789	1.268148
Average	0.872681	0.872681	24.6875	0.541142	1.542798
Range			16.5625		
Std Dev			6.77604		
P(Diff)(**)				0.894286892464096	0.670975
Composite	1.169761	1.169761	30.625	0.623009	1.149388

Combined

		Dust vs Clinker	Dust vs Feed
Kiln 1	Run 1	0.869674	1.150674
	Run 2	0.959239	0.969614
	Run 3	0.89418	1.00614
Kiln 2	Run 1	0.364929	0.943158
	Run 2	0.721707	2.417087
	Run 3	0.536789	1.268148
Average		0.72442	1.29247
Std Dev		0.211937	0.51538
P(Diff)(**)		0.919176	0.775519

* Slurry feed values are adjusted for moisture and reported in ppm.

** P(Diff) values indicate the probability that Dust and Feed concentrations or Dust and Clinker concentrations are statistically different at a 95% confidence level. Because of rounding, values >0.9999995 (indicating near certainty) are displayed as 1.

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Lead

System Metal Inputs

Kiln 1	Slurry Feed			Coal/Coke Feed			HFL			Spike		Total In (lb/hr)	
	ppm	lb/hr	Pct In	ppm	lb/hr	Pct In	ppm	lb/hr	Pct In	lb/hr	Pct In	min	max
Run 1	6.55	1.667428	4.1	15.2	0.224152	0.6	319	1.860146	4.6	36.9	90.77105	40.65173	40.65173
Run 2	6.92	1.761619	4.1	2.16	0.031853	0.1	400	2.332471	5.4	39.1	90.45494	43.22594	43.22594
Run 3	6.58	1.675065	3.6	16.1	0.237424	0.5	341	1.988431	4.2	43.1	91.70033	47.00092	47.00092
Average	6.683333	1.701371	3.9	11.15333	0.164476	0.4	353.3333	2.060349	4.7	39.7	90.97544	43.6262	43.6262
Range	0.37	0.094191		13.94	0.205571		81	0.472325		6.2			
Std Dev	0.167796	0.042716		6.369853	0.093935		34.19877	0.199419		2.56645			
Composite	6.36	1.61906	3.7	12.2	0.179911	0.4	329	1.918457	4.4	39.7	91.43793	43.41743	43.41743

Kiln 2	Slurry Feed			Coal/Coke Feed			HFL			Spike		Total In (lb/hr)	
	ppm	lb/hr	Pct In	ppm	lb/hr	Pct In	ppm	lb/hr	Pct In	lb/hr	Pct In	min	max
Run 1	7.49	3.765823	4.6	4.12	0.070024	0.1	325	7.418123	9.1	69.97	86.14452	81.22397	81.22397
Run 2	7.8	3.921685	4.7	5.24	0.08906	0.1	257	5.866023	7.1	73.17	88.10698	83.04677	83.04677
Run 3	7.19	3.614989	4.4	6.69	0.113704	0.1	321	7.326823	9.0	70.44	86.4342	81.49552	81.49552
Average	7.493333	3.767499	4.6	5.35	0.09093	0.1	301	6.870323	8.4	71.19333	86.89523	81.92208	81.92208
Range	0.61	0.306696		2.57	0.04368		68	1.552099		3.2			
Std Dev	0.249043	0.125214		1.052077	0.017881		31.15552	0.711125		1.410823			
Composite	7.19	3.614989	4.4	5.1	0.086681	0.1	304	6.938798	8.5	71.19	86.99694	81.83047	81.83047

System Metal Outputs

Kiln 1	Clinker			Kiln Dust Wasted			Emissions		Total Out (lb/hr)	
	ppm	lb/hr	Pct Out	ppm	lb/hr	Pct Out	lb/hr	Pct Out	min	max
Run 1	3.25	0.284375	0.8	1420	35.145	98.7	0.175112	0.49	35.60449	35.60449
Run 2	3.01	0.263375	0.6	1610	39.8475	98.2	0.480015	1.18	40.59089	40.59089
Run 3	2.18	0.19075	0.5	1650	40.8375	98.4	0.486335	1.17	41.51458	41.51458
Average	2.813333	0.246167	0.6	1560	38.61	98.4	0.380488	0.95	39.23665	39.23665
Range	1.07	0.093625		230	5.6925		0.311222			
Std Dev	0.458427	0.040112		100.3328	2.483236		0.145245			
Composite	6.32	0.553	1.4	1610	39.8475	97.7	0.380488	0.93	40.78099	40.78099

Kiln 2	Clinker			Kiln Dust Wasted			Emissions		Total Out (lb/hr)	
	ppm	lb/hr	Pct Out	ppm	lb/hr	Pct Out	lb/hr	Pct Out	min	max
Run 1	4.19	0.768167	1.2	1400	65.8	98.7	0.111874	0.17	66.68004	66.68004
Run 2	7.17	1.3145	1.9	1420	66.74	97.8	0.154546	0.23	68.20905	68.20905
Run 3	6.28	1.151333	1.6	1490	70.03	98.2	0.132562	0.19	71.3139	71.3139
Average	5.88	1.078	1.6	1436.667	67.52333	98.2	0.132994	0.19	68.73433	68.73433
Range	2.98	0.546333		90	4.23		0.042672			
Std Dev	1.249026	0.228988		38.58612	1.813548		0.017423			
Composite	5.87	1.076167	1.6	1420	66.74	98.2	0.132994	0.20	67.94916	67.94916

Partitioning

Kiln 1	Ratio In/Out		Adjusted Feed(*)	Dust vs Clinker	Dust vs Feed
	min	max			
Run 1	1.141758	1.141758	10.23438	436.9231	138.7481
Run 2	1.064917	1.064917	10.8125	534.8837	148.9017
Run 3	1.132154	1.132154	10.28125	756.8807	160.4863
Average	1.112943	1.112943	10.44271	576.2292	149.3787
Range			0.578125		
Std Dev			0.262182		
P(Diff)(**)				0.997915856042386	0.997915
Composite	1.064649	1.064649	9.9375	254.7468	162.0126

