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JAN 15 2009
BUREAU OF AIR REGULATION

KA 624-08-04
January 14, 2009

Mr. A.A. Linero
Bureau of Air Regulation
Department of Environmental Protection
2600 Blair Stone Road, MS # 5500
Tallahassee, Florida 32399-2400

SUBJECT: Response to 2nd Request for Additional Information (RAI)
dated December 10, 2008
Suwannee American Cement – Branford, Suwannee County
DEP File No. 1210465-016-AC (PSD-FL-259G)
Alternative Fuel Materials Testing – SAC Cement Kiln
P.E. Certification

Dear Mr. Linero:

The enclosed package includes the RAI response information requested by your letter to Tom Messer of Suwannee American Cement dated December 10, 2008 regarding the subject permit application. In accordance with Rule 62-4.050(3), I have sealed this letter with enclosure as certification by a professional engineer. Enclosed please find four (4) copies of the RAI response. I trust this response addresses the information of your request and appreciate your expedited review.

Please feel free to contact me at (352) 377-5822 or mlee@kooglerassociates.com if you have any questions regarding this submittal.

Sincerely,

Max Lee, Ph.D., P.E.

1/14/09
Date

P.E. Seal: 58091

Cc: Trina Vielhauer, FDEP
Tom Messer, SAC
Krishna Cole, SAC

Enclosure: 4 copies-AC Permit Application RAI Response

Suwannee American Cement
P.O. Box 410
Branford, FL 32008-0410
Phone (386) 935-5000 Fax (386) 935-5080

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BUREAU OF AIR REGULATION

January 13, 2009

Trina Vielhauer, Bureau Chief
Bureau of Air Regulation
Division of Air Resource Management
2600 Blair Stone Road
Tallahassee, FL 32399-2400

Re: DEP File No. 1210465-016-AC (PSD-FL-259G)
Alternative Fuel Materials Testing - SAC Cement Kiln
Branford, Suwannee County

Dear Ms. Vielhauer:

This letter is Suwannee American Cement's response to the Department's RAI dated December 10, 2008. In this response there is a lot of detail regarding the proposed test trials. However, there are some basic and important points to remember when considering this matter:

1. This air construction permit application is a proposal to only test ASR as a fuel at SAC, and does not constitute acceptance of this material as an alternative fuel by the Department. This application is only a method by which to assess the feasibility and acceptability of this material as an alternative fuel. Any subsequent use of this material at SAC would be dependent upon the outcome of these test trials.

2. SAC does not propose an increase of any of its permitted emission limits or production limits for these test trials.

3. SAC will not trigger PSD for any regulated pollutant during these test trials.

SAC feels that it is suited for these test trials for the following reasons:

1. SAC has demonstrated since initial operations in 2003 that it can successfully operate under strict regulatory requirements.

2. SAC supplies real time emissions data to the Department and the public.

3. SAC was the first facility in Florida to attain and maintain International Standards for Organization for its Environmental Management System (ISO 14001).

4. SAC has set benchmarks for energy efficiency, and is one of only 19 Cement Plants in the United States to be awarded the ENERGY STAR® Label.

5. SAC voluntarily installed a Selective Non-Catalytic Reduction System (SNCR) for NOx Control, and was awarded an EPA Certificate of Recognition for its NOx control strategy. This voluntary control system helps SAC to consistently meet current NOx emission limits for the plant that are near to current BACT limits for new cement plants in Florida.

6. SAC has continuously demonstrated its commitment to work closely with the Department in order to ensure that all concerns, including concerns regarding these test trials, are properly addressed.

Other important points to be considered:

1. Auto Shredder Residue (ASR) is a material high in energy content that is being landfilled at the rate of approximately 4 million tons per a year in the US.

2. The Florida Legislature passed Statute 403.7032 which mandates recycling 75% of landfilled material by 2020. Energy production from material that was to be landfilled is counted towards this mandate. The proposed use of Auto Shredder Residue (ASR) can be counted towards this goal.

3. There is currently no other feasible option for ASR besides landfill, and current laws and regulations do not promote a viable alternative at this time. These test trials may demonstrate that ASR is a suitable fuel source for cement kilns. This potential alternative material use for ASR would create an economic incentive for ASR producers to increase their efforts to further purify their material stream (e.g., improved methods to reduce mercury and lead content prior to shredding).

4. Although not landfilled in Florida, this material is being sent across the border to South Georgia to be landfilled. Much of the material ends up in landfills that are located near the head waters of some of Florida's major rivers.

5. Landfilling this material does not alleviate air emissions. Besides the potential for uncontrolled air emissions from landfill fires (≈8,300 landfill fires every year FEMA Study - May 2002/FA-225), landfill decomposition generates emissions of methane gas; a far more potent green house gas than carbon dioxide.

6. Recovering energy from this recovered material will offset the use of coal and other natural resources.

7. Cement Kilns offer the best opportunity for energy recovery of waste materials for several reasons:

   a. Highly efficient air pollution control equipment captures ASR ash (including semi-volatile and heavy metals) which is incorporated into the final product (cement).
   b. High efficiency combustion at long residence times and high burning zone temperatures ensure full energy utilization.
   c. Preheater/Precalciner and Kiln process design ensures raw materials (87% limestone) naturally act as gas stream scrubbing agents.
   d. Reduces coal combustion and all of the inherent emissions from the extraction and transportation of the replaced coal.
   e. Replaces coal with a readily available and local recovered energy source.

Below are the Departments questions in ***bold italics*** followed by SAC's response.

1. ***Please provide more specific details regarding the quality control plan that will be used at automobile shredder facilities (ASF) which are not located at SAC to ensure that metals like mercury and lead are removed from ASR prior to shipment to SAC. Specifically, provide detailed quality control procedures to ensure that metals are removed from the ASR prior to shipment to SAC. The Department may include such procedures in a construction permit to make such procedures a condition of testing and any future operation.***

An ASF typically receives their shredder feedstock from two primary sources; scrap yards and individuals. The bulk of all material shredded comes from scrap yards. Scrap yards collect vehicles and appliances from the public and remove all valuable parts, and attempt to find and remove all of the following unwanted materials (*Attachment 1*):

- Fluids
- Tires
- Batteries
- Battery Connectors
- Mercury Switches
- Propane Tanks
- Gas Tanks
- Aerosol Cans
- Pipes with lead
- Lead Lined Chemical tanks
- Ballasts
- Capacitors
- Air bag canisters
- Electronics
- Computers
- Military equipment
- Fertilizer equipment
- Wood
- Cement

After the cars have been processed at the scrap yard they are compressed for shipping and shipped to shredding facilities to recover and recycle the metal. The following methods are used to control the quality of the shredder feed stock:

- Visual Load Inspection (spot check incoming loads)
- Bulk Radiation Sensor Device (every load)
- Scrap Yard Audits (occasional)

If a load does not meet specification, the entire load is shipped back to the supplier at the supplier's expense. Long term contracts drive this relationship and give the shredding facility some leverage to control its feedstock.

Generally, a secondary source for shredder feedstock comes from individuals. Every load of shredder feedstock material that comes from an individual is inspected for the list of items above, and if these items are found the load is rejected until they have been removed by the individual.

Image 1: During a visit to one of the potential sources SAC witnessed one of the inspections and took a photo of it.

SAC's potential ASR suppliers have controls in place, and have assured SAC that they will increase their efforts to enforce those controls. There is clear economic incentive for them to improve the quality of their feedstock. However, SAC is not able to impose controls on any source not owned and operated by SAC. SAC can and will abide by its own proposed Quality Plan (see response to question two) and all requirements of its Quality Management System. Furthermore, SAC firmly believes that the economic incentives to the suppliers will be a driving force for them to voluntarily enforce their quality control plan.

2. ***Please provide information on how SAC will ensure that the quality control plan mentioned in item No. 1 above will be followed since the ASF is not located at SAC and is not owned or under the control of SAC. Please provide any agreements or understandings that have been reached with any ASF that will provide ASR to SAC.***

In order to operate successfully and produce a quality product; a cement manufacturing process must control all of the highly variable resources necessary to produce cement. SAC, early on, realized the importance of a world class Quality Management System (QMS); and in April 2004, SAC established a QMS that meets all requirements of the International Organization for Standardization (ISO) for QMS (ISO 9001). SAC has maintained its ISO 9001 certification since. In order to be ISO 9001 certified SAC's QMS must meet all of the requirements of the ISO 9001 standards (*Attachment 2*), and is independently audited at least once per year to ensure the status of its Quality Management System. SAC has operated and will continue to operate according to its established QMS. As part of its QMS, SAC has an established Quality Plan for raw materials and fuel sources (*Attachment 3*). The Quality Plan objective is to outline routine quality control testing protocol in order to ensure all raw materials (including fuels), in-process materials, and finished products are within required specification limits and tolerances. The Quality Plan establishes the following:

a) Sampling Location(s)
b) Sample size
c) Minimum frequency
d) Who collects
e) Sample preparation
f) Who analyzes (external/internal)
g) Type of analysis
h) Analysis method
i) Validation of process
j) Material Traceability
k) Requirements in the event of a non-conformity

During the proposed test trials SAC proposes the following minimum Quality Plan:

a) Sampling Location - Onsite sampling will occur prior to the Schenck Feeding System - Offsite sampling will occur at the supplier's stock pile prior to shipping. The onsite sampling location has been chosen because it will:
    - provide the most representative sample of the material being input into the system
    - reduce potential for sampler bias since material will be gathered from a stream rather than a stock pile
    - smaller particle size makes it easier to prepare sample for analysis

b) Sample Size - One Gallon Container (approximate)

c) Minimum Frequency - onsite sampling every 4 Hours (during operations), offsite sampling monthly (beginning one month prior to test trial). Sampling every four hours should ensure that samples are collected almost as frequently as trucks are received.

d) Who will collect the samples - Shift Lab Technician

e) Sample Preparation - as necessary per specific lab analysis requirements

f) Who will analyze the samples -
   - Internal Lab Analysis will analyze for %Sulfur, %Moisture, %Ash, Particle Size, Calorific Value [Btu/lb], and Volatility.
   - External Lab Analysis will analyze for total metals (i.e. Cd, Hg, Pb, and Tl)
   - External Lab Analysis will also be used to verify that materials are not classified as hazardous under 40 CFR 261.

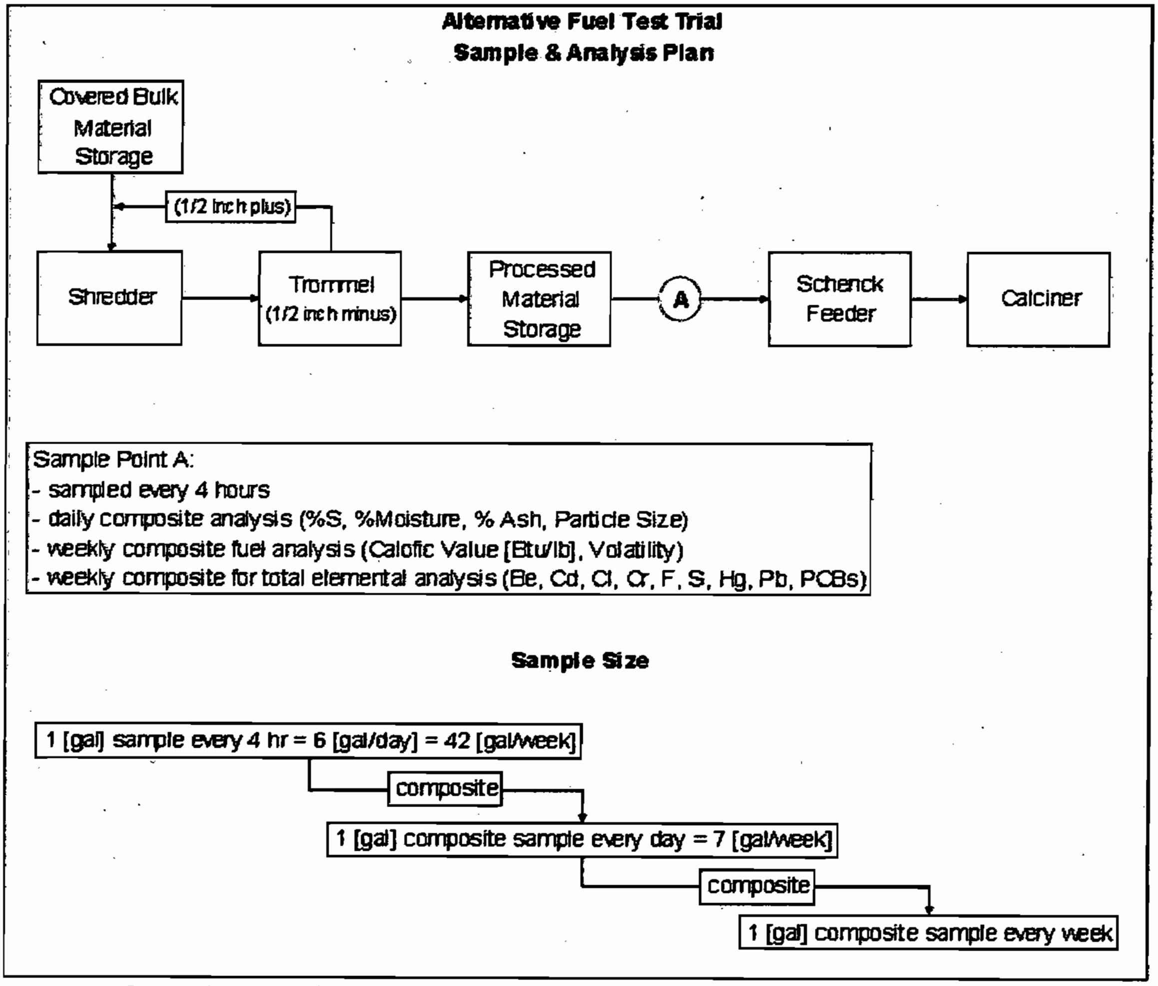
g) Type of Analysis -
   - Internal Lab Analysis - %Sulfur, %Moisture, %Ash, Particle Size, Calorific Value [Btu/lb], and Volatility.
   - External Lab Analysis - total concentrations for metals and other (i.e. Cd, Hg, Pb, and Tl)
   - External Lab Analysis - TCLP

h) Analysis Method -
   - Internal Lab Analysis will use established methods that are traceable to NIST or ASTM standards or other approved methods.
   - External Lab Analysis will use EPA approved methods or other approved methods.

i) Validation Process - the raw material bins have signs in the field, where the status of each material is provided. They are identified as "approved" (green) if within the specification; "in test" (yellow) if the material is under analysis or "Do not use" in red if the material is not approved. For material in process and final product, the validation is automatic. If there is no warning from Quality control to production or shipping: that means the product is approved.

j) Traceability - the material has identification and the traceability is by date of production or receiving.

k) Requirements in the event of non-conformity - data from the proposed test trial would help SAC and DEP establish material specifications for future use. However, at this point, SAC would consider a material non-conformity to be if the material could be classified as hazardous under 40 CFR 261. SAC proposes to conduct monthly source sampling and analysis beginning at least one month prior to test trial and during the test trial to ensure that material coming to the site is not classified as hazardous. If this non-conformity were to occur SAC would reject all further shipments from the source (until nonconformity could be corrected), test material in storage, and if necessary return all material in storage back to the source.



Sample Point A:
- sampled every 4 hours
- daily composite analysis (%S, %Moisture, % Ash, Particle Size)
- weekly composite fuel analysis (Calofic Value [Btu/lb], Volatility)
- weekly composite for total elemental analysis (Be, Cd, Cl, Cr, F, S, Hg, Pb, PCBs)

1 [gal] sample every 4 hr = 6 [gal/day] = 42 [gal/week]

1 [gal] composite sample every day = 7 [gal/week]

1 [gal] composite sample every week

Image 2: Above is a schematic of SAC's proposed sampling plan during the test trial.

It is very important to note that SAC, by this air construction permit application, is proposing temporary test trials to gather data. At this time the level of control that will be necessary for future use of this material (following test trials) is not yet fully understood; hence SAC has submitted this air construction permit application to propose these test trials. The primary goal of these test trials are to gather sufficient data to supply SAC and DEP with enough information to make knowledgeable decisions with regards to any subsequent requests by SAC (or other facilities) to use ASR as an alternative fuel. At this time, SAC believes it has developed a quality plan and test protocol that will ensure the data collected is representative of the population to be sampled.

As stated above, SAC's potential ASR suppliers have controls in place, and have assured SAC that they will increase their efforts to employ those controls. However, SAC is not able to impose controls on any source not owned and operated by SAC. SAC can and will abide by the proposed Quality Plan and all requirements of its QMS. SAC's QMS is in place to approve and disapprove suppliers based on their adherence to our specifications. The QMS involves pre-screening of suppliers, testing of materials, and periodic site audits of suppliers to make sure supplied materials are meeting all required specifications. SAC will continue to use these controls to protect its interests and will work with all suppliers to improve the quality of all materials supplied.

Furthermore, based on initial testing, mercury concentrations (≈ 1 ppm) limit the use of ASR at SAC. This is because SAC would be limited by its already permitted mercury limit of 97 pounds total inputs per 12 month rolling period. SAC is not seeking an increase of its currently permitted mercury limit, and at no time during the requested test trial will SAC exceed any of its permitted limits or trigger PSD. Therefore, after successful testing, it will be mutually beneficial for SAC and its suppliers to reduce mercury concentrations if there is a desire to increase coal replacement using ASR. With the mercury emission restrictions in place, creating the opportunity to use ASR as a fuel also creates an economic incentive for an ASF to further reduce mercury in ASR.

3. ***Please provide the detail testing protocols as per our discussion on Friday December 5th to show the ultimate fate of metals in the kiln system when burning ASR. Specifically, provide the protocols to show whether the ultimate fate of the metals is incorporation into the clinker or as air emissions from the kiln stack.***

SAC will incorporate a similar process of monitoring the mass balance for metals of concern with the Department as was proposed for mercury.

- Kiln Feed Input

- Clinker Output
- Stack Testing for Gas Phase Output

This would include sampling at intermediate points for metals such as kiln feed and baghouse dust over the course of the test to evaluate the potential build-up of a cycle for these materials.

With SAC's inline raw mill and dry preheater/precalciner system there are essentially two operating conditions; raw mill on and raw mill off. The process operates with the raw mill on the majority of the time (2007 - 7,148 hours or 88% of total kiln run time). The raw mill is designed to exceed the production capacity of the kiln so that it can be shut down for maintenance while maintaining kiln operations. When considering equilibration and process capture efficiencies of trace metals these two operating conditions must be taken into consideration.

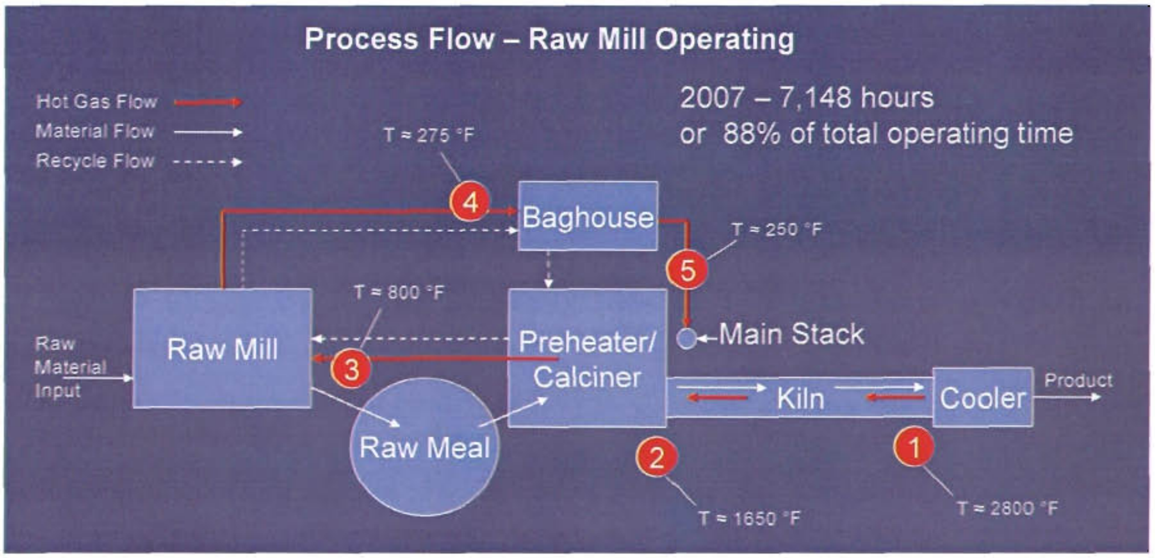
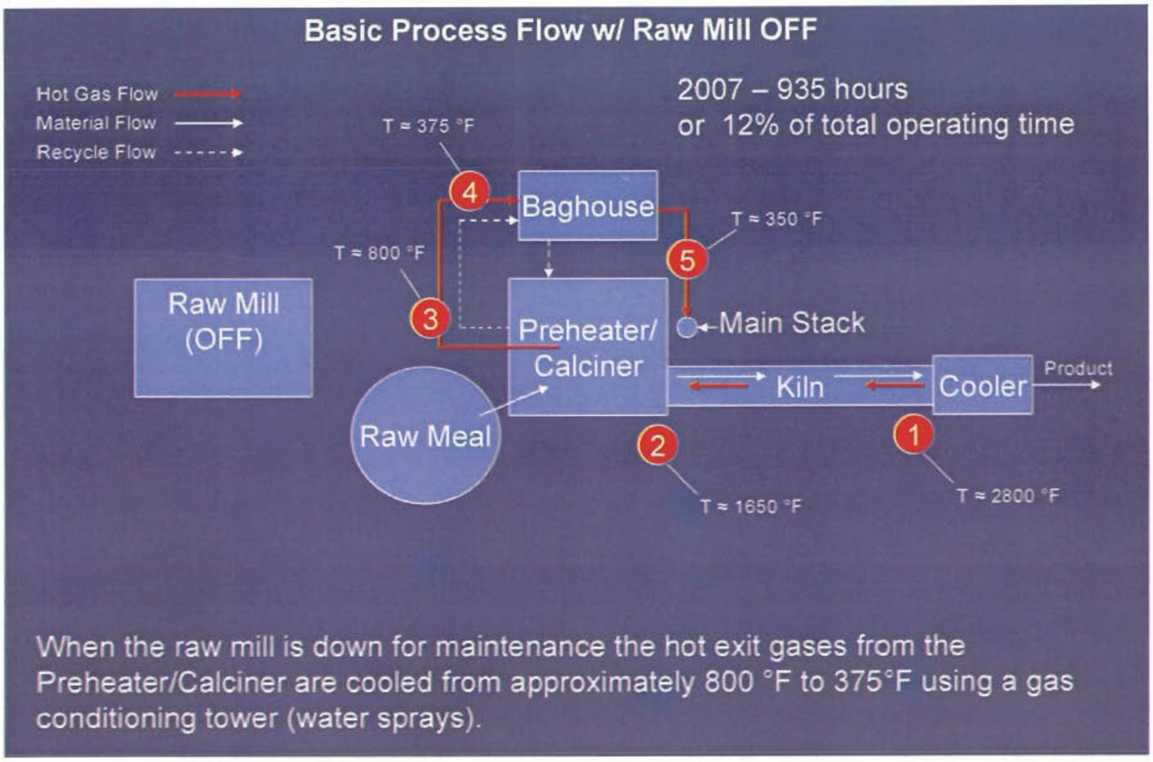


Image 3: Displays a simple gas & material flow diagram and nominal operating conditions with raw mill on.

During raw mill on conditions it is understood that the lower baghouse temperatures are not high enough to volatize metals and there is sufficient fresh feed of limestone (an efficient scrubbing agent) to scrub the exit gases passing through the raw mill. Therefore, it is understood that semi volatile and volatile metals (i.e. mercury, cadmium, thallium, and lead) are predominantly trapped and build in the system until the system reaches chemical equilibrium or raw mill off conditions.



Basic Process Flow w/ Raw Mill OFF

2007 – 935 hours
or 12% of total operating time

When the raw mill is down for maintenance the hot exit gases from the Preheater/Calciner are cooled from approximately 800 °F to 375°F using a gas conditioning tower (water sprays).

Image 4: Displays a simple gas & material flow diagram and nominal operating conditions with raw mill off.

During raw mill off conditions it is believed that the higher baghouse temperatures have the potential to volatize metals and also there is not a sufficient supply of fresh limestone to scrub the exit gases. Therefore, the belief is that chemical equilibrium changes and the semi volatile and volatile metals may be released from the system. However, this is a very simple description of the concept. In fact, there are many factors affecting the equilibrium of trace metals in the system. To date, there is little data available to support that bypassing a portion of baghouse dust will have a significant impact on metals reduction. It is generally accepted that there may be a window of opportunity to bypass baghouse dust and achieve some reduction in metals, but determining the equilibrium cycle has been elusive, and the effects this practice could have on production efficiency and quality could be significant.

There are two different sources for trace metal introduction into the system; raw materials and fuels. Metals introduced with the fuels behave differently than metals introduced with the raw materials. This is because raw materials are introduced in a different location at much lower temperatures (400 to 800 °F gas phase); whereas, fuels are introduced at much higher temperatures in the kiln and calciner (1600 to 3200 °F gas phase). Although, concentrations of metals in the fuel may be higher than in raw materials; metal contributions by fuels are generally small compared to those inputs by raw material due to the fact that the mass of raw materials is much greater than that of the fuels. Furthermore, metals in the fuel enter a region rich in calcium oxide (CaO), an extremely efficient scrubbing agent, and it is understood that most semi-volatile metals (i.e. cadmium, beryllium, lead, arsenic, etc.) are efficiently captured by the system and retained in the product (clinker). This understanding is based on other external facility test data supplied below:

Table 1. Results from Method 29 Stack Testing, (US Facility), 2003.

lbs/hr	Run 1; 1000-1210	Run 2; 1230-1437	Run 3; 1508-1719
Arsenic	6.25E-04	8.72E-04	4.80E-04
Cadmium	8.83E-04	4.04E-04	5.36E-04
Chromium	3.05E-03	2.54E-03	2.00E-03
Lead	9.84E-03	6.02E-03	5.76E-03
Nickel	6.19E-03	2.96E-03	2.37E-03
Percentage of Metals Through Stack			
	Run 1; 1000-1210	Run 2; 1230-1437	Run 3; 1508-1719
Arsenic	0.01%	0.02%	0.01%
Cadmium	0.23%	0.10%	0.12%
Chromium	0.02%	0.01%	0.01%
Lead	0.14%	0.09%	0.09%
Nickel	0.03%	0.02%	0.01%
Percentage of Metals Into Clinker			
	Run 1; 1000-1210	Run 2; 1230-1437	Run 3; 1508-1719
Arsenic	99.99%	99.99%	99.99%
Cadmium	99.77%	99.91%	99.88%
Chromium	99.99%	99.99%	99.99%
Lead	99.86%	99.91%	99.91%
Nickel	99.97%	99.99%	99.99%

Table 2. Results from Method 29 Stack Testing, (US Facility), 2008.

lbs/hr	Run 1; 803-1019	Run 2; 1142-1400	
Arsenic	7.12E-04	3.34E-04	
Cadmium	1.38E-03	2.74E-04	
Chromium	6.41E-03	2.54E-03	
Lead	6.36E-03	1.28E-03	
Nickel	5.29E-03	2.98E-03	
Percentage of Metals Through Stack			
	Run 1; 803-1019	Run 2; 1142-1400	
Arsenic	0.01%	0.00%	
Cadmium	0.16%	0.03%	
Chromium	0.01%	0.01%	
Lead	0.06%	0.01%	
Nickel	0.02%	0.01%	
Percentage of Metals Into Clinker			
	Run 1; 803-1019	Run 2; 1142-1400	
Arsenic	99.99%	100.00%	
Cadmium	99.84%	99.97%	
Chromium	99.99%	99.99%	
Lead	99.94%	99.99%	
Nickel	99.98%	99.99%	

Table 1 & 2: These tables summarize a review of the stack test results for metals involving hazardous waste combustion at a US Cement Facility. The metals tested include Arsenic, Cadmium, Chromium, Lead, and Nickel. These tables are a summary of the measured emission rates (lbs/hr) of the stack test. The Title V compliance test reports included a section where the metals content and throughput of the various kiln inputs (kiln feed, alternate fuels, and coal) were listed. Using this materials analysis, it was possible to calculate the partitioning of the input metal into the stack vs. clinker. The metal inputs are known and the stack emissions are known. Therefore, the system removal efficiency (SRE), or the "Percent of Metals into Clinker", is calculated as one hundred percent minus the percent of metals exiting as stack exhaust. It is SAC's understanding from review of the report and Method 29, that the metals analyzed are the actual metal inputs from the kiln feed and fuels, and do not include additional spiking.

SAC believes that lead and other semi-volatile metals would be efficiently recovered by the system in quantities greater than 99%. However, the argument has been made that the results of tests could be site or process design specific (i.e. bypass vs. no bypass). Therefore, in addition to the proposed stack testing using 40 CFR 60, Appendix A, Method 29, SAC proposes to test for SAC's system removal efficiency (SRE) of trace metals from fuel such as mercury, thallium, cadmium, and lead as follows:

Test Trial - SAC's Metals SRE Test Plan:

1. Method 29 stack testing will occur after at least 2.5 days of operating with ASR as a fuel with the raw mill on. This time frame is based on a blend silo turn over rate of 2.5 days, and would allow for metal concentrations in the blend silo to reach a potential maximum. Raw mill on conditions will be tested first followed by raw mill off conditions.

2. SAC will sample and analyze metal concentrations of all material inputs during the test trial. All of the potential material inputs during the test trial are:

   - Limestone
   - Flyash
   - Mill Scale
   - Sand/Clay

   Raw Meal - Captured by Kiln Feed sampling.

   - Coal
   - High Carbon Flyash
   - Auto Shredder Residue

3. During EPA Method 29 stack tests, SAC will gather samples at the following five locations (these sample points will capture all material input & output streams):

   - Kiln feed (prior to Poldos feeding system)
   - ASR feed
   - Milled coal feed
   - Main baghouse returns
   - Clinker conveyor

4. All feed rates will be measured during the test run. However, baghouse returns will be assumed to be 10% of kiln feed.

5. The following material balance will be used to calculate the SRE:

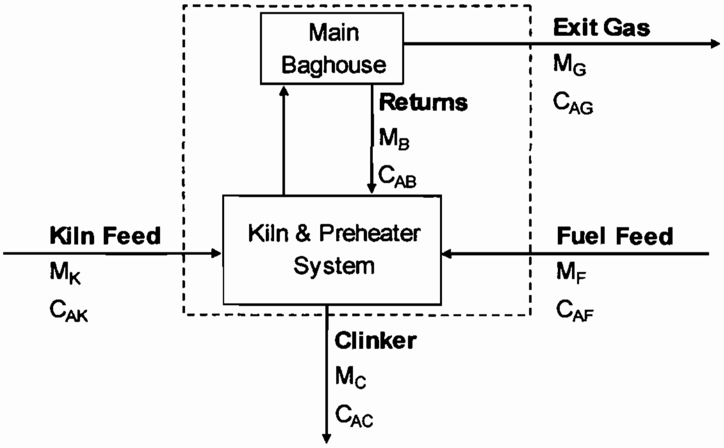


Image 5: Material Balance Diagram

System Removal Efficiency can be calculated as follows:

$$SRE_A = \left[1 - \frac{M_G C_{AG}}{M_K C_{AK} + M_F C_{AF}}\right] \times 100$$

SRE_A - System Removal Efficiency of analyte (the analyte is any metal of interest)

M_X - mass flow rate of material at x location

C_{AX} - concentration of analyte at x location

$M_G C_{AG}$ - total mass of analyte in the Exit Gas (like wise the other streams C, F, & K represent the location - see Image 5)

Analytes to be measured are: Cadmium (Cd), Lead (Pb), Mercury (Hg), and Thallium (Tl).

C_{AB}, C_{AC}, C_{AF}, and C_{AK} will be determined from composited grab samples, and $M_G C_{AG}$ will be determined using Test Method 29.

6. SAC proposes to gather at least 4 samples per hour (every 15 minutes) at each location during a Method 29 stack test. This will result in 12 samples from each location per a 3 hour test run. Samples will be composited into one test run sample for analysis.

4. ***In the material that SAC submitted in response to the Departments' RAI dated October 29, 2008, it was indicated that ASR had or was being used as an alternative fuel source at the Holcim cement plant in Michigan and the TXI cement plant in Texas. However, based on the Departments' review of the submitted material it was determined that ASR had not and was not being used at either facility as a fuel source. Consequently, please provide any information on other cement kilns in the U.S. or abroad that have in the past or that are currently using ASR as an alternative fuel source. If available, the information should include any constituents testing of the ASR such as metal content, stack emissions testing, and metal material balances that were done while burning ASR.***

At this time, SAC has not been able to obtain sufficient data on facilities in the US or abroad that may be currently using ASR as an alternative fuel. However, SAC believes based on research conducted, that there are some facilities in Germany, Canada, UK, and possibly Japan using ASR or considering ASR as a fuel; but SAC could not find evidence to demonstrate this conclusively. With regards to TXI Midlothian and Holcim Michigan SAC was apparently under the false impression, based on conversations with vendors and some internal research conducted, that they were using or may have used ASR derived fuels.

5. ***SAC indicated in Table 5 of Slide 23 of the presentation given during the meeting with Department staff on December 5th that testing by VDZ indicates that the fate of metals other than mercury in raw materials and fuel sources in modern preheater kiln systems is incorporation into the clinker. However this testing was conducted on kiln system where they likely have the ability to bleed filter dust to cement production (for example the case of thallium) and consequently any metal buildup cycle that may occur in the kiln system may be disrupted by bleeding the filter dust. Please explain how SAC infers that the VDZ test results are applicable to modern preheater kiln systems in North America where bleeding filter dust is not available.***

The data presented by the Verein Deutscher Zementwerke e.V. (VDZ) represents an average analysis for all kiln systems in Germany. The Table below from the VDZ Activity Report 2005 - 2007 shows the breakout of kiln types represented in the data provided.