Kiln 2	Ratio In/Out		Adjusted Feed(*)	Dust vs Clinker	Dust vs Feed
	min	max			
Run 1	1.218115	1.218115	11.70313	334.1289	119.6262
Run 2	1.217533	1.217533	12.1875	198.0474	116.5128
Run 3	1.142772	1.142772	11.23438	237.2611	132.6287
Average	1.192807	1.192807	11.70833	256.4791	122.9225
Range			0.953125		
Std Dev			0.389129		
P(Diff)(**)				0.99964622045647	0.999628
Composite	1.20429	1.20429	11.23438	241.908	126.3978

Combined

		Dust vs Clinker	Dust vs Feed
Kiln 1	Run 1	436.9231	138.7481
	Run 2	534.8837	148.9017
	Run 3	756.8807	160.4863
Kiln 2	Run 1	334.1289	119.6262
	Run 2	198.0474	116.5128
	Run 3	237.2611	132.6287
Average		416.3542	136.1506
Std Dev		190.142	15.45245
P(Diff)(**)		1	1

* Slurry feed values are adjusted for moisture and reported in ppm.

** P(Diff) values indicate the probability that Dust and Feed concentrations or Dust and Clinker concentrations are statistically different at a 95% confidence level. Because of rounding, values >0.9999995 (indicating near certainty) are displayed as 1.

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Antimony

System Metal Inputs

Kiln 1	Slurry Feed			Coal/Coke Feed			HFL			Spike		Total In (lb/hr)	
	ppm	lb/hr	Pct In	ppm	lb/hr	Pct In	ppm	lb/hr	Pct In	lb/hr	Pct In	min	max
Run 1	0.92	0.234204	1.8	< 0.759	< 0.011193	0.1	25.5	0.148695	1.1	12.8	97.01312	13.1829	13.19409
Run 2	1.27	0.323303	2.3	< 0.805	< 0.011871	0.1	31.1	0.18135	1.3	13.6	96.341	14.10465	14.11652
Run 3	< 0.63	< 0.160379	1.1	0.812	0.011974	0.1	22.9	0.133534	0.9	14.9	97.98836	15.04551	15.20589
Average	< 0.94	< 0.239295	1.7	< 0.792	< 0.011679	0.1	26.5	0.154526	1.1	13.76667	97.11416	13.92119	14.17217
Range	0.64	0.162924		0.053	0.000782		8.2	0.047816		2.1			
Std Dev	0.261661	0.066611		0.023509	0.000347		3.421501	0.019951		0.865384			
Composite	1	0.254569	1.8	1.26	0.018581	0.1	32.5	0.189513	1.3	13.8	96.75612	14.26266	14.26266

Kiln 2	Slurry Feed			Coal/Coke Feed			HFL			Spike		Total In (lb/hr)	
	ppm	lb/hr	Pct In	ppm	lb/hr	Pct In	ppm	lb/hr	Pct In	lb/hr	Pct In	min	max
Run 1	1.37	0.688809	2.7	1.06	0.018016	0.1	26.8	0.61171	2.4	23.79	94.74866	25.10853	25.10853
Run 2	1.24	0.623447	2.4	1.21	0.020565	0.1	25.1	0.572907	2.2	24.88	95.33692	26.09692	26.09692
Run 3	0.945	0.475127	1.9	0.808	0.013733	0.1	26	0.59345	2.4	23.95	95.67635	25.03231	25.03231
Average	1.185	0.595794	2.3	1.026	0.017438	0.1	25.96667	0.592689	2.3	24.20667	95.25398	25.41259	25.41259
Range	0.425	0.213682		0.402	0.006832		1.7	0.038802		1.09			
Std Dev	0.177811	0.0894		0.165867	0.002819		0.694422	0.01585		0.480578			
Composite	1.1	0.553058	2.2	0.922	0.01567	0.1	34.3	0.782897	3.1	24.21	94.71229	25.56163	25.56163

System Metal Outputs

Kiln 1	Clinker			Kiln Dust Wasted			Emissions		Total Out (lb/hr)	
	ppm	lb/hr	Pct Out	ppm	lb/hr	Pct Out	lb/hr	Pct Out	min	max
Run 1	152	13.3	78.4	148	3.663	21.6	0.001661	0.01	16.96466	16.96466
Run 2	162	14.175	78.5	157	3.88575	21.5	0.001956	0.01	18.06271	18.06271
Run 3	165	14.4375	76.9	175	4.33125	23.1	0.001639	0.01	18.77039	18.77039
Average	159.6667	13.97083	77.9	160	3.96	22.1	0.001752	0.01	17.93259	17.93259
Range	13	1.1375		27	0.66825		0.000317			
Std Dev	5.557777	0.486306		11.22497	0.277818		0.000145			
Composite	152	13.3	76.9	161	3.98475	23.1	0.001752	0.01	17.2865	17.2865

Kiln 2	Clinker			Kiln Dust Wasted			Emissions		Total Out (lb/hr)	
	ppm	lb/hr	Pct Out	ppm	lb/hr	Pct Out	lb/hr	Pct Out	min	max
Run 1	94	17.23333	73.1	135	6.345	26.9	0.000848	0.00	23.57918	23.57918
Run 2	93.2	17.08667	93.4	25.7	1.2079	6.6	0.001064	0.01	18.29563	18.29563
Run 3	126	23.1	76.5	151	7.097	23.5	0.000877	0.00	30.19788	30.19788
Average	104.4	19.14	81.0	103.9	4.8833	19.0	0.00093	0.00	24.02423	24.02423
Range	32.8	6.013333		125.3	5.8891		0.000216			
Std Dev	15.277	2.800783		55.68022	2.61697		9.57E-05			
Composite	94	17.23333	77.1	109	5.123	22.9	0.00093	0.00	22.35726	22.35726