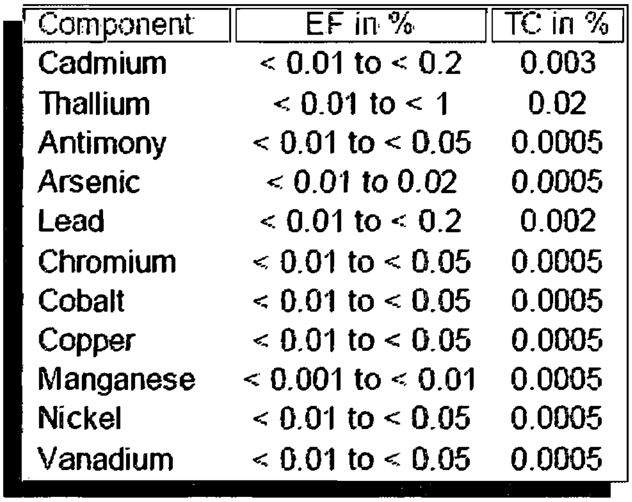
Table I-1: Number and capacity of the kilns with operating permits in Germany in the years from 2004 to 2006

		As at 1 Jan. 2005			As at 1 Jan. 2006			As at 1 Jan. 2007		
		Number	Capacity		Number	Capacity		Number	Capacity	
			t/d	%		t/d	%		t/d	%
Kilns with cyclone preheaters		45	114750	88.3	42	103650	91.1	41	100550	90.8
Kilns with grate preheaters		16	14070	10.8	11	8970	7.9	11	8970	8.1
Shaft kilns		8	1200	0.9	8	1200	1.0	8	1200	1.1
Total		69	130020	100	61	113820	100	60	110720	100
Average kiln capacity in t/d	Rotary kilns		2112			2124			2106	
	Shaft kilns		150			150			150	
Clinker production[1] (year) million t/a			(2004)			(2005)			(2006)	
million t/a			26.3			24.4			24.9	
Utilisation[2] %			63			67			70	

[1] according to CO_2 monitoring
[2] assumed availability 320 d/a

The report does not specify what percentages of the kiln systems with cyclone preheater utilizing a bypass. It would be assumed that some mix of kiln systems contain bypasses versus those that do not.

Additionally SAC has included in Attachment 4 the updated Environmental Data of the German Cement Industry 2007. On page 31 the report explains again the relationship of metals present in the fuel and the Transfer Coefficient (TC) to the gas phase emitted from the plant. Please see the table from the report showing these TC rates with Lead showing a 99.998% capture rate into the clinker with the exception of Thallium. Mercury is not shown due to its high volatility and Thallium contains the explanation that the TC rate incorporates the wasting of baghouse dust to achieve the shown 99.98% capture rate. Since Lead is a semi-volatile metal it is also explained that the TC rate shown is incorporating into the clinker.



Component	EF in %	TC in %
Cadmium	< 0.01 to < 0.2	0.003
Thallium	< 0.01 to < 1	0.02
Antimony	< 0.01 to < 0.05	0.0005
Arsenic	< 0.01 to 0.02	0.0005
Lead	< 0.01 to < 0.2	0.002
Chromium	< 0.01 to < 0.05	0.0005
Cobalt	< 0.01 to < 0.05	0.0005
Copper	< 0.01 to < 0.05	0.0005
Manganese	< 0.001 to < 0.01	0.0005
Nickel	< 0.01 to < 0.05	0.0005
Vanadium	< 0.01 to < 0.05	0.0005

Table 5-4: Emission factors (EF, emitted portion of the total input) and transfer coefficients (TC, emitted portion of the fuel input) for rotary kiln systems with cyclone pre-heater

Additionally SAC has presented additional information on the fate of metals from other US Cement Plants in response to Question #3. These results come from Plants utilizing hazardous waste fuels in modern Preheater/Calciner Kilns with tests conducted in accordance with the Hazardous Waste Combustor MACT (HWC MACT).

Finally SAC seeks to generate site specific data during the test. The intent for SAC requesting a test for the proposed fuels is to generate site-specific data to address any issues and concerns the Department or the public may have.

SAC's Testing Plan Summary:

1. Install test equipment to re-shred and feed alternative fuel materials to the calciner or main burner using the existing high carbon fly ash feed line.

2. Install covered storage for the test to keep materials from coming in contact with stormwater runoff.

3. Conduct tests and analysis regarding internal production and quality concerns such as:

    a. Process fan capacities (K11 & E20) for increased air flow
    b. Cyclone efficiencies with increased material flow
    c. Impact on pre-heater and kiln refractory life
    d. Increase of build up formation on riser duct
    e. Impact on fuel efficiency per consumption (kcal/kg clinker)
    f. Combustion efficiency / size needed for complete burn out
    g. Affects on clinker microscopy
    h. Affects on cement strengths

4. Conduct tests and analysis for all environmental concerns as follows:

    a. Conduct alternative fuel material sampling and analysis as per the Quality Plan specified above in response to question two of this document.

    b. Continuously Monitor:

        - Nitrogen Oxides (NOx)
        - Sulfur Dioxide (SO_2)
        - THC (as VOC)
        - Particulate Matter (PM), as opacity
        - Carbon Monoxide (CO, process monitor)

    c. Stack Testing:

        - Dioxin & Furans (Method 23)
        - HCl (Method 26)
        - PM/PM10 (Method 5)
        - Metals (Method 29)
        - SAM (Method 8)
        - CO (Method 10)

    d. Conduct a System Recovery Efficiency (SRE) test for metals as per the SRE test plan described above in response to question three of this document.

5. Report all results of required material analysis, continuous monitoring, and stack testing to the Department at the conclusion of the test trial.

6. Pursuant to the discussion in Question Number 5 above, as part of this alternative fuel testing project, is SAC considering pursuing

the bleeding of filter dust to ensure that metals such lead, cadmium and thallium from the ASR is incorporated into the clinker and do not exit via the kiln stack? Additionally, bleeding of filter dust during this project would also allow the effect of dust bleeding on mercury emissions to be explored.

As previously discussed, SAC has and will continue to explore methods of bleeding baghouse dust and inter-grinding into the cement for removal of mercury from cycles within the kiln system and in-line raw mill. SAC will monitor baghouse dust metal concentrations (as described above) during the Alternate Fuel test which may provide additional data for the optimum time to bleed dust and "enrich" with mercury. SAC will continue to work with the Department on a long-term approach for this beyond the test period for Alternate Fuels Testing.

As previously discussed and as provided in response to questions #3 and #5 cadmium and lead are considered semi-volatile metals in cement pyro-processing and thus have been shown with high Transfer Coefficient (TC) rates and/or System Removal Efficiencies (SRE) to be almost completely incorporated into the clinker. During the Alternate Fuel Test SAC has proposed to monitor and conduct a mass balance analysis for Lead and Cadmium including analysis of the baghouse dust to assess potential of re-circulation cycles within the "raw-mill, baghouse" circuit as outlined in response to Question #3.

Thallium is consider a volatile metal and has a vapor pressure that typically results in a cyclical buildup within the baghouse, enriching the baghouse dust. SAC will conduct the same material balance analysis as outlined in response to Question #3 to determine the presence of such a cycle. Additionally as discussed, with mercury, SAC will use these test trials to determine the feasibility and methods for bleeding baghouse dust and inter-grinding into the cement to alleviate this cycle should the data show Hg to accumulate within the baghouse dust at significant levels.

Sincerely,

Tom Messer
Plant Manager

ATTACHMENT 1

Source's List of Materials Not Accepted

[redacted]

This section illustrates the materials that [redacted] mill locations will not accept from any of its suppliers. Please find below some examples and photos of materials that are not accepted. Certain [redacted] recycling yards may accept some of the following items. Please contact the appropriate yard for further information.

Materials Not Accepted

Sealed & Flammable Containers

Propane Tanks

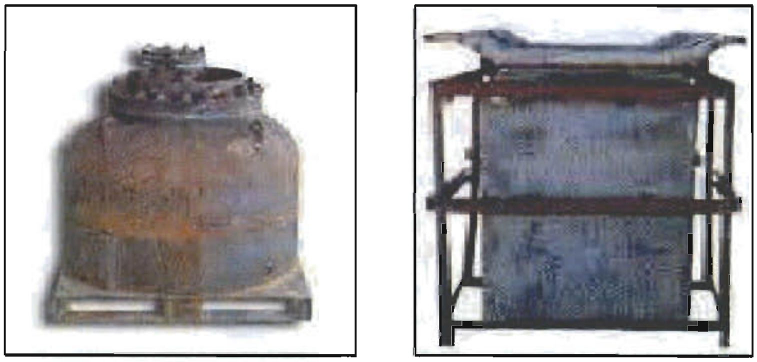
Gas Tanks

Aerosol Containers

Scrap Bearing Lead

Pipes with lead

Chemical tanks with lead lining

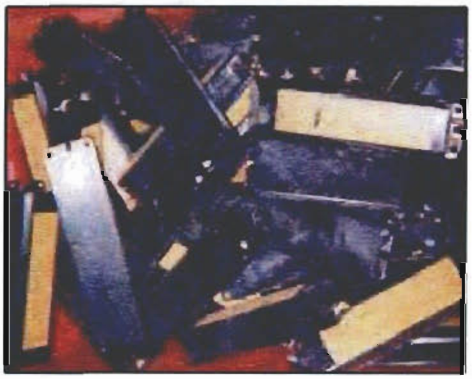


[redacted]

Materials Not Accepted

PCB Containing Devices (capacitors, ballasts, microwave ovens, etc)

Ballasts



Capacitors

Batteries

[redacted]

Materials Not Accepted

Miscellaneous items (material containing Freon, transformers, liquids or sludge, lead battery cable ends, heavy steel, mercury-containing devices, computers, electronics, etc.)

Air bag canisters

Mercury switches

Electronics

Computers

Heavy O/S Steel

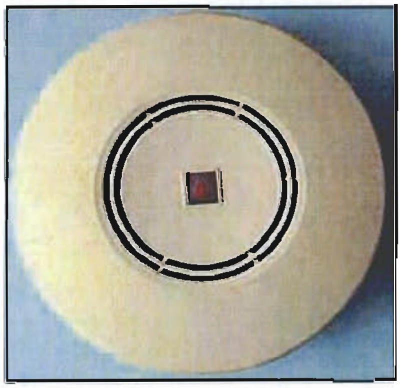
[redacted]

Materials Not Accepted

Radioactive material (military equipment, fertilizer related equipment, etc)

Radium dial

Smoke detectors



Contaminants (dirt, wood, plastic, water, cement, tires, etc)

Wood

Tires

Cement

ATTACHMENT 2

ISO 9001 – Quality Management System
&
ISO 14001 – Environmental Management System

Certificate of Registration

ENVIRONMENTAL MANAGEMENT SYSTEM - ISO 14001:2004

This is to certify that:

Suwannee American Cement
5117, US 27
Branford
Florida
32008
USA

Holds Certificate No: **EMS 78352**

and operates an Environmental Management System which complies with the requirements of ISO 14001:2004 for the following scope:

The production of Portland cement.

For and on behalf of BSI:

Gary L Pearson

President, BSI Management Systems America, Inc.

Originally registered: **06/11/2004** Latest Issue: **04/14/2007** Expiry Date: **04/13/2010**

This certificate remains the property of BSI and shall be returned immediately upon request.
An electronic certificate can be authenticated online. Printed copies can be validated at www.bsi-global.com/ClientDirectory
To be read in conjunction with the scope above or the attached appendix.

BSI Management Systems

Certificate No: **EMS 78352**

Location	***Registered Activities***
Suwannee American Cement 5117, US 27 Branford Florida 32008 USA	Portland Cement Production.

Originally registered: **06/11/2004** Latest Issue: **04/14/2007** Expiry Date: **04/13/2010**

INTERNATIONAL STANDARD

ISO 14001

Second edition
2004-11-15

Environmental management systems — Requirements with guidance for use

Systèmes de management environnemental — Exigences et lignes directrices pour son utilisation

Reference number

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Contents

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 14001 was prepared by Technical Committee ISO/TC 207, *Environmental management*, Subcommittee SC 1, *Environmental management systems*.

This second edition cancels and replaces the first edition (ISO 14001:1996), which has been technically revised.

Introduction

Organizations of all kinds are increasingly concerned with achieving and demonstrating sound environmental performance by controlling the impacts of their activities, products and services on the environment, consistent with their environmental policy and objectives. They do so in the context of increasingly stringent legislation, the development of economic policies and other measures that foster environmental protection, and increased concern expressed by interested parties about environmental matters and sustainable development.

Many organizations have undertaken environmental "reviews" or "audits" to assess their environmental performance. On their own, however, these "reviews" and "audits" may not be sufficient to provide an organization with the assurance that its performance not only meets, but will continue to meet, its legal and policy requirements. To be effective, they need to be conducted within a structured management system that is integrated within the organization.

International Standards covering environmental management are intended to provide organizations with the elements of an effective environmental management system (EMS) that can be integrated with other management requirements and help organizations achieve environmental and economic goals. These standards, like other International Standards, are not intended to be used to create non-tariff trade barriers or to increase or change an organization's legal obligations.

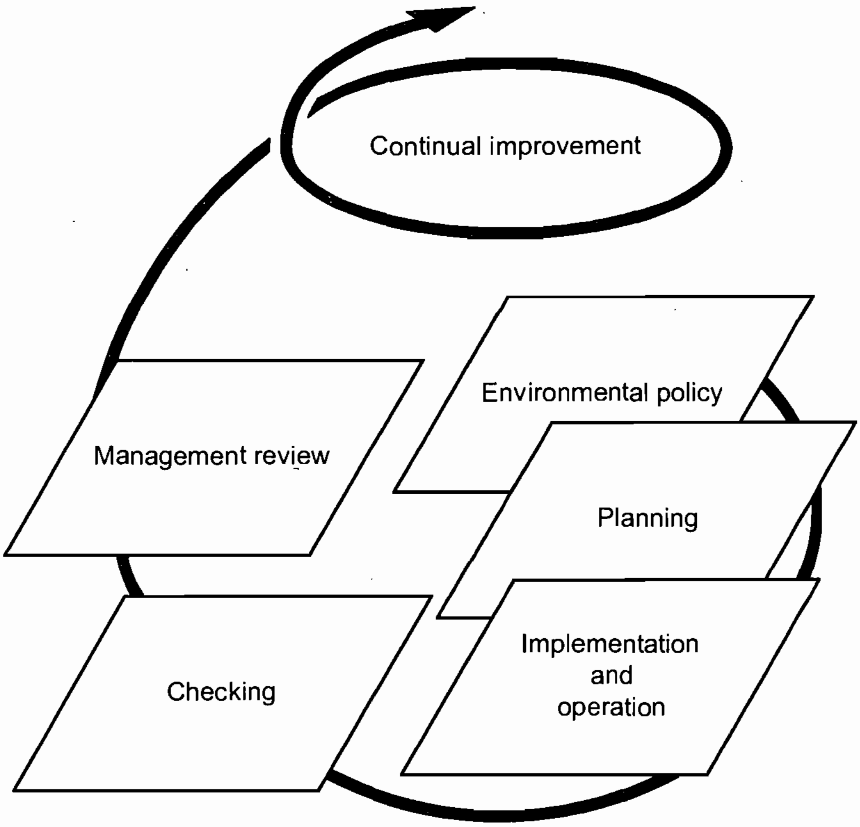
This International Standard specifies requirements for an environmental management system to enable an organization to develop and implement a policy and objectives which take into account legal requirements and information about significant environmental aspects. It is intended to apply to all types and sizes of organization and to accommodate diverse geographical, cultural and social conditions. The basis of the approach is shown in Figure 1. The success of the system depends on commitment from all levels and functions of the organization, and especially from top management. A system of this kind enables an organization to develop an environmental policy, establish objectives and processes to achieve the policy commitments, take action as needed to improve its performance and demonstrate the conformity of the system to the requirements of this International Standard. The overall aim of this International Standard is to support environmental protection and prevention of pollution in balance with socio-economic needs. It should be noted that many of the requirements can be addressed concurrently or revisited at any time.

The second edition of this International Standard is focused on clarification of the first edition, and has taken due consideration of the provisions of ISO 9001 to enhance the compatibility of the two standards for the benefit of the user community.

For ease of use, the subclause numbers in Clause 4 of the body of this International Standard and in Annex A have been related. For example, 4.3.3 and A.3.3 both deal with objectives, targets and programme(s), and 4.5.5 and A.5.5 both deal with internal audit. In addition, Annex B identifies broad technical correspondences between ISO 14001:2004 and ISO 9001:2000 and *vice versa*.

There is an important distinction between this International Standard, which describes the requirements for an organization's environmental management system and can be used for certification/registration and/or self-declaration of an organization's environmental management system, and a non-certifiable guideline intended to provide generic assistance to an organization for establishing, implementing or improving an environmental management system. Environmental management encompasses a full range of issues, including those with strategic and competitive implications. Demonstration of successful implementation of this International Standard can be used by an organization to assure interested parties that an appropriate environmental management system is in place.

Guidance on supporting environmental management techniques is contained in other International Standards,



NOTE This International Standard is based on the methodology known as Plan-Do-Check-Act (PDCA). PDCA can be briefly described as follows.

- Plan: establish the objectives and processes necessary to deliver results in accordance with the organization's environmental policy.
- Do: implement the processes.
- Check: monitor and measure processes against environmental policy, objectives, targets, legal and other requirements, and report the results.
- Act: take actions to continually improve performance of the environmental management system.

Many organizations manage their operations via the application of a system of processes and their interactions, which can be referred to as the "process approach". ISO 9001 promotes the use of the process approach. Since PDCA can be applied to all processes, the two methodologies are considered to be compatible.

Figure 1 — Environmental management system model for this International Standard

This International Standard contains only those requirements that can be objectively audited. Those organizations requiring more general guidance on a broad range of environmental management system issues are referred to ISO 14004.

This International Standard does not establish absolute requirements for environmental performance beyond the commitments, in the environmental policy, to comply with applicable legal requirements and with other requirements to which the organization subscribes, to prevention of pollution and to continual improvement. Thus, two organizations carrying out similar operations but having different environmental performance can both conform to its requirements.

The adoption and implementation of a range of environmental management techniques in a systematic manner can contribute to optimal outcomes for all interested parties. However, adoption of this International Standard will not in itself guarantee optimal environmental outcomes. In order to achieve environmental objectives, the environmental management system can encourage organizations to consider implementation of the best available techniques, where appropriate and where economically viable, and fully take into account the cost-effectiveness of such techniques.

This International Standard does not include requirements specific to other management systems, such as those for quality, occupational health and safety, financial or risk management, though its elements can be aligned or integrated with those of other management systems. It is possible for an organization to adapt its existing management system(s) in order to establish an environmental management system that conforms to the requirements of this International Standard. It is pointed out, however, that the application of various elements of the management system might differ depending on the intended purpose and the interested parties involved.

The level of detail and complexity of the environmental management system, the extent of documentation and the resources devoted to it depend on a number of factors, such as the scope of the system, the size of an organization and the nature of its activities, products and services. This may be the case in particular for small and medium-sized enterprises.

INTERNATIONAL STANDARD **ISO 14001:2004(E)**

Environmental management systems — Requirements with guidance for use

1 Scope

This International Standard specifies requirements for an environmental management system to enable an organization to develop and implement a policy and objectives which take into account legal requirements and other requirements to which the organization subscribes, and information about significant environmental aspects. It applies to those environmental aspects that the organization identifies as those which it can control and those which it can influence. It does not itself state specific environmental performance criteria.

This International Standard is applicable to any organization that wishes to

a) establish, implement, maintain and improve an environmental management system,

b) assure itself of conformity with its stated environmental policy,

c) demonstrate conformity with this International Standard by

  1) making a self-determination and self-declaration, or

  2) seeking confirmation of its conformance by parties having an interest in the organization, such as customers, or

  3) seeking confirmation of its self-declaration by a party external to the organization, or

  4) seeking certification/registration of its environmental management system by an external organization.

All the requirements in this International Standard are intended to be incorporated into any environmental management system. The extent of the application depends on factors such as the environmental policy of the organization, the nature of its activities, products and services and the location where and the conditions in which it functions. This International Standard also provides, in Annex A, informative guidance on its use.

2 Normative references

No normative references are cited. This clause is included in order to retain clause numbering identical with the previous edition (ISO 14001:1996).

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
auditor
person with the competence to conduct an audit

[ISO 9000:2000, 3.9.9]

3.2
continual improvement
recurring process of enhancing the **environmental management system** (3.8) in order to achieve

NOTE The process need not take place in all areas of activity simultaneously.

3.3

corrective action

action to eliminate the cause of a detected **nonconformity** (3.15)

3.4

document

information and its supporting medium

NOTE 1 The medium can be paper, magnetic, electronic or optical computer disc, photograph or master sample, or a combination thereof.

NOTE 2 Adapted from ISO 9000:2000, 3.7.2.

3.5

environment

surroundings in which an **organization** (3.16) operates, including air, water, land, natural resources, flora, fauna, humans, and their interrelation

NOTE Surroundings in this context extend from within an **organization** (3.16) to the global system.

3.6

environmental aspect

element of an **organization's** (3.16) activities or products or services that can interact with the **environment** (3.5)

NOTE A significant environmental aspect has or can have a significant **environmental impact** (3.7).

3.7

environmental impact

any change to the **environment** (3.5), whether adverse or beneficial, wholly or partially resulting from an **organization's** (3.16) **environmental aspects** (3.6)

3.8

environmental management system

EMS

part of an **organization's** (3.16) management system used to develop and implement its **environmental policy** (3.11) and manage its **environmental aspects** (3.6)

NOTE 1 A management system is a set of interrelated elements used to establish policy and objectives and to achieve those objectives.

NOTE 2 A management system includes organizational structure, planning activities, responsibilities, practices, **procedures** (3.19), processes and resources.

3.9

environmental objective

overall environmental goal, consistent with the **environmental policy** (3.11), that an **organization** (3.16) sets itself to achieve

3.10

environmental performance

measurable results of an **organization's** (3.16) management of its **environmental aspects** (3.6)

NOTE In the context of **environmental management systems** (3.8), results can be measured against the **organization's**

3.11

environmental policy

overall intentions and direction of an **organization** (3.16) related to its **environmental performance** (3.10) as formally expressed by top management

NOTE The environmental policy provides a framework for action and for the setting of **environmental objectives** (3.9) and **environmental targets** (3.12).

3.12

environmental target

detailed performance requirement, applicable to the **organization** (3.16) or parts thereof, that arises from the **environmental objectives** (3.9) and that needs to be set and met in order to achieve those objectives

3.13

interested party

person or group concerned with or affected by the **environmental performance** (3.10) of an **organization** (3.16)

3.14

internal audit

systematic, independent and documented process for obtaining audit evidence and evaluating it objectively to determine the extent to which the environmental management system audit criteria set by the **organization** (3.16) are fulfilled

NOTE In many cases, particularly in smaller organizations, independence can be demonstrated by the freedom from responsibility for the activity being audited.

3.15

nonconformity

non-fulfilment of a requirement

[ISO 9000:2000, 3.6.2]

3.16

organization

company, corporation, firm, enterprise, authority or institution, or part or combination thereof, whether incorporated or not, public or private, that has its own functions and administration

NOTE For organizations with more than one operating unit, a single operating unit may be defined as an organization.

3.17

preventive action

action to eliminate the cause of a potential **nonconformity** (3.15)

3.18

prevention of pollution

use of processes, practices, techniques, materials, products, services or energy to avoid, reduce or control (separately or in combination) the creation, emission or discharge of any type of pollutant or waste, in order to reduce adverse **environmental impacts** (3.7)

NOTE Prevention of pollution can include source reduction or elimination, process, product or service changes, efficient use of resources, material and energy substitution, reuse, recovery, recycling, reclamation and treatment.

3.19

procedure

specified way to carry out an activity or a process

NOTE 1 Procedures can be documented or not.

3.20

record

document (3.4) stating results achieved or providing evidence of activities performed

NOTE Adapted from ISO 9000:2000, 3.7.6.

4 Environmental management system requirements

4.1 General requirements

The organization shall establish, document, implement, maintain and continually improve an environmental management system in accordance with the requirements of this International Standard and determine how it will fulfil these requirements.

The organization shall define and document the scope of its environmental management system.

4.2 Environmental policy

Top management shall define the organization's environmental policy and ensure that, within the defined scope of its environmental management system, it

a) is appropriate to the nature, scale and environmental impacts of its activities, products and services,

b) includes a commitment to continual improvement and prevention of pollution,

c) includes a commitment to comply with applicable legal requirements and with other requirements to which the organization subscribes which relate to its environmental aspects,

d) provides the framework for setting and reviewing environmental objectives and targets,

e) is documented, implemented and maintained,

f) is communicated to all persons working for or on behalf of the organization, and

g) is available to the public.

4.3 Planning

4.3.1 Environmental aspects

The organization shall establish, implement and maintain a procedure(s)

a) to identify the environmental aspects of its activities, products and services within the defined scope of the environmental management system that it can control and those that it can influence taking into account planned or new developments, or new or modified activities, products and services, and

b) to determine those aspects that have or can have significant impact(s) on the environment (i.e. significant environmental aspects).

The organization shall document this information and keep it up to date.

The organization shall ensure that the significant environmental aspects are taken into account in establishing

4.3.2 Legal and other requirements

The organization shall establish, implement and maintain a procedure(s)

a) to identify and have access to the applicable legal requirements and other requirements to which the organization subscribes related to its environmental aspects, and

b) to determine how these requirements apply to its environmental aspects.

The organization shall ensure that these applicable legal requirements and other requirements to which the organization subscribes are taken into account in establishing, implementing and maintaining its environmental management system.

4.3.3 Objectives, targets and programme(s)

The organization shall establish, implement and maintain documented environmental objectives and targets, at relevant functions and levels within the organization.

The objectives and targets shall be measurable, where practicable, and consistent with the environmental policy, including the commitments to prevention of pollution, to compliance with applicable legal requirements and with other requirements to which the organization subscribes, and to continual improvement.

When establishing and reviewing its objectives and targets, an organization shall take into account the legal requirements and other requirements to which the organization subscribes, and its significant environmental aspects. It shall also consider its technological options, its financial, operational and business requirements, and the views of interested parties.

The organization shall establish, implement and maintain a programme(s) for achieving its objectives and targets. Programme(s) shall include

a) designation of responsibility for achieving objectives and targets at relevant functions and levels of the organization, and

b) the means and time-frame by which they are to be achieved.

4.4 Implementation and operation

4.4.1 Resources, roles, responsibility and authority

Management shall ensure the availability of resources essential to establish, implement, maintain and improve the environmental management system. Resources include human resources and specialized skills, organizational infrastructure, technology and financial resources.

Roles, responsibilities and authorities shall be defined, documented and communicated in order to facilitate effective environmental management.

The organization's top management shall appoint a specific management representative(s) who, irrespective of other responsibilities, shall have defined roles, responsibilities and authority for

a) ensuring that an environmental management system is established, implemented and maintained in accordance with the requirements of this International Standard,

b) reporting to top management on the performance of the environmental management system for review, including recommendations for improvement.

4.4.2 Competence, training and awareness

The organization shall ensure that any person(s) performing tasks for it or on its behalf that have the potential to

The organization shall identify training needs associated with its environmental aspects and its environmental management system. It shall provide training or take other action to meet these needs, and shall retain associated records.

The organization shall establish, implement and maintain a procedure(s) to make persons working for it or on its behalf aware of

a) the importance of conformity with the environmental policy and procedures and with the requirements of the environmental management system,

b) the significant environmental aspects and related actual or potential impacts associated with their work, and the environmental benefits of improved personal performance,

c) their roles and responsibilities in achieving conformity with the requirements of the environmental management system, and

d) the potential consequences of departure from specified procedures.

4.4.3 Communication

With regard to its environmental aspects and environmental management system, the organization shall establish, implement and maintain a procedure(s) for

a) internal communication among the various levels and functions of the organization,

b) receiving, documenting and responding to relevant communication from external interested parties.

The organization shall decide whether to communicate externally about its significant environmental aspects, and shall document its decision. If the decision is to communicate, the organization shall establish and implement a method(s) for this external communication.

4.4.4 Documentation

The environmental management system documentation shall include

a) the environmental policy, objectives and targets,

b) description of the scope of the environmental management system,

c) description of the main elements of the environmental management system and their interaction, and reference to related documents,

d) documents, including records, required by this International Standard, and

e) documents, including records, determined by the organization to be necessary to ensure the effective planning, operation and control of processes that relate to its significant environmental aspects.

4.4.5 Control of documents

Documents required by the environmental management system and by this International Standard shall be controlled. Records are a special type of document and shall be controlled in accordance with the requirements given in 4.5.4.

The organization shall establish, implement and maintain a procedure(s) to

a) approve documents for adequacy prior to issue,

b) review and update as necessary and re-approve documents,

c) ensure that changes and the current revision status of documents are identified,

d) ensure that relevant versions of applicable documents are available at points of use,

f) ensure that documents of external origin determined by the organization to be necessary for the planning and operation of the environmental management system are identified and their distribution controlled, and

g) prevent the unintended use of obsolete documents and apply suitable identification to them if they are retained for any purpose.

4.4.6 Operational control

The organization shall identify and plan those operations that are associated with the identified significant environmental aspects consistent with its environmental policy, objectives and targets, in order to ensure that they are carried out under specified conditions, by

a) establishing, implementing and maintaining a documented procedure(s) to control situations where their absence could lead to deviation from the environmental policy, objectives and targets, and

b) stipulating the operating criteria in the procedure(s), and

c) establishing, implementing and maintaining procedures related to the identified significant environmental aspects of goods and services used by the organization and communicating applicable procedures and requirements to suppliers, including contractors.

4.4.7 Emergency preparedness and response

The organization shall establish, implement and maintain a procedure(s) to identify potential emergency situations and potential accidents that can have an impact(s) on the environment and how it will respond to them.

The organization shall respond to actual emergency situations and accidents and prevent or mitigate associated adverse environmental impacts.

The organization shall periodically review and, where necessary, revise its emergency preparedness and response procedures, in particular, after the occurrence of accidents or emergency situations.

The organization shall also periodically test such procedures where practicable.

4.5 Checking

4.5.1 Monitoring and measurement

The organization shall establish, implement and maintain a procedure(s) to monitor and measure, on a regular basis, the key characteristics of its operations that can have a significant environmental impact. The procedure(s) shall include the documenting of information to monitor performance, applicable operational controls and conformity with the organization's environmental objectives and targets.

The organization shall ensure that calibrated or verified monitoring and measurement equipment is used and maintained and shall retain associated records.

4.5.2 Evaluation of compliance

4.5.2.1 Consistent with its commitment to compliance, the organization shall establish, implement and maintain a procedure(s) for periodically evaluating compliance with applicable legal requirements.

The organization shall keep records of the results of the periodic evaluations.

4.5.2.2 The organization shall evaluate compliance with other requirements to which it subscribes. The organization may wish to combine this evaluation with the evaluation of legal compliance referred to in 4.5.2.1 or to establish a separate procedure(s).

4.5.3 Nonconformity, corrective action and preventive action

The organization shall establish, implement and maintain a procedure(s) for dealing with actual and potential nonconformity(ies) and for taking corrective action and preventive action. The procedure(s) shall define requirements for

a) identifying and correcting nonconformity(ies) and taking action(s) to mitigate their environmental impacts,

b) investigating nonconformity(ies), determining their cause(s) and taking actions in order to avoid their recurrence,

c) evaluating the need for action(s) to prevent nonconformity(ies) and implementing appropriate actions designed to avoid their occurrence,

d) recording the results of corrective action(s) and preventive action(s) taken, and

e) reviewing the effectiveness of corrective action(s) and preventive action(s) taken.

Actions taken shall be appropriate to the magnitude of the problems and the environmental impacts encountered.

The organization shall ensure that any necessary changes are made to environmental management system documentation.

4.5.4 Control of records

The organization shall establish and maintain records as necessary to demonstrate conformity to the requirements of its environmental management system and of this International Standard, and the results achieved.

The organization shall establish, implement and maintain a procedure(s) for the identification, storage, protection, retrieval, retention and disposal of records.

Records shall be and remain legible, identifiable and traceable.

4.5.5 Internal audit

The organization shall ensure that internal audits of the environmental management system are conducted at planned intervals to

a) determine whether the environmental management system

    1) conforms to planned arrangements for environmental management including the requirements of this International Standard, and

    2) has been properly implemented and is maintained, and

b) provide information on the results of audits to management.

Audit programme(s) shall be planned, established, implemented and maintained by the organization, taking into consideration the environmental importance of the operation(s) concerned and the results of previous audits.

Audit procedure(s) shall be established, implemented and maintained that address

— the responsibilities and requirements for planning and conducting audits, reporting results and retaining associated records,

— the determination of audit criteria, scope, frequency and methods.

4.6 Management review

Top management shall review the organization's environmental management system, at planned intervals, to ensure its continuing suitability, adequacy and effectiveness. Reviews shall include assessing opportunities for improvement and the need for changes to the environmental management system, including the environmental policy and environmental objectives and targets. Records of the management reviews shall be retained.

Input to management reviews shall include

a) results of internal audits and evaluations of compliance with legal requirements and with other requirements to which the organization subscribes,

b) communication(s) from external interested parties, including complaints,

c) the environmental performance of the organization,

d) the extent to which objectives and targets have been met,

e) status of corrective and preventive actions,

f) follow-up actions from previous management reviews,

g) changing circumstances, including developments in legal and other requirements related to its environmental aspects, and

h) recommendations for improvement.

The outputs from management reviews shall include any decisions and actions related to possible changes to environmental policy, objectives, targets and other elements of the environmental management system, consistent with the commitment to continual improvement.

Annex A
(informative)

Guidance on the use of this International Standard

A.1 General requirements

The additional text given in this annex is strictly informative and is intended to prevent misinterpretation of the requirements contained in Clause 4 of this International Standard. While this information addresses and is consistent with the requirements of Clause 4, it is not intended to add to, subtract from, or in any way modify these requirements.

The implementation of an environmental management system specified by this International Standard is intended to result in improved environmental performance. Therefore this International Standard is based on the premise that the organization will periodically review and evaluate its environmental management system to identify opportunities for improvement and their implementation. The rate, extent and timescale of this continual improvement process are determined by the organization in the light of economic and other circumstances. Improvements in its environmental management system are intended to result in further improvements in environmental performance.

This International Standard requires an organization to

a) establish an appropriate environmental policy,

b) identify the environmental aspects arising from the organization's past, existing or planned activities, products and services, in order to determine the environmental impacts of significance,

c) identify applicable legal requirements and other requirements to which the organization subscribes,

d) identify priorities and set appropriate environmental objectives and targets,

e) establish a structure and a programme(s) to implement the policy and achieve objectives and meet targets,

f) facilitate planning, control, monitoring, preventive and corrective actions, auditing and review activities to ensure both that the policy is complied with and that the environmental management system remains appropriate, and

g) be capable of adapting to changing circumstances.

An organization with no existing environmental management system should, initially, establish its current position with regard to the environment by means of a review. The aim of this review should be to consider all environmental aspects of the organization as a basis for establishing the environmental management system.