Partitioning

Kiln 1	Ratio In/Out		Adjusted Feed(*)	Dust vs Clinker	Dust vs Feed
	min	max			
Run 1	0.77708	0.77774	1.4375	0.973684	102.9565
Run 2	0.780872	0.781529	1.984375	0.969136	79.11811
Run 3	0.801556	0.8101	< 0.984375	1.060606	177.7778
Average	0.786502	0.789789	< 1.46875	1.001142	119.9508
Range			1		
Std Dev			0.408846		
P(Diff)(**)				0.048621663820711	0.997388
Composite	0.825075	0.825075	1.5625	1.059211	103.04

Kiln 2	Ratio In/Out		Adjusted Feed(*)	Dust vs Clinker	Dust vs Feed
	min	max			
Run 1	1.06486	1.06486	2.140625	1.43617	63.06569
Run 2	1.426402	1.426402	1.9375	0.275751	13.26452
Run 3	0.828943	0.828943	1.476563	1.198413	102.2646
Average	1.106735	1.106735	1.851563	0.970111	59.53159
Range			0.664063		
Std Dev			0.277829		
P(Diff)(**)				0.01045435789442	0.877497
Composite	1.143325	1.143325	1.71875	1.159574	63.41818

Combined

		Dust vs Clinker	Dust vs Feed
Kiln 1	Run 1	0.973684	102.9565
	Run 2	0.969136	79.11811
	Run 3	1.060606	177.7778
Kiln 2	Run 1	1.43617	63.06569
	Run 2	0.275751	13.26452
	Run 3	1.198413	102.2646
Average		0.985627	89.74119
Std Dev		0.355487	49.59004
P(Diff)(**)		0.004141	0.998045

* Slurry feed values are adjusted for moisture and reported in ppm.

** P(Diff) values indicate the probability that Dust and Feed concentrations or Dust and Clinker concentrations are statistically different at a 95% confidence level. Because of rounding, values >0.9999995 (indicating near certainty) are displayed as 1.

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Selenium

System Metal Inputs

Kiln 1	Slurry Feed			Coal/Coke Feed			HFL			Spike		Total In (lb/hr)	
	ppm	lb/hr	Pct In	ppm	lb/hr	Pct In	ppm	lb/hr	Pct In	lb/hr	Pct In	min	max
Run 1	< 0.599	< 0.152487	83.0	1.42	0.02094	11.4	1.75	0.010205	5.6	0	0	0.031145	0.183632
Run 2	< 0.634	< 0.161397	87.5	< 0.815	< 0.012019	6.5	1.91	0.011138	6.0	0	0	0.011138	0.184553
Run 3	< 0.637	< 0.162161	89.4	1.08	0.015927	8.8	0.579	0.003376	1.9	0	0	0.019303	0.181463
Average	< 0.623333	< 0.158681	86.6	< 1.105	< 0.016295	8.9	1.413	0.008239	4.5	0	0	0.008239	0.183216
Range	0.038	0.009674		0.605	0.008922		1.331	0.007761		0			
Std Dev	0.01725	0.004391		0.247622	0.003652		0.593334	0.00346		0			
Composite	0.707	0.17998	90.4	< 0.791	< 0.011665	5.9	1.27	0.007406	3.7	0	0	0.187386	0.199051

Kiln 2	Slurry Feed			Coal/Coke Feed			HFL			Spike		Total In (lb/hr)	
	ppm	lb/hr	Pct In	ppm	lb/hr	Pct In	ppm	lb/hr	Pct In	lb/hr	Pct In	min	max
Run 1	< 0.735	< 0.369543	85.6	1.8	0.030593	7.1	1.38	0.031498	7.3	0	0	0.062092	0.431635
Run 2	0.693	0.348427	85.5	2.33	0.039601	9.7	0.859	0.019607	4.8	0	0	0.407634	0.407634
Run 3	< 0.669	< 0.33636	85.1	2.35	0.039941	10.1	0.824	0.018808	4.8	0	0	0.058749	0.395109
Average	< 0.699	< 0.351443	85.4	2.16	0.036712	9.0	1.021	0.023304	5.6	0	0	0.060016	0.411459
Range	0.066	0.033183		0.55	0.009348		0.556	0.012691		0			
Std Dev	0.027276	0.013714		0.254689	0.004329		0.254253	0.005803		0			
Composite	< 6.98	< 3.509405	98.2	1.78	0.030253	0.8	1.51	0.034466	1.0	0	0	0.064719	3.574124

System Metal Outputs

Kiln 1	Clinker			Kiln Dust Wasted			Emissions		Total Out (lb/hr)	
	ppm	lb/hr	Pct Out	ppm	lb/hr	Pct Out	lb/hr	Pct Out	min	max
Run 1	< 0.82	< 0.07175	23.9	9.05	0.223988	74.7	0.003956	1.32	0.227943	0.299693
Run 2	< 0.748	< 0.06545	23.4	8.23	0.203693	72.9	0.010335	3.70	0.214027	0.279477
Run 3	< 0.692	< 0.06055	23.4	7.62	0.188595	73.0	0.009203	3.56	0.197798	0.258348
Average	< 0.753333	< 0.065917	23.6	8.3	0.205425	73.5	0.007831	2.86	0.213256	0.279173
Range	0.128	0.0112		1.43	0.035393		0.006379			
Std Dev	0.052392	0.004584		0.58589	0.014501		0.002779			
Composite	< 0.797	< 0.069738	23.0	9.1	0.225225	74.4	0.007831	2.59	0.233056	0.302794

Kiln 2	Clinker			Kiln Dust Wasted			Emissions		Total Out (lb/hr)	
	ppm	lb/hr	Pct Out	ppm	lb/hr	Pct Out	lb/hr	Pct Out	min	max
Run 1	< 0.785	< 0.143917	31.7	6.57	0.30879	68.0	0.001306	0.29	0.310096	0.454013
Run 2	< 0.704	< 0.129067	30.4	6.26	0.29422	69.4	0.000656	0.15	0.294876	0.423943
Run 3	< 0.58	< 0.106333	21.5	8.27	0.38869	78.4	0.000515	0.10	0.389205	0.495539
Average	< 0.689667	< 0.126439	27.9	7.033333	0.330567	72.0	0.000826	0.18	0.331393	0.457832
Range	0.205	0.037583		2.01	0.09447		0.000791			
Std Dev	0.084302	0.015455		0.883566	0.041528		0.000344			
Composite	< 0.665	< 0.121917	31.1	5.73	0.26931	68.7	0.000826	0.21	0.270136	0.392053

Partitioning

Kiln 1	Ratio In/Out min	Ratio In/Out max	Adjusted Feed(*)	Dust vs Clinker	Dust vs Feed
Run 1	0.103923	0.805603	< 0.935938	11.03659	9.669449
Run 2	0.039851	0.862288	< 0.990625	11.00267	8.307886
Run 3	0.074716	0.917419	< 0.995313	11.01156	7.655887
Average	0.07283	0.86177	< 0.973958	11.01694	8.544407
Range			0.059375		
Std Dev			0.026953		
P(Diff)(**)				0.99751052119531	0.996539
Composite	0.618857	0.854089	1.104688	11.41782	8.237624

Kiln 2	Ratio In/Out min	Ratio In/Out max	Adjusted Feed(*)	Dust vs Clinker	Dust vs Feed
Run 1	0.136762	1.391939	< 1.148438	8.369427	5.720816
Run 2	0.961531	1.382391	1.082813	8.892045	5.781241
Run 3	0.118555	1.015168	< 1.045313	14.25862	7.91151
Average	0.405616	1.263166	< 1.092188	10.5067	6.471189
Range			0.103125		
Std Dev			0.042619		
P(Diff)(**)				0.988821016485619	0.988396
Composite	0.165077	13.23083	< 10.90625	8.616541	0.525387

Combined

		Dust vs Clinker	Dust vs Feed
Kiln 1	Run 1	11.03659	9.669449
	Run 2	11.00267	8.307886
	Run 3	11.01156	7.655887
Kiln 2	Run 1	8.369427	5.720816
	Run 2	8.892045	5.781241
	Run 3	14.25862	7.91151
Average		10.76182	7.507798
Std Dev		1.899258	1.394758
P(Diff)(**)		0.999982	0.999969

* Slurry feed values are adjusted for moisture and reported in ppm.

** P(Diff) values indicate the probability that Dust and Feed concentrations or Dust and Clinker concentrations are statistically different at a 95% confidence level. Because of rounding, values >0.9999995 (indicating near certainty) are displayed as 1.

Holnam - Holly Hill 1992 BIF Compliance Test / Trial Burn

Thallium

System Metal Inputs

Kiln 1	Slurry Feed			Coal/Coke Feed			HFL			Spike		Total In (lb/hr)	
	ppm	lb/hr	Pct In	ppm	lb/hr	Pct In	ppm	lb/hr	Pct In	lb/hr	Pct In	min	max
Run 1	< 0.599	< 0.152487	90.6	< 0.769	< 0.01134	6.7	< 0.758	< 0.00442	2.6	0	0	0	0.168247
Run 2	< 0.634	< 0.161397	91.1	< 0.815	< 0.012019	6.8	< 0.644	< 0.003755	2.1	0	0	0	0.177171
Run 3	< 0.637	< 0.162161	93.0	< 0.677	< 0.009984	5.7	< 0.392	< 0.002286	1.3	0	0	0	0.17443
Average	< 0.623333	< 0.158681	91.6	< 0.753667	< 0.011114	6.4	< 0.598	< 0.003487	2.0	0	0	0	0.173283
Range	0.038	0.009674		0.138	0.002035		0.366	0.002134		0			
Std Dev	0.01725	0.004391		0.057372	0.000846		0.152918	0.000892		0			
Composite	< 0.567	< 0.144341	73.5	< 0.791	< 0.011665	5.9	< 6.94	< 0.040468	20.6	0	0	0	0.196474

Kiln 2	Slurry Feed			Coal/Coke Feed			HFL			Spike		Total In (lb/hr)	
	ppm	lb/hr	Pct In	ppm	lb/hr	Pct In	ppm	lb/hr	Pct In	lb/hr	Pct In	min	max
Run 1	0.972	0.488702	94.2	< 0.818	< 0.013903	2.7	< 0.712	< 0.016251	3.1	0	0	0.488702	0.518857
Run 2	< 0.586	< 0.294629	90.7	< 0.771	< 0.013104	4.0	< 0.749	< 0.017096	5.3	0	0	0	0.324829
Run 3	< 0.669	< 0.33636	92.1	< 0.673	< 0.011438	3.1	< 0.765	< 0.017461	4.8	0	0	0	0.365259
Average	< 0.742333	< 0.37323	92.3	< 0.754	< 0.012815	3.3	< 0.742	< 0.016936	4.4	0	0	0	0.402982
Range	0.386	0.194073		0.145	0.002464		0.053	0.00121		0			
Std Dev	0.165896	0.083409		0.060404	0.001027		0.022196	0.000507		0			
Composite	0.821	0.412782	92.3	1.07	0.018186	4.1	< 0.718	< 0.016388	3.7	0	0	0.430968	0.447357