The review should cover four key areas:

- identification of environmental aspects, including those associated with normal operating conditions, abnormal conditions including start-up and shut-down, and emergency situations and accidents;
- identification of applicable legal requirements and other requirements to which the organization subscribes;
- examination of existing environmental management practices and procedures, including those associated with procurement and contracting activities;
- evaluation of previous emergency situations and accidents.

Tools and methods for undertaking a review might include checklists, conducting interviews, direct inspection and measurement, results of previous audits or other reviews, depending on the nature of the activities.

An organization has the freedom and flexibility to define its boundaries and may choose to implement this scope is intended to clarify the boundaries of the organization to which the environmental management system will apply, especially if the organization is a part of a larger organization at a given location. Once the scope is defined, all activities, products and services of the organization within that scope need to be included in the environmental management system. When setting the scope, it should be noted that the credibility of the environmental management system will depend upon the choice of organizational boundaries. If a part of an organization is excluded from the scope of its environmental management system, the organization should be able to explain the exclusion. If this International Standard is implemented for a specific operating unit, policies and procedures developed by other parts of the organization can be used to meet the requirements of this International Standard, provided that they are applicable to that specific operating unit.

A.2 Environmental policy

The environmental policy is the driver for implementing and improving an organization's environmental management system so that it can maintain and potentially improve its environmental performance. This policy should therefore reflect the commitment of top management to comply with applicable legal requirements and other requirements, to prevent pollution and to continually improve. The environmental policy forms the basis upon which the organization sets its objectives and targets. The environmental policy should be sufficiently clear to be able to be understood by internal and external interested parties, and should be periodically reviewed and revised to reflect changing conditions and information. Its area of application (i.e. scope) should be clearly identifiable and should reflect the unique nature, scale and environmental impacts of the activities, products and services within the defined scope of the environmental management system.

The environmental policy should be communicated to all persons who work for, or on behalf of, the organization, including contractors working at an organization's facility. Communication to contractors can be in alternative forms to the policy statement itself, such as rules, directives and procedures, and may therefore only include pertinent sections of the policy. The organization's environmental policy should be defined and documented by its top management within the context of the environmental policy of any broader corporate body of which it is a part, and with the endorsement of that body.

NOTE Top management usually consists of a person or group of people who direct and control an organization at the highest level.

A.3 Planning

A.3.1 Environmental aspects

Subclause 4.3.1 is intended to provide a process for an organization to identify environmental aspects, and to determine those that are significant which should be addressed as a priority by the organization's environmental management system.

An organization should identify the environmental aspects within the scope of its environmental management system, taking into account the inputs and outputs (both intended and unintended) associated with its current and relevant-past activities, products and services, planned or new developments, or new or modified activities, products and services. This process should consider normal and abnormal operating conditions, shut-down and start-up conditions, as well as reasonably foreseeable emergency situations.

Organizations do not have to consider each product, component or raw material input individually. They may select categories of activities, products and services to identify their environmental aspects.

Although there is no single approach for identifying environmental aspects, the approach selected could for example consider

a) emissions to air,

b) releases to water,

c) releases to land,

e) use of energy,

f) energy emitted, e.g. heat, radiation, vibration,

g) waste and by-products, and

h) physical attributes, e.g. size, shape, colour, appearance.

In addition to those environmental aspects an organization can control directly, an organization should also consider aspects that it can influence, e.g. those related to goods and services used by the organization and those related to products and services that it provides. Some guidance to evaluate control and influence is provided below. However, in all circumstances it is the organization that determines the degree of control and also the aspects it can influence.

Consideration should be given to aspects related to the organization's activities, products and services, such as

— design and development,

— manufacturing processes,

— packaging and transportation,

— environmental performance and practices of contractors and suppliers,

— waste management,

— extraction and distribution of raw materials and natural resources,

— distribution, use and end-of-life of products, and

— wildlife and biodiversity.

The control and influence over the environmental aspects of a product supplied to an organization can vary significantly, depending on the organization's market situation and its suppliers. An organization that is responsible for its own product design can influence such aspects significantly by changing, for example, a single input material, while an organization that needs to supply in accordance with externally determined product specifications may have little choice.

With respect to products provided, it is recognized that organizations may have limited control over the use and disposal of their products, e.g. by users, but they can consider, where practicable, communication of proper handling and disposal mechanisms to these users in order to exert influence.

Changes to the environment, either adverse or beneficial, that result wholly or partially from environmental aspects are called environmental impacts. The relationship between environmental aspects and impacts is one of cause and effect.

In some locations cultural heritage can be an important element of the surroundings in which an organization operates, and therefore should be taken into account in the understanding of its environmental impacts.

Since an organization might have many environmental aspects and associated impacts, it should establish criteria and a method to determine those that it considers significant. There is no single method for determining significant environmental aspects. However, the method used should provide consistent results and include the establishment and application of evaluation criteria, such as those related to environmental matters, legal issues and the concerns of internal and external interested parties.

When developing information relating to its significant environmental aspects, the organization should consider the need to retain the information for historical purposes as well as how to use it in designing and implementing its environmental management system.

The process of identification and evaluation of environmental aspects should take into account the location of activities, cost and time to undertake the analysis, and the availability of reliable data. The identification of

This process of identifying and evaluating environmental aspects is not intended to change or increase an organization's legal obligations.

A.3.2 Legal and other requirements

The organization needs to identify the legal requirements that are applicable to its environmental aspects. These may include

a) national and international legal requirements,

b) state/provincial/departmental legal requirements,

c) local governmental legal requirements.

Examples of other requirements to which the organization may subscribe include, if applicable,

— agreements with public authorities,

— agreements with customers,

— non-regulatory guidelines,

— voluntary principles or codes of practice,

— voluntary environmental labelling or product stewardship commitments,

— requirements of trade associations,

— agreements with community groups or non-governmental organizations,

— public commitments of the organization or its parent organization,

— corporate/company requirements.

The determination of how legal and other requirements apply to an organization's environmental aspects is usually accomplished in the process of identifying these requirements. It may not be necessary, therefore, to have a separate or additional procedure in order to make this determination.

A.3.3 Objectives, targets and programme(s)

The objectives and targets should be specific and measurable wherever practicable. They should cover short- and long-term issues.

When considering its technological options, an organization should consider the use of best-available techniques where economically viable, cost-effective and judged appropriate.

The reference to the financial requirements of the organization is not intended to imply that organizations are obliged to use environmental cost-accounting methodologies.

The creation and use of one or more programmes is important to the successful implementation of an environmental management system. Each programme should describe how the organization's objectives and targets will be achieved, including timescales, necessary resources and personnel responsible for implementing the programme(s). This (these) programme(s) may be subdivided to address specific elements of the organization's operations.

The programme should include, where appropriate and practical, consideration of planning, design, production, marketing and disposal stages. This may be undertaken for both current and new activities, products or services. For products, this can address design, materials, production processes, use and ultimate disposal.

A.4 Implementation and operation

A.4.1 Resources, roles, responsibility and authority

The successful implementation of an environmental management system calls for a commitment from all persons working for the organization or on its behalf. Environmental roles and responsibilities therefore should not be seen as confined to the environmental management function, but can also cover other areas of an organization, such as operational management or staff functions other than environmental.

This commitment should begin at the highest levels of management. Accordingly, top management should establish the organization's environmental policy and ensure that the environmental management system is implemented. As part of this commitment, top management should designate a specific management representative(s) with defined responsibility and authority for implementing the environmental management system. In large or complex organizations, there may be more than one designated representative. In small or medium-sized enterprises, these responsibilities may be undertaken by one individual. Management should also ensure that appropriate resources, such as organizational infrastructure, are provided to ensure that the environmental management system is established, implemented and maintained. Examples of organizational infrastructure include buildings, communication lines, underground tanks, drainage, etc.

It is also important that the key environmental management system roles and responsibilities are well defined and communicated to all persons working for or on behalf of the organization.

A.4.2 Competence, training and awareness

The organization should identify the awareness, knowledge, understanding and skills needed by any person with the responsibility and authority to perform tasks on its behalf.

This International Standard requires that

a) those persons whose work could cause significant environmental impact(s) identified by the organization are competent to perform the tasks to which they are assigned,

b) training needs are identified and actions are taken to ensure the provision of training,

c) all persons are aware of the organization's environmental policy and environmental management system and the environmental aspects of the organization's activities, products and services that could be affected by their work.

Awareness, knowledge, understanding and competence may be obtained or improved through training, education or work experience.

The organization should require that contractors working on its behalf are able to demonstrate that their employees have the requisite competence and/or appropriate training.

Management should determine the level of experience, competence and training necessary to ensure the capability of personnel, especially those carrying out specialized environmental management functions.

A.4.3 Communication

Internal communication is important to ensure the effective implementation of the environmental management systems. Methods of internal communication may include regular work group meetings, newsletters, bulletin boards and intranet sites.

Organizations should implement a procedure for receiving, documenting and responding to relevant communications from interested parties. This procedure may include a dialogue with interested parties and consideration of their relevant concerns. In some circumstances, responses to interested parties' concerns may include relevant information about the environmental aspects and impacts associated with the organization's

The organization may wish to plan its communication taking into account the decisions made on relevant target groups, the appropriate messages and subjects, and the choice of means.

When considering external communication about environmental aspects, organizations should take into consideration the views and information needs of all interested parties. If the organization decides to communicate externally on its environmental aspects, the organization may establish a procedure to do so. This procedure could change depending on several factors including the type of information to be communicated, the target group and the individual circumstances of the organization. Methods for external communication can include annual reports, newsletters, websites and community meetings.

A.4.4 Documentation

The level of detail of the documentation should be sufficient to describe the environmental management system and how its parts work together, and to provide direction on where to obtain more detailed information on the operation of specific parts of the environmental management system. This documentation may be integrated with documentation of other systems implemented by the organization. It does not have to be in the form of a manual.

The extent of the environmental management system documentation may differ from one organization to another, depending on

a) the size and type of organization and its activities, products or services,

b) the complexity of processes and their interactions, and

c) the competence of personnel.

Examples of documents include

- statements of policy, objectives and targets,
- information on significant environmental aspects,
- procedures,
- process information,
- organizational charts,
- internal and external standards,
- site emergency plans, and
- records.

Any decision to document procedure(s) should be based on issues such as

- the consequences, including those to the environment, of not doing so,
- the need to demonstrate compliance with legal and with other requirements to which the organization subscribes,
- the need to ensure that the activity is undertaken consistently,
- the advantages of doing so, which can include easier implementation through communication and training, easier maintenance and revision, less risk of ambiguity and deviations, and demonstrability and visibility,
- the requirements of this International Standard.

Documents originally created for purposes other than the environmental management system may be used as

A.4.5 Control of documents

The intent of 4.4.5 is to ensure that organizations create and maintain documents in a manner sufficient to implement the environmental management system. However, the primary focus of organizations should be on effective implementation of the environmental management system and on environmental performance, not on a complex document control system.

A.4.6 Operational control

An organization should evaluate those of its operations that are associated with its identified significant environmental aspects and ensure that they are conducted in a way that will control or reduce the adverse impacts associated with them, in order to fulfil the requirements of its environmental policy and meet its objectives and targets. This should include all parts of its operations, including maintenance activities.

As this part of the environmental management system provides direction on how to take the system requirements into day-to-day operations, 4.4.6 a) requires the use of documented procedure(s) to control situations where the absence of documented procedures could lead to deviations from the environmental policy and the objectives and targets.

A.4.7 Emergency preparedness and response

It is the responsibility of each organization to develop emergency preparedness and response procedure(s) that suits its own particular needs. In developing its procedure(s), the organization should include consideration of

a) the nature of on-site hazards, e.g. flammable liquids, storage tanks and compressed gases, and measures to be taken in the event of spillages or accidental releases,

b) the most likely type and scale of an emergency situation or accident,

c) the most appropriate method(s) for responding to an accident or emergency situation,

d) internal and external communication plans,

e) the action(s) required to minimize environmental damage,

f) mitigation and response action(s) to be taken for different types of accident or emergency situation,

g) the need for a process(es) for post-accident evaluation to establish and implement corrective and preventive actions,

h) periodic testing of emergency response procedure(s),

i) training of emergency response personnel,

j) a list of key personnel and aid agencies, including contact details (e.g. fire department, spillage clean-up services),

k) evacuation routes and assembly points,

l) the potential for an emergency situation(s) or accident(s) at a nearby facility (e.g. plant, road, railway line), and

m) the possibility of mutual assistance from neighbouring organizations.

A.5 Checking

A.5.1 Monitoring and measurement

The operations of an organization can have a variety of characteristics. For example, characteristics related to

Data collected from monitoring and measurement can be analysed to identify patterns and obtain information. Knowledge gained from this information can be used to implement corrective and preventive action.

Key characteristics are those that the organization needs to consider to determine how it is managing its significant environmental aspects, achieving objectives and targets, and improving environmental performance.

When necessary to ensure valid results, measuring equipment should be calibrated or verified at specified intervals, or prior to use, against measurement standards traceable to international or national measurement standards. If no such standards exist, the basis used for calibration should be recorded.

A.5.2 Evaluation of compliance

The organization should be able to demonstrate that it has evaluated compliance with the legal requirements identified, including applicable permits or licences.

The organization should be able to demonstrate that it has evaluated compliance with the other identified requirements to which it has subscribed.

A.5.3 Nonconformity, corrective action and preventive action

Depending on the nature of the nonconformity, by establishing procedures to deal with these requirements, organizations may be able to accomplish them with a minimum of formal planning, or it may be a more complex and long-term activity. Any documentation should be appropriate to the level of action.

A.5.4 Control of records

Environmental records can include, among others,

a) complaint records,

b) training records,

c) process monitoring records,

d) inspection, maintenance and calibration records,

e) pertinent contractor and supplier records,

f) incident reports,

g) records of tests for emergency preparedness,

h) audit results,

i) management review results,

j) external communications decision,

k) records of applicable legal requirements,

l) records of significant environmental aspects,

m) records of environmental meetings,

n) environmental performance information,

o) legal compliance records, and

p) communications with interested parties.

Proper account should be taken of confidential information.

A.5.5 Internal audit

Internal audits of an environmental management system can be performed by personnel from within the organization or by external persons selected by the organization, working on its behalf. In either case, the persons conducting the audit should be competent and in a position to do so impartially and objectively. In smaller organizations, auditor independence can be demonstrated by an auditor being free from responsibility for the activity being audited.

NOTE 1 If an organization wishes to combine audits of its environmental management system with environmental compliance audits, the intent and scope of each should be clearly defined. Environmental compliance audits are not covered by this International Standard.

NOTE 2 Guidance on auditing of environmental management systems is given in ISO 19011.

A.6 Management review

The management review should cover the scope of the environmental management system, although not all elements of the environmental management system need to be reviewed at once and the review process may take place over a period of time.

Annex B
(informative)

Correspondence between ISO 14001:2004 and ISO 9001:2000

Table B.1 and Table B.2 identify broad technical correspondences between ISO 14001:2004 and ISO 9001:2000 and *vice versa*.

The objective of the comparison is to demonstrate that both systems can be used together for those organizations that already operate one of these International Standards and wish to operate both.

A direct correspondence between subclauses of the two International Standards has only been established if the two subclauses are largely congruent in requirements. Beyond that, many detailed cross-connections of minor relevance exist which could not be shown here.