System Metal Outputs

Kiln 1	Clinker			Kiln Dust Wasted			Emissions		Total Out (lb/hr)	
	ppm	lb/hr	Pct Out	ppm	lb/hr	Pct Out	lb/hr	Pct Out	min	max
Run 1	< 0.82	< 0.07175	62.3	1.61	0.039848	34.6	0.003577	3.11	0.043425	0.115175
Run 2	< 0.748	< 0.06545	62.3	1.52	0.03762	35.8	0.001907	1.82	0.039527	0.104977
Run 3	< 0.692	< 0.06055	57.7	1.71	0.042323	40.3	0.002073	1.98	0.044395	0.104945
Average	< 0.753333	< 0.065917	60.8	1.613333	0.03993	36.9	0.002519	2.30	0.042449	0.108366
Range	0.128	0.0112		0.19	0.004702		0.00167			
Std Dev	0.052392	0.004584		0.077603	0.001921		0.000751			
Composite	< 0.797	< 0.069738	65.4	1.39	0.034403	32.3	0.002519	2.36	0.036922	0.106659

Kiln 2	Clinker			Kiln Dust Wasted			Emissions		Total Out (lb/hr)	
	ppm	lb/hr	Pct Out	ppm	lb/hr	Pct Out	lb/hr	Pct Out	min	max
Run 1	< 0.785	< 0.143917	73.0	1.06	0.04982	25.3	0.003399	1.72	0.053219	0.197135
Run 2	0.808	0.148133	75.3	0.982	0.046154	23.5	0.002522	1.28	0.196809	0.196809
Run 3	< 0.58	< 0.106333	70.4	0.894	0.042018	27.8	0.00276	1.83	0.044778	0.151111
Average	< 0.724333	< 0.132794	72.9	0.978667	0.045997	25.5	0.002894	1.61	0.048891	0.181685
Range	0.228	0.0418		0.166	0.007802		0.000877			
Std Dev	0.10249	0.01879		0.06781	0.003187		0.00037			
Composite	< 0.665	< 0.121917	77.9	0.675	0.031725	20.3	0.002894	1.85	0.034619	0.156535

Partitioning

Kiln 1	Ratio In/Out		Adjusted Feed(*)	Dust vs Clinker	Dust vs Feed
	min	max			
Run 1	0	3.87447	< 0.935938	1.963415	1.7202
Run 2	0	4.482218	< 0.990625	2.032086	1.534385
Run 3	0	3.92903	< 0.995313	2.471098	1.718053
Average	0	4.095239	< 0.973958	2.155533	1.657546
Range			0.059375		
Std Dev			0.026953		
P(Diff)(**)				0.991631383891559	0.992353
Composite	0	5.321381	< 0.885938	1.74404	1.568959

Kiln 2	Ratio In/Out		Adjusted Feed(*)	Dust vs Clinker	Dust vs Feed
	min	max			
Run 1	2.479019	9.74952	1.51875	1.350318	0.697942
Run 2	0	1.650476	< 0.915625	1.215347	1.072491
Run 3	0	8.157135	< 1.045313	1.541379	0.855247
Average	0.82634	6.519044	< 1.159896	1.369015	0.875227
Range			0.603125		
Std Dev			0.259213		
P(Diff)(**)				0.974137899020124	0.643763
Composite	2.753172	12.92246	1.282813	1.015038	0.526188

Combined

		Dust vs Clinker	Dust vs Feed
Kiln 1	Run 1	1.963415	1.7202
	Run 2	2.032086	1.534385
	Run 3	2.471098	1.718053
Kiln 2	Run 1	1.350318	0.697942
	Run 2	1.215347	1.072491
	Run 3	1.541379	0.855247
Average		1.762274	1.266387
Std Dev		0.434611	0.410596
P(Diff)(**)		0.989099	0.701876

* Slurry feed values are adjusted for moisture and reported in ppm.

** P(Diff) values indicate the probability that Dust and Feed concentrations or Dust and Clinker concentrations are statistically different at a 95% confidence level. Because of rounding, values >0.9999995 (indicating near certainty) are displayed as 1.

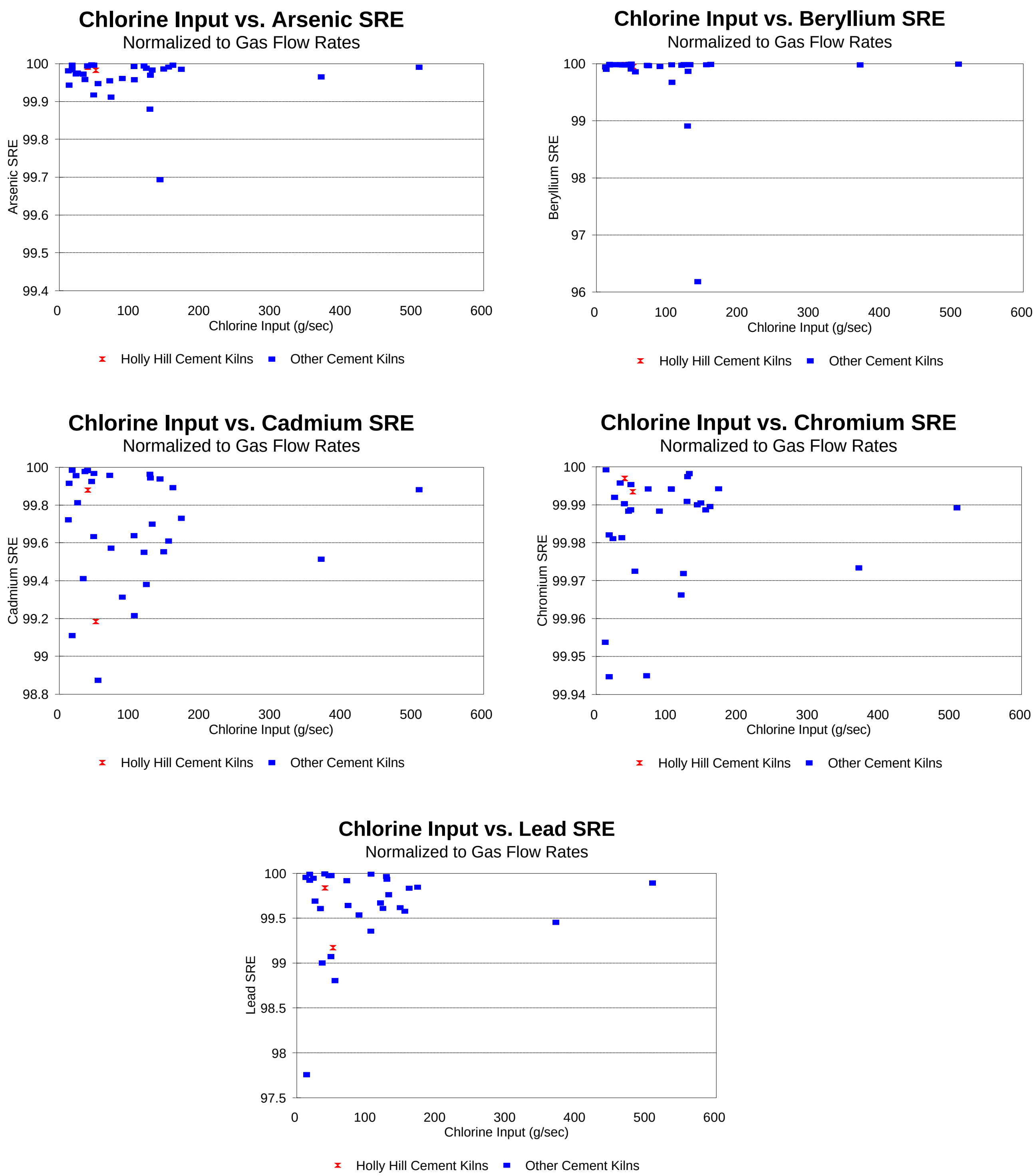

Figure 1. Chlorine Input vs. Metal SREs

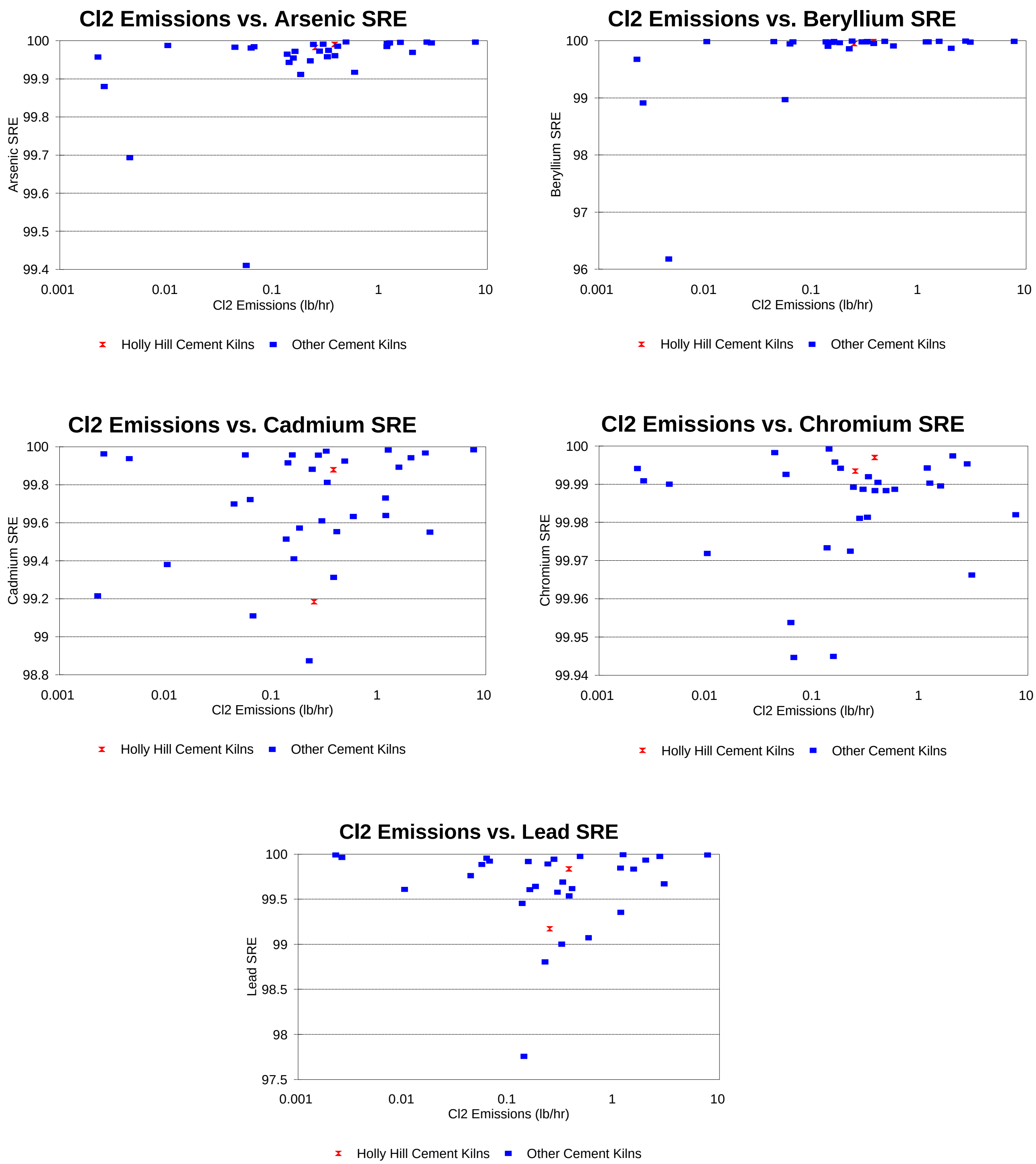

Figure 2. Cl2 Emissions vs. Metal SREs