Table B.1 — Correspondence between ISO 14001:2004 and ISO 9001:2000

ISO 14001:2004		ISO 9001:2000	
Environmental management system requirements (title only)	4	4	Quality management system (title only)
General requirements	4.1	4.1	General requirements
Environmental policy	4.2	5.1	Management commitment
		5.3	Quality policy
		8.5.1	Continual improvement
Planning (title only)	4.3	5.4	Planning (title only)
Environmental aspects	4.3.1	5.2	Customer focus
		7.2.1	Determination of requirements related to the product
		7.2.2	Review of requirements related to the product
Legal and other requirements	4.3.2	5.2	Customer focus
		7.2.1	Determination of requirements related to the product
Objectives, targets and programme(s)	4.3.3	5.4.1	Quality objectives
		5.4.2	Quality management system planning
		8.5.1	Continual improvement
Implementation and operation (title only)	4.4	7	Product realization (title only)
Resources, roles, responsibility and authority	4.4.1	5.1	Management commitment
		5.5.1	Responsibility and authority
		5.5.2	Management representative
		6.1	Provision of resources
		6.3	Infrastructure
Competence, training and awareness	4.4.2	6.2.1	(Human resources) General
		6.2.2	Competence, awareness and training
Communication	4.4.3	5.5.3	Internal communication
		7.2.3	Customer communication
Documentation	4.4.4	4.2.1	(Documentation requirements) General
Control of documents	4.4.5	4.2.3	Control of documents

Table B.1 — Correspondence between ISO 14001:2004 and ISO 9001:2000 (*continued*)

ISO 14001:2004		ISO 9001:2000	
Operational control	4.4.6	7.1	Planning of product realization
		7.2.1	Determination of requirements related to the product
		7.2.2	Review of requirements related to the product
		7.3.1	Design and development planning
		7.3.2	Design and development inputs
		7.3.3	Design and development outputs
		7.3.4	Design and development review
		7.3.5	Design and development verification
		7.3.6	Design and development validation
		7.3.7	Control of design and development changes
		7.4.1	Purchasing process
		7.4.2	Purchasing information
		7.4.3	Verification of purchassed product
		7.5.1	Control of production and service provision
		7.5.2	Validation of processes for production and service provision
		7.5.5	Preservation of product
Emergency preparedness and response	4.4.7	8.3	Control of nonconforming product
Checking (title only)	4.5	8	Measurement, analysis and improvement (title only)
Monitoring and measurement	4.5.1	7.6	Control of monitoring and measuring devices
		8.1	(measurement, analysis and improvement) General
		8.2.3	Monitoring and measurement of processes
		8.2.4	Monitoring and measurement of product
		8.4	Analysis of data
Evaluation of compliance	4.5.2	8.2.3	Monitoring and measurement of processes
		8.2.4	Monitoring and measurement of product
Nonconformity, corrective action and preventive action	4.5.3	8.3	Control of nonconforming product
		8.4	Analysis of data
		8.5.2	Corrective action
		8.5.3	Preventive action
Control of records	4.5.4	4.2.4	Control of records
Internal audit	4.5.5	8.2.2	Internal audit
Management review	4.6	5.1	Management committment
		5.6	Management review (title only)
		5.6.1	General
		5.6.2	Review input
		5.6.3	Review output
		8.5.1	Continual improvement

Table B.2 — Correspondence between ISO 9001:2000 and ISO 14001:2004

ISO 9001:2000		ISO 14001:2004	
Quality management system (title only)	4	4	Environmental management system requirements
General requirements	4.1	4.1	General requirements
Documentation requirements (title only)	4.2		
General	4.2.1	4.4.4	Documentation
Quality manual	4.2.2		
Control of documents	4.2.3	4.4.5	Control of documents
Control of records	4.2.4	4.5.4	Control of records
Management responsibility (title only)	5		
Management commitment	5.1	4.2 4.4.1	Environmental policy Resources, roles, responsibility and authority
Customer focus	5.2	4.3.1 4.3.2 4.6	Environmental aspects Legal and other requirements Management review
Quality policy	5.3	4.2	Environmental policy
Planning (title only)	5.4	4.3	Planning
Quality objectives	5.4.1	4.3.3	Objectives, targets and programme(s)
Quality management system planning	5.4.2	4.3.3	Objectives, targets and programme(s)
Responsibility, autority and communication (title only)	5.5		
Responsibility and authority	5.5.1	4.4.1	Resources, roles, responsibility and authority
Management representative	5.5.2	4.4.1	Resources, roles, responsibility and authority
Internal communication	5.5.3	4.4.3	Communication
Management review (title only)	5.6		
General	5.6.1	4.6	Management review
Review input	5.6.2	4.6	Management review
Review output	5.6.3	4.6	Management review
Resource management (title only)	6		
Provision of resources	6.1	4.4.1	Resources, roles, responsibility and authority
Human resources (title only)	6.2		
General	6.2.1	4.4.2	Competence, training and awareness
Comptetence, awareness and training	6.2.2	4.4.2	Competence, training and awareness
Infrastructure	6.3	4.4.1	Resources, roles, responsibility and authority
Work environment	6.4		
Product realization (title only)	7	4.4	Implementation and operation
Planning of product realization	7.1	4.4.6	Operational control
Customer-related processes (title only)	7.2		
Determination of requirements related to the product	7.2.1	4.3.1 4.3.2 4.4.6	Environmental aspects Legal and other requirements Operational control
Review of requirements related to the product	7.2.2	4.3.1 4.4.6	Environmental aspects Operational control
Customer communication	7.2.3	4.4.3	Communication

Table B.2 — Correspondence between ISO 9001:2000 and ISO 14001:2004 (*continued*)

ISO 9001:2000		ISO 14001:2004	
Design and development (title only)	7.3		
Design and development planning	7.3.1	4.4.6	Operational control
Design and development inputs	7.3.2	4.4.6	Operational control
Design and development outputs	7.3.3	4.4.6	Operational control
Design and development review	7.3.4	4.4.6	Operational control
Design and development verification	7.3.5	4.4.6	Operational control
Design and development validation	7.3.6	4.4.6	Operational control
Control of design and development changes	7.3.7	4.4.6	Operational control
Purchasing (title only)	7.4		
Purchasing process	7.4.1	4.4.6	Operational control
Purchasing information	7.4.2	4.4.6	Operational control
Verification of purchased product	7.4.3	4.4.6	Operational control
Production and service provision (title only)	7.5		
Control of production and service provision	7.5.1	4.4.6	Operational control
Validation of processes for production and service provision	7.5.2	4.4.6	Operational control
Identification and traceability	7.5.3		
Customer property	7.5.4		
Preservation of product	7.5.5	4.4.6	Operational control
Control of monitoring and measuring devices	7.6	4.5.1	Monitoring and measurement
Measurement, analysis and improvement (title only)	8	4.5	Checking
General	8.1	4.5.1	Monitoring and measurement
Monitoring and measurement (title only)	8.2		
Customer satisfaction	8.2.1		
Internal audit	8.2.2	4.5.5	Internal audit
Monitoring and measurement of processes	8.2.3	4.5.1	Monitoring and measurement
		4.5.2	Evaluation of compliance
Monitoring and measurement of product	8.2.4	4.5.1	Monitoring and measurement
		4.5.2	Evaluation of compliance
Control of nonconforming product	8.3	4.4.7	Emergency preparedness and response
		4.5.3	Nonconformity, corrective action and preventive action
Analysis of data	8.4	4.5.1	Monitoring and measurement
Improvement (title only)	8.5		
Continual improvement	8.5.1	4.2	Environmental policy
		4.3.3	Objectives, targets and programme(s)
		4.6	Management review
Corrective action	8.5.2	4.5.3	Nonconformity, corrective action and preventive action
Preventive action	8.5.3	4.5.3	Nonconformity, corrective action and preventive action

Bibliography

[1] ISO 9000:2000, *Quality management systems — Fundamentals and vocabulary*

[2] ISO 9001:2000, *Quality management systems — Requirements*

[3] ISO 14004:2004, *Environmental management systems — General guidelines on principles, systems and support techniques*

[4] ISO 19011:2002, *Guidelines for quality and/or environmental management systems auditing*

CERTIFICATE OF REGISTRATION

Quality Management System

This is to certify that:

Suwanee American Cement
PO Box 410
5117, US 27
Branford
Florida
USA
32008

Hold Certificate No: **FM 78351**
and operate a Quality Management System, which complies with the requirements of BS EN ISO 9001:2000 for the following scope:

Portland cement production

For and on behalf of BSI, Inc.:

Gary L Pearson
President

Originally registered: **14 Apr 2004** *Latest issue:* **14 Apr 2004** *Page:* 1 of 1

This certificate remains the property of BSI, Inc. It does not expire but is contingent on meeting agreed contractual requirements. Validity is maintained through a process of continual assessments and reassessments. To check validity call 703 437 9000 or visit www.bsiamericas.com. To be read in conjunction with the scope of registration shown above or on the attached appendix.

INTERNATIONAL
STANDARD

ISO
9001

Third edition
2000-12-15

Quality management systems — Requirements

Systèmes de management de la qualité — Exigences

Reference number
ISO 9001:2000(E)

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 9001 was prepared by Technical Committee ISO/TC 176, *Quality management and quality assurance*, Subcommittee SC 2, *Quality systems*.

This third edition of ISO 9001 cancels and replaces the second edition (ISO 9001:1994) together with ISO 9002:1994 and ISO 9003:1994. It constitutes a technical revision of these documents. Those organizations which have used ISO 9002:1994 and ISO 9003:1994 in the past may use this International Standard by excluding certain requirements in accordance with 1.2.

The title of ISO 9001 has been revised in this edition and no longer includes the term “Quality assurance”. This reflects the fact that the quality management system requirements specified in this edition of ISO 9001, in addition to quality assurance of product, also aim to enhance customer satisfaction.

Annexes A and B of this International Standard are for information only.

Introduction

0.1 General

The adoption of a quality management system should be a strategic decision of an organization. The design and implementation of an organization's quality management system is influenced by varying needs, particular objectives, the products provided, the processes employed and the size and structure of the organization. It is not the intent of this International Standard to imply uniformity in the structure of quality management systems or uniformity of documentation.

The quality management system requirements specified in this International Standard are complementary to requirements for products. Information marked "NOTE" is for guidance in understanding or clarifying the associated requirement.

This International Standard can be used by internal and external parties, including certification bodies, to assess the organization's ability to meet customer, regulatory and the organization's own requirements.

The quality management principles stated in ISO 9000 and ISO 9004 have been taken into consideration during the development of this International Standard.

0.2 Process approach

This International Standard promotes the adoption of a process approach when developing, implementing and improving the effectiveness of a quality management system, to enhance customer satisfaction by meeting customer requirements.

For an organization to function effectively, it has to identify and manage numerous linked activities. An activity using resources, and managed in order to enable the transformation of inputs into outputs, can be considered as a process. Often the output from one process directly forms the input to the next.

The application of a system of processes within an organization, together with the identification and interactions of these processes, and their management, can be referred to as the "process approach".

An advantage of the process approach is the ongoing control that it provides over the linkage between the individual processes within the system of processes, as well as over their combination and interaction.

When used within a quality management system, such an approach emphasizes the importance of

a) understanding and meeting requirements,

b) the need to consider processes in terms of added value,

c) obtaining results of process performance and effectiveness, and

d) continual improvement of processes based on objective measurement.

The model of a process-based quality management system shown in Figure 1 illustrates the process linkages presented in clauses 4 to 8. This illustration shows that customers play a significant role in defining requirements as inputs. Monitoring of customer satisfaction requires the evaluation of information relating to customer perception as to whether the organization has met the customer requirements. The model shown in Figure 1 covers all the

NOTE In addition, the methodology known as "Plan-Do-Check-Act" (PDCA) can be applied to all processes. PDCA can be briefly described as follows.

Plan:	establish the objectives and processes necessary to deliver results in accordance with customer requirements and the organization's policies.
Do:	implement the processes.
Check:	monitor and measure processes and product against policies, objectives and requirements for the product and report the results.
Act:	take actions to continually improve process performance.

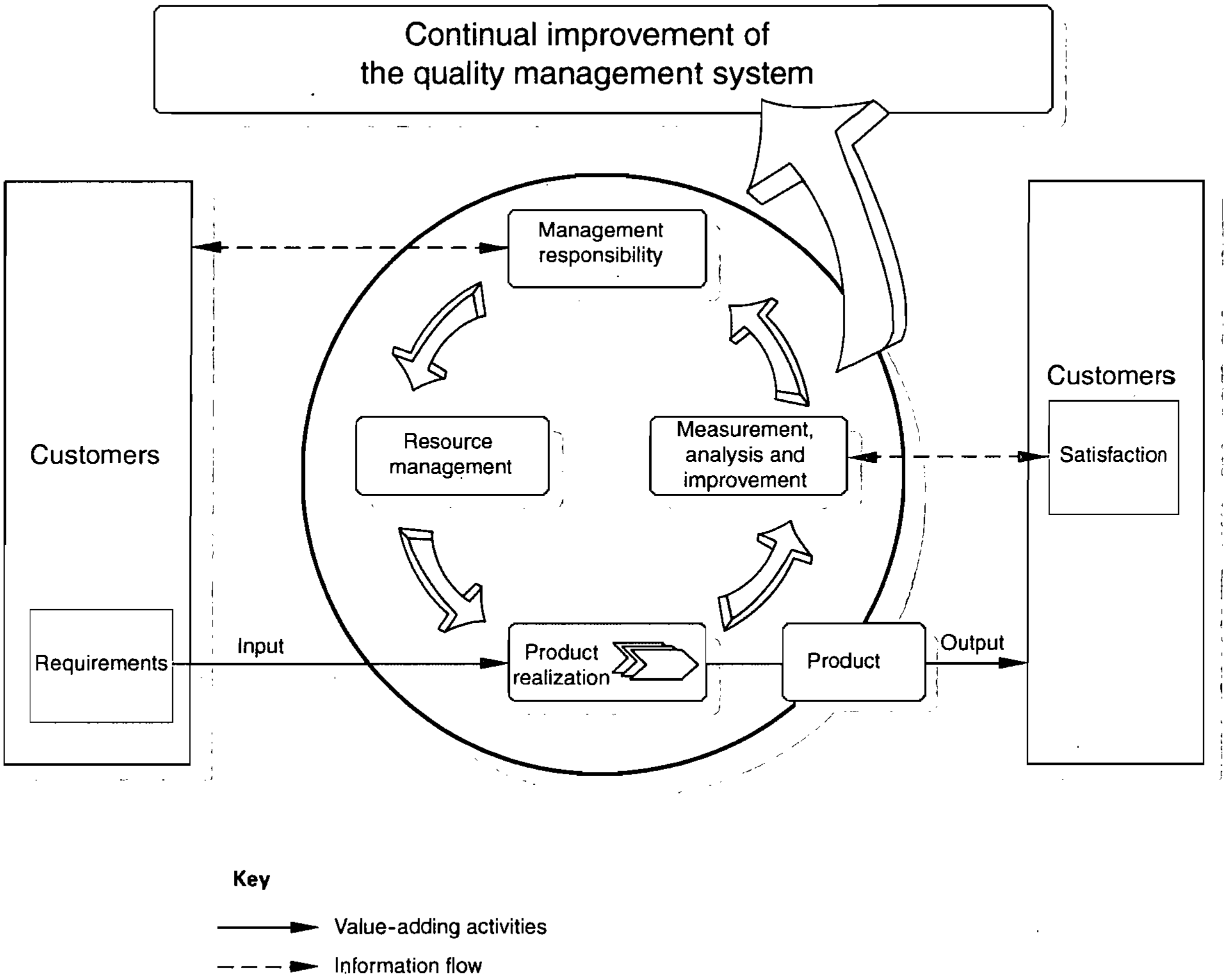

Figure 1 — Model of a process-based quality management system

0.3 Relationship with ISO 9004

The present editions of ISO 9001 and ISO 9004 have been developed as a consistent pair of quality management system standards which have been designed to complement each other, but can also be used independently. Although the two International Standards have different scopes, they have similar structures in order to assist their application as a consistent pair.

ISO 9001 specifies requirements for a quality management system that can be used for internal application by organizations, or for certification, or for contractual purposes. It focuses on the effectiveness of the quality

ISO 9004 gives guidance on a wider range of objectives of a quality management system than does ISO 9001, particularly for the continual improvement of an organization's overall performance and efficiency, as well as its effectiveness. ISO 9004 is recommended as a guide for organizations whose top management wishes to move beyond the requirements of ISO 9001, in pursuit of continual improvement of performance. However, it is not intended for certification or for contractual purposes.

0.4 Compatibility with other management systems

This International Standard has been aligned with ISO 14001:1996 in order to enhance the compatibility of the two standards for the benefit of the user community.

This International Standard does not include requirements specific to other management systems, such as those particular to environmental management, occupational health and safety management, financial management or risk management. However, this International Standard enables an organization to align or integrate its own quality management system with related management system requirements. It is possible for an organization to adapt its existing management system(s) in order to establish a quality management system that complies with the requirements of this International Standard.

Quality management systems — Requirements

1 Scope

1.1 General

This International Standard specifies requirements for a quality management system where an organization

a) needs to demonstrate its ability to consistently provide product that meets customer and applicable regulatory requirements, and

b) aims to enhance customer satisfaction through the effective application of the system, including processes for continual improvement of the system and the assurance of conformity to customer and applicable regulatory requirements.

NOTE In this International Standard, the term "product" applies only to the product intended for, or required by, a customer.

1.2 Application

All requirements of this International Standard are generic and are intended to be applicable to all organizations, regardless of type, size and product provided.

Where any requirement(s) of this International Standard cannot be applied due to the nature of an organization and its product, this can be considered for exclusion.

Where exclusions are made, claims of conformity to this International Standard are not acceptable unless these exclusions are limited to requirements within clause 7, and such exclusions do not affect the organization's ability, or responsibility, to provide product that meets customer and applicable regulatory requirements.

2 Normative reference

The following normative document contains provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent edition of the normative document indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 9000:2000, *Quality management systems — Fundamentals and vocabulary*.

3 Terms and definitions

For the purposes of this International Standard, the terms and definitions given in ISO 9000 apply.

The following terms, used in this edition of ISO 9001 to describe the supply chain, have been changed to reflect the vocabulary currently used:

supplier ⟶ **organization** ⟶ **customer**

The term "organization" replaces the term "supplier" used in ISO 9001:1994, and refers to the unit to which this International Standard applies. Also, the term "supplier" now replaces the term "subcontractor".

Throughout the text of this International Standard, wherever the term "product" occurs, it can also mean "service".

4 Quality management system

4.1 General requirements

The organization shall establish, document, implement and maintain a quality management system and continually improve its effectiveness in accordance with the requirements of this International Standard.

The organization shall

a) identify the processes needed for the quality management system and their application throughout the organization (see 1.2),

b) determine the sequence and interaction of these processes,

c) determine criteria and methods needed to ensure that both the operation and control of these processes are effective,

d) ensure the availability of resources and information necessary to support the operation and monitoring of these processes,

e) monitor, measure and analyse these processes, and

f) implement actions necessary to achieve planned results and continual improvement of these processes.

These processes shall be managed by the organization in accordance with the requirements of this International Standard.

Where an organization chooses to outsource any process that affects product conformity with requirements, the organization shall ensure control over such processes. Control of such outsourced processes shall be identified within the quality management system.

NOTE Processes needed for the quality management system referred to above should include processes for management activities, provision of resources, product realization and measurement.

4.2 Documentation requirements

4.2.1 General

The quality management system documentation shall include

a) documented statements of a quality policy and quality objectives,

b) a quality manual,

c) documented procedures required by this International Standard,

d) documents needed by the organization to ensure the effective planning, operation and control of its processes, and

e) records required by this International Standard (see 4.2.4).

NOTE 1 Where the term "documented procedure" appears within this International Standard, this means that the procedure is

NOTE 2 The extent of the quality management system documentation can differ from one organization to another due to

a) the size of organization and type of activities,

b) the complexity of processes and their interactions, and

c) the competence of personnel.

NOTE 3 The documentation can be in any form or type of medium.

4.2.2 Quality manual

The organization shall establish and maintain a quality manual that includes

a) the scope of the quality management system, including details of and justification for any exclusions (see 1.2),

b) the documented procedures established for the quality management system, or reference to them, and

c) a description of the interaction between the processes of the quality management system.

4.2.3 Control of documents

Documents required by the quality management system shall be controlled. Records are a special type of document and shall be controlled according to the requirements given in 4.2.4.

A documented procedure shall be established to define the controls needed

a) to approve documents for adequacy prior to issue,

b) to review and update as necessary and re-approve documents,

c) to ensure that changes and the current revision status of documents are identified,

d) to ensure that relevant versions of applicable documents are available at points of use,

e) to ensure that documents remain legible and readily identifiable,

f) to ensure that documents of external origin are identified and their distribution controlled, and

g) to prevent the unintended use of obsolete documents, and to apply suitable identification to them if they are retained for any purpose.

4.2.4 Control of records

Records shall be established and maintained to provide evidence of conformity to requirements and of the effective operation of the quality management system. Records shall remain legible, readily identifiable and retrievable. A documented procedure shall be established to define the controls needed for the identification, storage, protection, retrieval, retention time and disposition of records.

5 Management responsibility

5.1 Management commitment

Top management shall provide evidence of its commitment to the development and implementation of the quality management system and continually improving its effectiveness by

a) communicating to the organization the importance of meeting customer as well as statutory and regulatory requirements,

b) establishing the quality policy,

d) conducting management reviews, and

e) ensuring the availability of resources.

5.2 Customer focus

Top management shall ensure that customer requirements are determined and are met with the aim of enhancing customer satisfaction (see 7.2.1 and 8.2.1).

5.3 Quality policy

Top management shall ensure that the quality policy

a) is appropriate to the purpose of the organization,

b) includes a commitment to comply with requirements and continually improve the effectiveness of the quality management system,

c) provides a framework for establishing and reviewing quality objectives,

d) is communicated and understood within the organization, and

e) is reviewed for continuing suitability.

5.4 Planning

5.4.1 Quality objectives

Top management shall ensure that quality objectives, including those needed to meet requirements for product [see 7.1 a)], are established at relevant functions and levels within the organization. The quality objectives shall be measurable and consistent with the quality policy.

5.4.2 Quality management system planning

Top management shall ensure that

a) the planning of the quality management system is carried out in order to meet the requirements given in 4.1, as well as the quality objectives, and

b) the integrity of the quality management system is maintained when changes to the quality management system are planned and implemented.

5.5 Responsibility, authority and communication

5.5.1 Responsibility and authority

Top management shall ensure that responsibilities and authorities are defined and communicated within the organization.

5.5.2 Management representative

Top management shall appoint a member of management who, irrespective of other responsibilities, shall have responsibility and authority that includes

a) ensuring that processes needed for the quality management system are established, implemented and

b) reporting to top management on the performance of the quality management system and any need for improvement, and

c) ensuring the promotion of awareness of customer requirements throughout the organization.

NOTE The responsibility of a management representative can include liaison with external parties on matters relating to the quality management system.

5.5.3 Internal communication

Top management shall ensure that appropriate communication processes are established within the organization and that communication takes place regarding the effectiveness of the quality management system.

5.6 Management review

5.6.1 General

Top management shall review the organization's quality management system, at planned intervals, to ensure its continuing suitability, adequacy and effectiveness. This review shall include assessing opportunities for improvement and the need for changes to the quality management system, including the quality policy and quality objectives.

Records from management reviews shall be maintained (see 4.2.4).

5.6.2 Review input

The input to management review shall include information on

a) results of audits,

b) customer feedback,

c) process performance and product conformity,

d) status of preventive and corrective actions,

e) follow-up actions from previous management reviews,

f) changes that could affect the quality management system, and

g) recommendations for improvement.

5.6.3 Review output

The output from the management review shall include any decisions and actions related to

a) improvement of the effectiveness of the quality management system and its processes,

b) improvement of product related to customer requirements, and

c) resource needs.

6 Resource management

6.1 Provision of resources

The organization shall determine and provide the resources needed

a) to implement and maintain the quality management system and continually improve its effectiveness, and

6.2 Human resources

6.2.1 General

Personnel performing work affecting product quality shall be competent on the basis of appropriate education, training, skills and experience.

6.2.2 Competence, awareness and training

The organization shall

a) determine the necessary competence for personnel performing work affecting product quality,

b) provide training or take other actions to satisfy these needs,

c) evaluate the effectiveness of the actions taken,

d) ensure that its personnel are aware of the relevance and importance of their activities and how they contribute to the achievement of the quality objectives, and

e) maintain appropriate records of education, training, skills and experience (see 4.2.4).

6.3 *Infrastructure*

The organization shall determine, provide and maintain the infrastructure needed to achieve conformity to product requirements. Infrastructure includes, as applicable

a) buildings, workspace and associated utilities,

b) process equipment (both hardware and software), and

c) supporting services (such as transport or communication).

6.4 Work environment

The organization shall determine and manage the work environment needed to achieve conformity to product requirements.

7 Product realization

7.1 Planning of product realization

The organization shall plan and develop the processes needed for product realization. Planning of product realization shall be consistent with the requirements of the other processes of the quality management system (see 4.1).

In planning product realization, the organization shall determine the following, as appropriate:

a) quality objectives and requirements for the product;

b) the need to establish processes, documents, and provide resources specific to the product;

c) required verification, validation, monitoring, inspection and test activities specific to the product and the criteria for product acceptance;

d) records needed to provide evidence that the realization processes and resulting product meet requirements

The output of this planning shall be in a form suitable for the organization's method of operations.

NOTE 1 A document specifying the processes of the quality management system (including the product realization processes) and the resources to be applied to a specific product, project or contract, can be referred to as a quality plan.

NOTE 2 The organization may also apply the requirements given in 7.3 to the development of product realization processes.

7.2 Customer-related processes

7.2.1 Determination of requirements related to the product

The organization shall determine

a) requirements specified by the customer, including the requirements for delivery and post-delivery activities,

b) requirements not stated by the customer but necessary for specified or intended use, where known,

c) statutory and regulatory requirements related to the product, and

d) any additional requirements determined by the organization.

7.2.2 Review of requirements related to the product

The organization shall review the requirements related to the product. This review shall be conducted prior to the organization's commitment to supply a product to the customer (e.g. submission of tenders, acceptance of contracts or orders, acceptance of changes to contracts or orders) and shall ensure that

a) product requirements are defined,

b) contract or order requirements differing from those previously expressed are resolved, and

c) the organization has the ability to meet the defined requirements.

Records of the results of the review and actions arising from the review shall be maintained (see 4.2.4).

Where the customer provides no documented statement of requirement, the customer requirements shall be confirmed by the organization before acceptance.

Where product requirements are changed, the organization shall ensure that relevant documents are amended and that relevant personnel are made aware of the changed requirements.

NOTE In some situations, such as internet sales, a formal review is impractical for each order. Instead the review can cover relevant product information such as catalogues or advertising material.

7.2.3 Customer communication

The organization shall determine and implement effective arrangements for communicating with customers in relation to

a) product information,

b) enquiries, contracts or order handling, including amendments, and

7.3 Design and development

7.3.1 Design and development planning

The organization shall plan and control the design and development of product.

During the design and development planning, the organization shall determine

a) the design and development stages,

b) the review, verification and validation that are appropriate to each design and development stage, and

c) the responsibilities and authorities for design and development.

The organization shall manage the interfaces between different groups involved in design and development to ensure effective communication and clear assignment of responsibility.

Planning output shall be updated, as appropriate, as the design and development progresses.

7.3.2 Design and development inputs

Inputs relating to product requirements shall be determined and records maintained (see 4.2.4). These inputs shall include

a) functional and performance requirements,

b) applicable statutory and regulatory requirements,

c) where applicable, information derived from previous similar designs, and

d) other requirements essential for design and development.

These inputs shall be reviewed for adequacy. Requirements shall be complete, unambiguous and not in conflict with each other.

7.3.3 Design and development outputs

The outputs of design and development shall be provided in a form that enables verification against the design and development input and shall be approved prior to release.

Design and development outputs shall

a) meet the input requirements for design and development,

b) provide appropriate information for purchasing, production and for service provision,

c) contain or reference product acceptance criteria, and

d) specify the characteristics of the product that are essential for its safe and proper use.

7.3.4 Design and development review

At suitable stages, systematic reviews of design and development shall be performed in accordance with planned arrangements (see 7.3.1)

a) to evaluate the ability of the results of design and development to meet requirements, and

b) to identify any problems and propose necessary actions.

Participants in such reviews shall include representatives of functions concerned with the design and development stage(s) being reviewed. Records of the results of the reviews and any necessary actions shall be maintained (see

7.3.5 Design and development verification

Verification shall be performed in accordance with planned arrangements (see 7.3.1) to ensure that the design and development outputs have met the design and development input requirements. Records of the results of the verification and any necessary actions shall be maintained (see 4.2.4).

7.3.6 Design and development validation

Design and development validation shall be performed in accordance with planned arrangements (see 7.3.1) to ensure that the resulting product is capable of meeting the requirements for the specified application or intended use, where known. Wherever practicable, validation shall be completed prior to the delivery or implementation of the product. Records of the results of validation and any necessary actions shall be maintained (see 4.2.4).

7.3.7 Control of design and development changes

Design and development changes shall be identified and records maintained. The changes shall be reviewed, verified and validated, as appropriate, and approved before implementation. The review of design and development changes shall include evaluation of the effect of the changes on constituent parts and product already delivered.

Records of the results of the review of changes and any necessary actions shall be maintained (see 4.2.4).

7.4 Purchasing

7.4.1 Purchasing process

The organization shall ensure that purchased product conforms to specified purchase requirements. The type and extent of control applied to the supplier and the purchased product shall be dependent upon the effect of the purchased product on subsequent product realization or the final product.

The organization shall evaluate and select suppliers based on their ability to supply product in accordance with the organization's requirements. Criteria for selection, evaluation and re-evaluation shall be established. Records of the results of evaluations and any necessary actions arising from the evaluation shall be maintained (see 4.2.4).

7.4.2 Purchasing information

Purchasing information shall describe the product to be purchased, including where appropriate

a) requirements for approval of product, procedures, processes and equipment,

b) requirements for qualification of personnel, and

c) quality management system requirements.

The organization shall ensure the adequacy of specified purchase requirements prior to their communication to the supplier.

7.4.3 Verification of purchased product

The organization shall establish and implement the inspection or other activities necessary for ensuring that purchased product meets specified purchase requirements.

Where the organization or its customer intends to perform verification at the supplier's premises, the organization

7.5 Production and service provision

7.5.1 Control of production and service provision

The organization shall plan and carry out production and service provision under controlled conditions. Controlled conditions shall include, as applicable

a) the availability of information that describes the characteristics of the product,

b) the availability of work instructions, as necessary,

c) the use of suitable equipment,

d) the availability and use of monitoring and measuring devices,

e) the implementation of monitoring and measurement, and

f) the implementation of release, delivery and post-delivery activities.

7.5.2 Validation of processes for production and service provision

The organization shall validate any processes for production and service provision where the resulting output cannot be verified by subsequent monitoring or measurement. This includes any processes where deficiencies become apparent only after the product is in use or the service has been delivered.

Validation shall demonstrate the ability of these processes to achieve planned results.

The organization shall establish arrangements for these processes including, as applicable

a) defined criteria for review and approval of the processes,

b) approval of equipment and qualification of personnel,

c) use of specific methods and procedures,

d) requirements for records (see 4.2.4), and

e) revalidation.

7.5.3 Identification and traceability

Where appropriate, the organization shall identify the product by suitable means throughout product realization.

The organization shall identify the product status with respect to monitoring and measurement requirements.

Where traceability is a requirement, the organization shall control and record the unique identification of the product (see 4.2.4).

NOTE In some industry sectors, configuration management is a means by which identification and traceability are maintained.

7.5.4 Customer property

The organization shall exercise care with customer property while it is under the organization's control or being used by the organization. The organization shall identify, verify, protect and safeguard customer property provided for use or incorporation into the product. If any customer property is lost, damaged or otherwise found to be unsuitable for use, this shall be reported to the customer and records maintained (see 4.2.4).

7.5.5 Preservation of product

The organization shall preserve the conformity of product during internal processing and delivery to the intended destination. This preservation shall include identification, handling, packaging, storage and protection. Preservation shall also apply to the constituent parts of a product.

7.6 Control of monitoring and measuring devices

The organization shall determine the monitoring and measurement to be undertaken and the monitoring and measuring devices needed to provide evidence of conformity of product to determined requirements (see 7.2.1).

The organization shall establish processes to ensure that monitoring and measurement can be carried out and are carried out in a manner that is consistent with the monitoring and measurement requirements.

Where necessary to ensure valid results, measuring equipment shall

a) be calibrated or verified at specified intervals, or prior to use, against measurement standards traceable to international or national measurement standards; where no such standards exist, the basis used for calibration or verification shall be recorded;

b) be adjusted or re-adjusted as necessary;

c) be identified to enable the calibration status to be determined;

d) be safeguarded from adjustments that would invalidate the measurement result;

e) be protected from damage and deterioration during handling, maintenance and storage.

In addition, the organization shall assess and record the validity of the previous measuring results when the equipment is found not to conform to requirements. The organization shall take appropriate action on the equipment and any product affected. Records of the results of calibration and verification shall be maintained (see 4.2.4).

When used in the monitoring and measurement of specified requirements, the ability of computer software to satisfy the intended application shall be confirmed. This shall be undertaken prior to initial use and reconfirmed as necessary.

NOTE See ISO 10012-1 and ISO 10012-2 for guidance.

8 Measurement, analysis and improvement

8.1 General

The organization shall plan and implement the monitoring, measurement, analysis and improvement processes needed

a) to demonstrate conformity of the product,

b) to ensure conformity of the quality management system, and

c) to continually improve the effectiveness of the quality management system.

This shall include determination of applicable methods, including statistical techniques, and the extent of their use.

8.2 Monitoring and measurement

8.2.1 Customer satisfaction

As one of the measurements of the performance of the quality management system, the organization shall monitor information relating to customer perception as to whether the organization has met customer requirements. The

8.2.2 Internal audit

The organization shall conduct internal audits at planned intervals to determine whether the quality management system

a) conforms to the planned arrangements (see 7.1), to the requirements of this International Standard and to the quality management system requirements established by the organization, and

b) is effectively implemented and maintained.

An audit programme shall be planned, taking into consideration the status and importance of the processes and areas to be audited, as well as the results of previous audits. The audit criteria, scope, frequency and methods shall be defined. Selection of auditors and conduct of audits shall ensure objectivity and impartiality of the audit process. Auditors shall not audit their own work.

The responsibilities and requirements for planning and conducting audits, and for reporting results and maintaining records (see 4.2.4) shall be defined in a documented procedure.

The management responsible for the area being audited shall ensure that actions are taken without undue delay to eliminate detected nonconformities and their causes. Follow-up activities shall include the verification of the actions taken and the reporting of verification results (see 8.5.2).

NOTE See ISO 10011-1, ISO 10011-2 and ISO 10011-3 for guidance.

8.2.3 Monitoring and measurement of processes

The organization shall apply suitable methods for monitoring and, where applicable, measurement of the quality management system processes. These methods shall demonstrate the ability of the processes to achieve planned results. When planned results are not achieved, correction and corrective action shall be taken, as appropriate, to ensure conformity of the product.

8.2.4 Monitoring and measurement of product

The organization shall monitor and measure the characteristics of the product to verify that product requirements have been met. This shall be carried out at appropriate stages of the product realization process in accordance with the planned arrangements (see 7.1).

Evidence of conformity with the acceptance criteria shall be maintained. Records shall indicate the person(s) authorizing release of product (see 4.2.4).

Product release and service delivery shall not proceed until the planned arrangements (see 7.1) have been satisfactorily completed, unless otherwise approved by a relevant authority and, where applicable, by the customer.

8.3 Control of nonconforming product

The organization shall ensure that product which does not conform to product requirements is identified and controlled to prevent its unintended use or delivery. The controls and related responsibilities and authorities for dealing with nonconforming product shall be defined in a documented procedure.

The organization shall deal with nonconforming product by one or more of the following ways:

a) by taking action to eliminate the detected nonconformity;

b) by authorizing its use, release or acceptance under concession by a relevant authority and, where applicable, by the customer;

c) by taking action to preclude its original intended use or application.

Records of the nature of nonconformities and any subsequent actions taken, including concessions obtained, shall

When nonconforming product is corrected it shall be subject to re-verification to demonstrate conformity to the requirements.

When nonconforming product is detected after delivery or use has started, the organization shall take action appropriate to the effects, or potential effects, of the nonconformity.