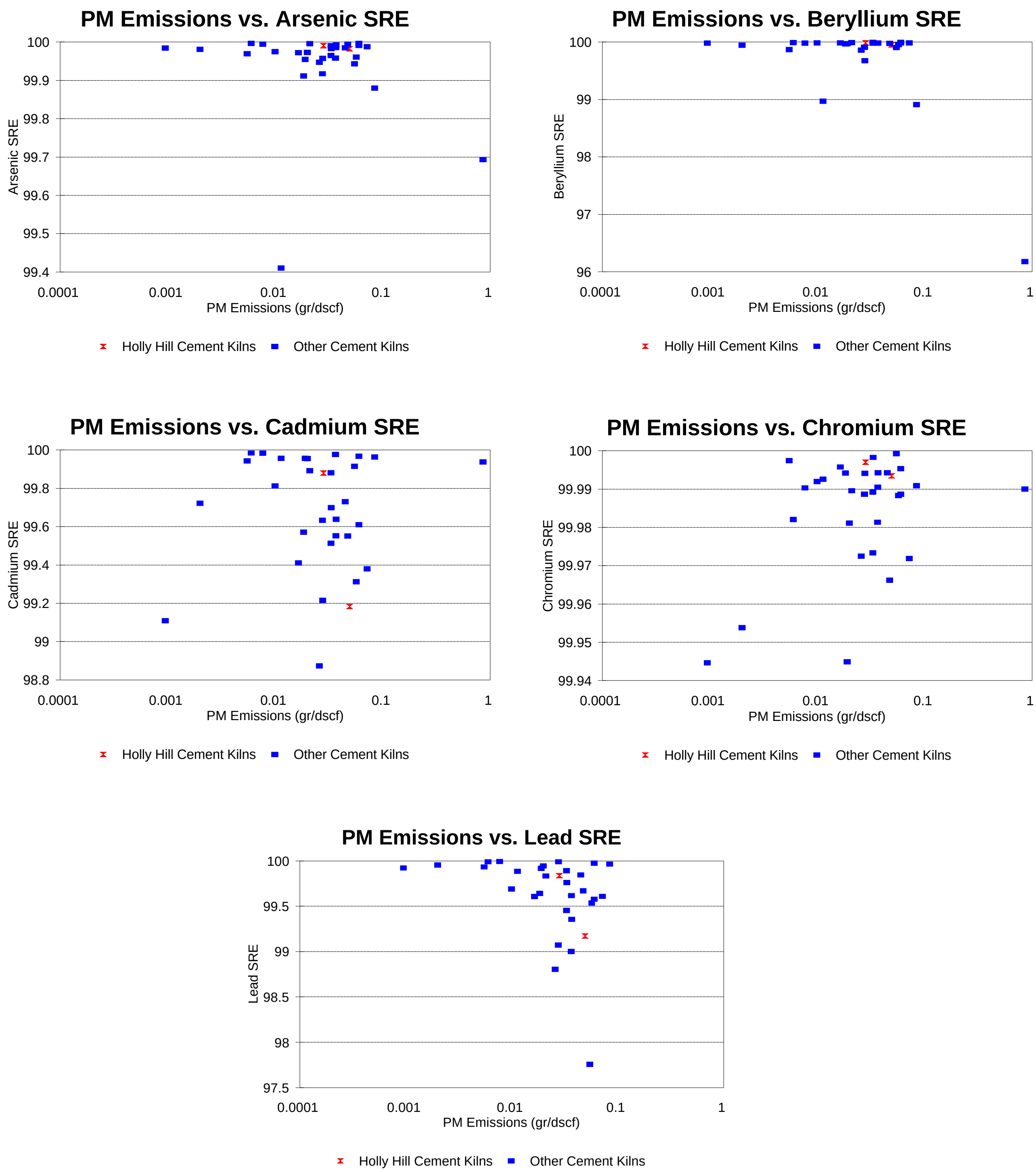

Figure 3. Particulate Matter Emissions vs. Metal SREs

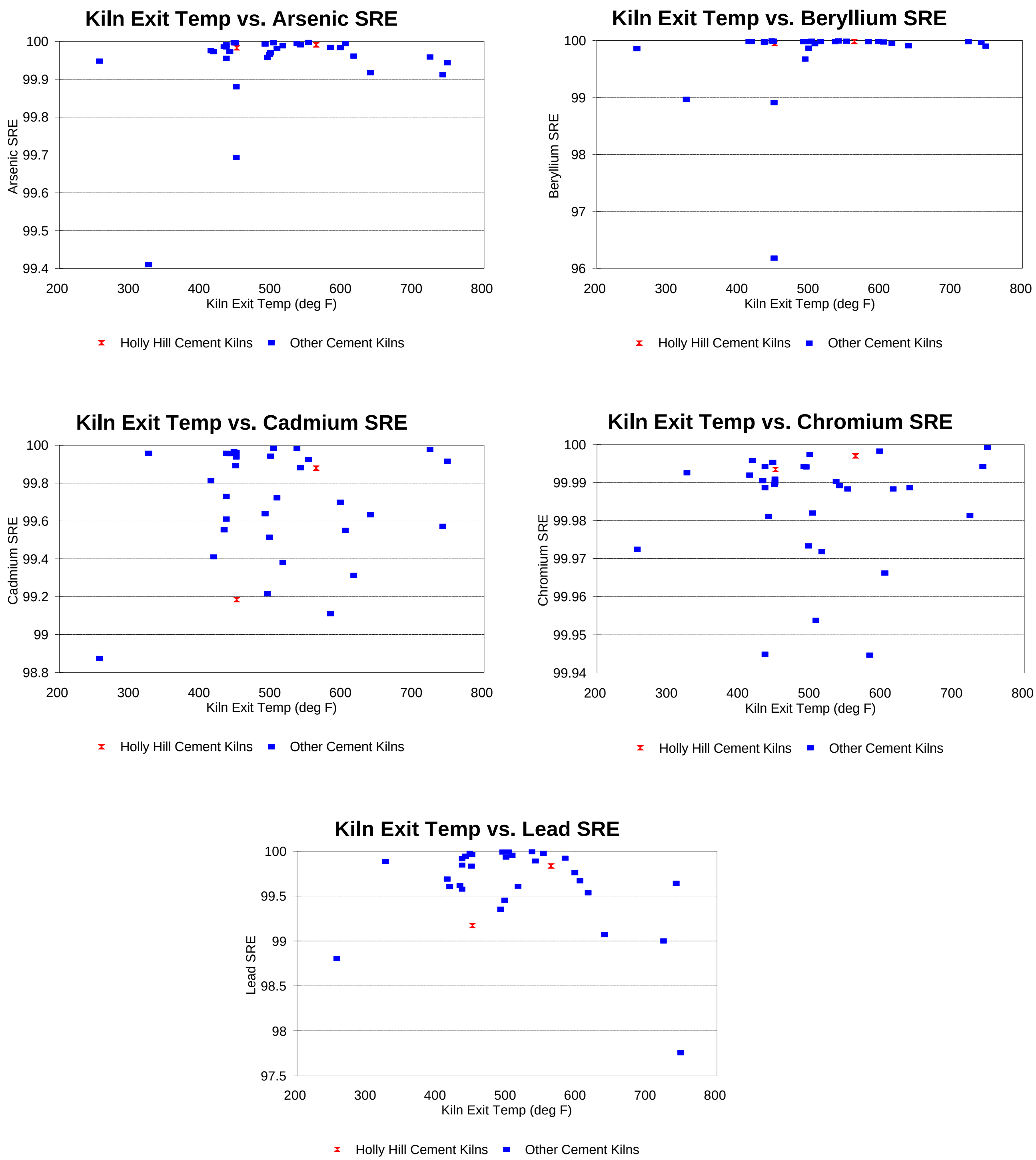

Figure 4. Kiln Exit Temperatures vs. Metal SREs

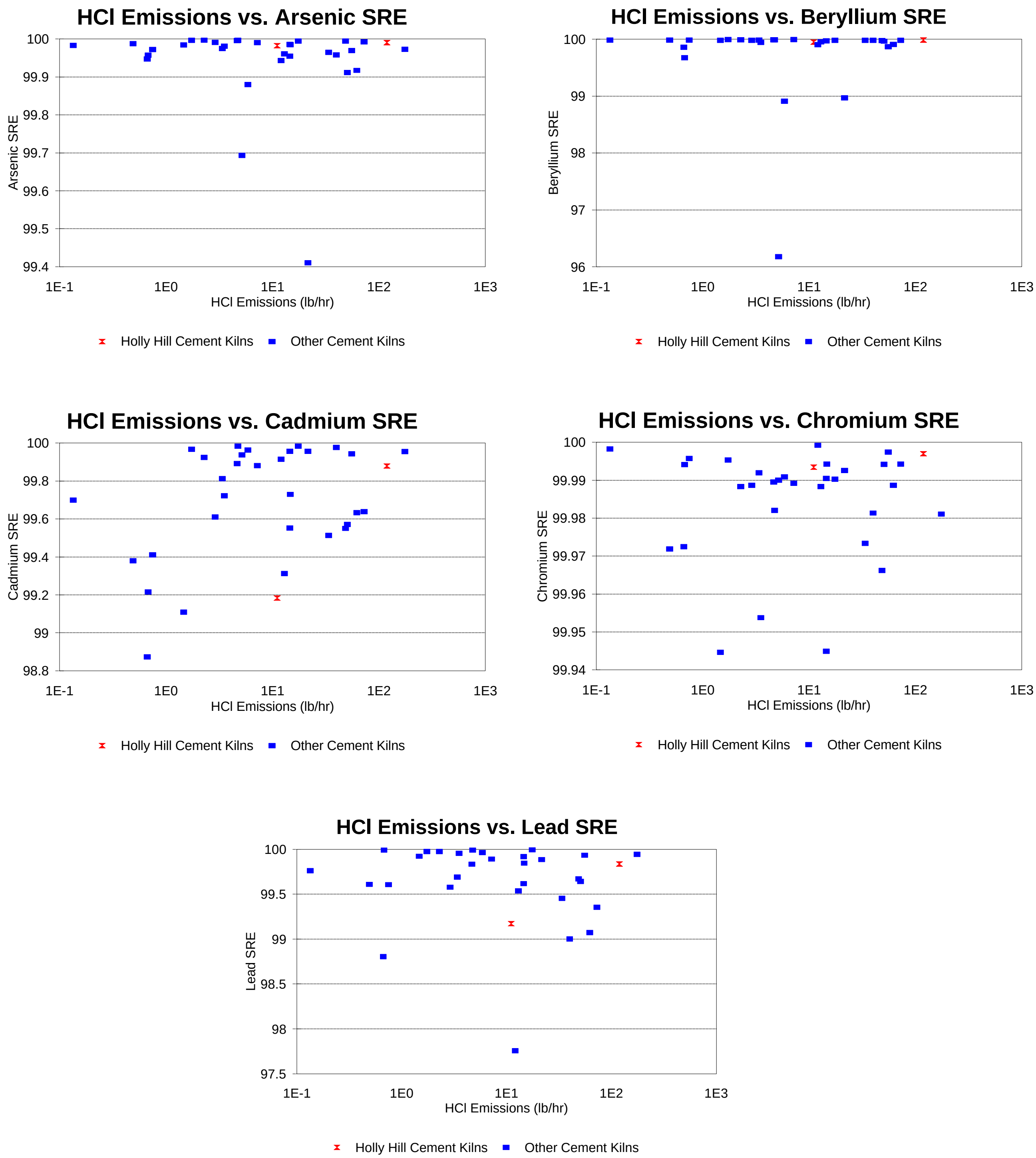

Figure 5. HCl Emissions vs. Metal SREs

Key Words

BIF

Clinker

EPA

Kiln

Metal

Precompliance

Recertification

Risk

Spike

SREs