8.4 Analysis of data

The organization shall determine, collect and analyse appropriate data to demonstrate the suitability and effectiveness of the quality management system and to evaluate where continual improvement of the effectiveness of the quality management system can be made. This shall include data generated as a result of monitoring and measurement and from other relevant sources.

The analysis of data shall provide information relating to

a) customer satisfaction (see 8.2.1),

b) conformity to product requirements (see 7.2.1),

c) characteristics and trends of processes and products including opportunities for preventive action, and

d) suppliers.

8.5 Improvement

8.5.1 Continual improvement

The organization shall continually improve the effectiveness of the quality management system through the use of the quality policy, quality objectives, audit results, analysis of data, corrective and preventive actions and management review.

8.5.2 Corrective action

The organization shall take action to eliminate the cause of nonconformities in order to prevent recurrence. Corrective actions shall be appropriate to the effects of the nonconformities encountered.

A documented procedure shall be established to define requirements for

a) reviewing nonconformities (including customer complaints),

b) determining the causes of nonconformities,

c) evaluating the need for action to ensure that nonconformities do not recur,

d) determining and implementing action needed,

e) records of the results of action taken (see 4.2.4), and

f) reviewing corrective action taken.

8.5.3 Preventive action

The organization shall determine action to eliminate the causes of potential nonconformities in order to prevent their

A documented procedure shall be established to define requirements for

a) determining potential nonconformities and their causes,

b) evaluating the need for action to prevent occurrence of nonconformities,

c) determining and implementing action needed,

d) records of results of action taken (see 4.2.4), and

e) reviewing preventive action taken.

Annex A
(informative)

Correspondence between ISO 9001:2000 and ISO 14001:1996

Table A.1 — Correspondence between ISO 9001:2000 and ISO 14001:1996

ISO 9001:2000		ISO 14001:1996	
Introduction			**Introduction**
General	0.1		
Process approach	0.2		
Relationship with ISO 9004	0.3		
Compatibility with other management systems	0.4		
Scope	**1**	**1**	**Scope**
General	1.1		
Application	1.2		
Normative reference	**2**	**2**	**Normative references**
Terms and definitions	**3**	**3**	**Definitions**
Quality management system	**4**	**4**	**Environmental management system requirements**
General requirements	4.1	4.1	General requirements
Documentation requirements	4.2		
General	4.2.1	4.4.4	Environmental management system documentation
Quality manual	4.2.2	4.4.4	Environmental management system documentation
Control of documents	4.2.3	4.4.5	Document control
Control of records	4.2.4	4.5.3	Records
Management responsibility	**5**	4.4.1	Structure and responsibility
Management commitment	5.1	4.2 4.4.1	Environmental policy Structure and responsibility
Customer focus	5.2	4.3.1 4.3.2	Environmental aspects Legal and other requirements
Quality policy	5.3	4.2	Environmental policy
Planning	5.4	4.3	Planning
Quality objectives	5.4.1	4.3.3	Objectives and targets
Quality management system planning	5.4.2	4.3.4	Environmental management programme(s)
Responsibility, authority and communication	5.5	4.1	General requirements
Responsibility and authority	5.5.1	4.4.1	Structure and responsibility
Management representative	5.5.2		
Internal communication	5.5.3	4.4.3	Communication
Management review	5.6	4.6	Management review
General	5.6.1		
Review input	5.6.2		
Review output	5.6.3		
Resource management	**6**	4.4.1	Structure and responsibility
Provision of resources	6.1		
Human resources	6.2		
General	6.2.1		
Competence, awareness and training	6.2.2	4.4.2	Training, awareness and competence
Infrastructure	6.3	4.4.1	Structure and responsibility
Work environment	6.4		

Table A.1 — Correspondence between ISO 9001:2000 and ISO 14001:1996 (*continued*)

ISO 9001:2000		ISO 14001:1996	
Product realization	**7**	4.4 4.4.6	Implementation and operation Operational control
Planning of product realization	7.1	4.4.6	Operational control
Customer-related processes	7.2		
Determination of requirements related to the product	7.2.1	4.3.1 4.3.2 4.4.6	Environmental aspects Legal and other requirements Operational control
Review of requirements related to the product	7.2.2	4.4.6 4.3.1	Operational control Environmental aspects
Customer communication	7.2.3	4.4.3	Communications
Design and development	7.3		
Design and development planning	7.3.1	4.4.6	Operational control
Design and development inputs	7.3.2		
Design and development outputs	7.3.3		
Design and development review	7.3.4		
Design and development verification	7.3.5		
Design and development validation	7.3.6		
Control of design and development changes	7.3.7		
Purchasing	7.4	4.4.6	Operational control
Purchasing process	7.4.1		
Purchasing information	7.4.2		
Verification of purchased product	7.4.3		
Production and service provision	7.5	4.4.6	Operational control
Control of production and service provision	7.5.1		
Validation of processes for production and service provision	7.5.2		
Identification and traceability	7.5.3		
Customer property	7.5.4		
Preservation of product	7.5.5		
Control of monitoring and measuring devices	7.6	4.5.1	Monitoring and measurement
Measurement, analysis and improvement	**8**	4.5	Checking and corrective action
General	8.1	4.5.1	Monitoring and measurement
Monitoring and measurement	8.2		
Customer satisfaction	8.2.1		
Internal audit	8.2.2	4.5.4	Environmental management system audit
Monitoring and measurement of processes	8.2.3	4.5.1	Monitoring and measurement
Monitoring and measurement of product	8.2.4		
Control of nonconforming product	8.3	4.5.2 4.4.7	Nonconformance and corrective and preventive action Emergency preparedness and response
Analysis of data	8.4	4.5.1	Monitoring and measurement
Improvement	8.5	4.2	Environmental policy
Continual improvement	8.5.1	4.3.4	Environmental management programme(s)
Corrective action	8.5.2	4.5.2	Nonconformance and corrective and preventive action
Preventive action	8.5.3		

Table A.2 — Correspondence between ISO 14001:1996 and ISO 9001:2000

ISO 14001:1996		ISO 9001:2000	
Introduction	—	**0**	**Introduction**
		0.1	General
		0.2	Process approach
		0.3	Relationship with ISO 9004
		0.4	Compatibility with other management systems
Scope	**1**	**1**	**Scope**
		1.1	General
		1.2	Application
Normative references	**2**	**2**	**Normative reference**
Definitions	**3**	**3**	**Terms and definitions**
Environmental management system requirements	**4**	**4**	**Quality management system**
General requirements	4.1	4.1	General requirements
		5.5	Responsibility, authority and communication
		5.5.1	Responsibility and authority
Environmental policy	4.2	5.1	Management commitment
		5.3	Quality policy
		8.5	Improvement
Planning	4.3	5.4	Planning
Environmental aspects	4.3.1	5.2	Customer focus
		7.2.1	Determination of requirements related to the product
		7.2.2	Review of requirements related to the product
Legal and other requirements	4.3.2	5.2	Customer focus
		7.2.1	Determination of requirements related to the product
Objectives and targets	4.3.3	5.4.1	Quality objectives
Environmental management programme(s)	4.3.4	5.4.2	Quality management system planning
		8.5.1	Continual improvement
Implementation and operation	4.4	**7**	**Product realization**
		7.1	Planning of product realization
Structure and responsibility	4.4.1	**5**	**Management responsibility**
		5.1	Management commitment
		5.5.1	Responsibility and authority
		5.5.2	Management representative
		6	**Resource management**
		6.1	Provision of resources
		6.2	Human resources
		6.2.1	General
		6.3	Infrastructure
		6.4	Work environment
Training, awareness and competence	4.4.2	6.2.2	Competence, awareness and training
Communication	4.4.3	5.5.3	Internal communication
		7.2.3	Customer communication
Environmental management system documentation	4.4.4	4.2	Documentation requirements
		4.2.1	General
		4.2.2	Quality manual

Table A.2 — Correspondence between ISO 14001:1996 and ISO 9001:2000 (*continued*)

ISO 14001:1996		ISO 9001:2000	
Document control	4.4.5	4.2.3	Control of documents
Operational control	4.4.6	**7**	**Product realization**
		7.1	Planning of product realization
		7.2	Customer-related processes
		7.2.1	Determination of requirements related to the product
		7.2.2	Review of requirements related to the product
		7.3	Design and development
		7.3.1	Design and development planning
		7.3.2	Design and development inputs
		7.3.3	Design and development outputs
		7.3.4	Design and development review
		7.3.5	Design and development verification
		7.3.6	Design and development validation
		7.3.7	Control of design and development changes
		7.4	Purchasing
		7.4.1	Purchasing process
		7.4.2	Purchasing information
		7.4.3	Verification of purchased product
		7.5	Production and service provision
		7.5.1	Control of production and service provision
		7.5.3	Identification and traceability
		7.5.4	Customer property
		7.5.5	Preservation of product
		7.5.2	Validation of processes for production and service provision
Emergency preparedness and response	4.4.7	8.3	Control of nonconforming product
Checking and corrective action	4.5	**8**	**Measurement, analysis and improvement**
Monitoring and measurement	4.5.1	7.6	Control of monitoring and measuring devices
		8.1	General
		8.2	Monitoring and measurement
		8.2.1	Customer satisfaction
		8.2.3	Monitoring and measurement of processes
		8.2.4	Monitoring and measurement of product
		8.4	Analysis of data
Nonconformance and corrective and preventive action	4.5.2	8.3	Control of nonconforming product
		8.5.2	Corrective action
		8.5.3	Preventive action
Records	4.5.3	4.2.4	Control of records
Environmental management system audit	4.5.4	8.2.2	Internal audit
Management review	4.6	5.6	Management review
		5.6.1	General
		5.6.2	Review input
		5.6.3	Review output

Annex B
(informative)

Correspondence between ISO 9001:2000 and ISO 9001:1994

Table B.1 — *Correspondence between ISO 9001:1994 and ISO 9001:2000*

ISO 9001:1994	ISO 9001:2000
1 Scope	**1**
2 Normative reference	**2**
3 Definitions	**3**
4 Quality system requirements [title only]	
4.1 Management responsibility [title only]	
4.1.1 Quality policy	5.1 + 5.3 + 5.4.1
4.1.2 Organization [title only]	
4.1.2.1 Responsibility and authority	5.5.1
4.1.2.2 Resources	6.1 + 6.2.1
4.1.2.3 Management representative	5.5.2
4.1.3 Management review	5.6.1 + 8.5.1
4.2 Quality system [title only]	
4.2.1 General	4.1 + 4.2.2
4.2.2 Quality system procedures	4.2.1
4.2.3 Quality planning	5.4.2 + 7.1
4.3 Contract review [title only]	
4.3.1 General	
4.3.2 Review	5.2 + 7.2.1 + 7.2.2 + 7.2.3
4.3.3 Amendment to a contract	7.2.2
4.3.4 Records	7.2.2
4.4 Design control [title only]	
4.4.1 General	
4.4.2 Design and development planning	7.3.1
4.4.3 Organizational and technical interfaces	7.3.1
4.4.4 Design input	7.2.1 + 7.3.2
4.4.5 Design output	7.3.3
4.4.6 Design review	7.3.4
4.4.7 Design verification	7.3.5
4.4.8 Design validation	7.3.6
4.4.9 Design changes	7.3.7
4.5 Document and data control [title only]	
4.5.1 General	4.2.3
4.5.2 Document and data approval and issue	4.2.3
4.5.3 Document and data changes	4.2.3
4.6 Purchasing [title only]	
4.6.1 General	
4.6.2 Evaluation of subcontractors	7.4.1
4.6.3 Purchasing data	7.4.2
4.6.4 Verification of purchased product	7.4.3

Table B.1 — Correspondence between ISO 9001:1994 and ISO 9001:2000 (*continued*)

ISO 9001:1994	ISO 9001:2000
4.7 Control of customer-supplied product	7.5.4
4.8 Product identification and traceability	7.5.3
4.9 Process control	6.3 + 6.4 + 7.5.1 + 7.5.2
4.10 Inspection and testing [title only]	
4.10.1 General	7.1 + 8.1
4.10.2 Receiving inspection and testing	7.4.3 + 8.2.4
4.10.3 In-process inspection and testing	8.2.4
4.10.4 Final inspection and testing	8.2.4
4.10.5 Inspection and test records	7.5.3 + 8.2.4
4.11 Control of inspection, measuring and test equipment [title only]	
4.11.1 General	7.6
4.11.2 Control procedure	7.6
4.12 Inspection and test status	7.5.3
4.13 Control of nonconforming product [title only]	
4.13.1 General	8.3
4.13.2 Review and disposition of nonconforming product	8.3
4.14 Corrective and preventive action [title only]	
4.14.1 General	8.5.2 + 8.5.3
4.14.2 Corrective action	8.5.2
4.14.3 Preventive action	8.5.3
4.15 Handling, storage, packaging, preservation & delivery [title only]	
4.15.1 General	
4.15.2 Handling	7.5.5
4.15.3 Storage	7.5.5
4.15.4 Packaging	7.5.5
4.15.5 Preservation	7.5.5
4.15.6 Delivery	7.5.1
4.16 Control of quality records	4.2.4
4.17 Internal quality audits	8.2.2 + 8.2.3
4.18 Training	6.2.2
4.19 Servicing	7.5.1
4.20 Statistical techniques [title only]	
4.20.1 Identification of need	8.1 + 8.2.3 + 8.2.4 + 8.4
4.20.2 Procedures	8.1 + 8.2.3 + 8.2.4 + 8.4

Table B.2 — Correspondence between ISO 9001:2000 and ISO 9001:1994

ISO 9001:2000	ISO 9001:1994
1 Scope	1
1.1 General	
1.2 Application	
2 Normative reference	2
3 Terms and definitions	3
4 Quality management system [title only]	
4.1 General requirements	4.2.1
4.2 Documentation requirements [title only]	
4.2.1 General	4.2.2
4.2.2 Quality manual	4.2.1
4.2.3 Control of documents	4.5.1 + 4.5.2 + 4.5.3
4.2.4 Control of records	4.16
5 Management responsibility [title only]	
5.1 Management commitment	4.1.1
5.2 Customer focus	4.3.2
5.3 Quality policy	4.1.1
5.4 Planning [title only]	
5.4.1 Quality objectives	4.1.1
5.4.2 Quality management system planning	4.2.3
5.5 Responsibility, authority and communication [title only]	
5.5.1 Responsibility and authority	4.1.2.1
5.5.2 Management representative	4.1.2.3
5.5.3 Internal communication	
5.6 Management review [title only]	
5.6.1 General	4.1.3
5.6.2 Review input	
5.6.3 Review output	
6 Resource management [title only]	
6.1 Provision of resources	4.1.2.2
6.2 Human resources [title only]	
6.2.1 General	4.1.2.2
6.2.2 Competence, awareness and training	4.18
6.3 Infrastructure	4.9
6.4 Work environment	4.9
7 Product realization [title only]	
7.1 Planning of product realization	4.2.3 + 4.10.1
7.2 Customer-related processes [title only]	
7.2.1 Determination of requirements related to the product	4.3.2 + 4.4.4
7.2.2 Review of requirements related to the product	4.3.2 + 4.3.3 + 4.3.4
7.2.3 Customer communication	4.3.2
7.3 Design and development [title only]	
7.3.1 Design and development planning	4.4.2 + 4.4.3
7.3.2 Design and development inputs	4.4.4

Table B.2 — Correspondence between ISO 9001:2000 and ISO 9001:1994 (*continued*)

ISO 9001:2000	ISO 9001:1994
7.3.3 Design and development outputs	4.4.5
7.3.4 Design and development review	4.4.6
7.3.5 Design and development verification	4.4.7
7.3.6 Design and development validation	4.4.8
7.3.7 Control of design and development changes	4.4.9
7.4 Purchasing [title only]	
7.4.1 Purchasing process	4.6.2
7.4.2 Purchasing information	4.6.3
7.4.3 Verification of purchased product	4.6.4 + 4.10.2
7.5 Production and service provision [title only]	
7.5.1 Control of production and service provision	4.9 + 4.15.6 + 4.19
7.5.2 Validation of processes for production and service provision	4.9
7.5.3 Identification and traceability	4.8 + 4.10.5 + 4.12
7.5.4 Customer property	4.7
7.5.5 Preservation of product	4.15.2 + 4.15.3 + 4.15.4 +.4.15.5
7.6 Control of monitoring and measuring devices	4.11.1 + 4.11.2
8 Measurement, analysis and improvement [title only]	
8.1 General	4.10.1 + 4.20.1 + 4.20.2
8.2 Monitoring and measurement [title only]	
8.2.1 Customer satisfaction	
8.2.2 Internal audit	4.17
8.2.3 Monitoring and measurement of processes	4.17 + 4.20.1 + 4.20.2
8.2.4 Monitoring and measurement of product	4.10.2 + 4.10.3 + 4.10.4 + 4.10.5 + 4.20.1 + 4.20.2
8.3 Control of nonconforming product	4.13.1 + 4.13.2
8.4 Analysis of data	4.20.1 + 4.20.2
8.5 Improvement [title only]	
8.5.1 Continual improvement	4.1.3
8.5.2 Corrective action	4.14.1 + 4.14.2
8.5.3 Preventive action	4.14.1 + 4.14.3

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[16] IEC 60300-1:—2), *Dependability management — Part 1: Dependability programme management.*

[17] *Quality Management Principles Brochure*3).

[18] *ISO 9000 + ISO 14000 News* (a bimonthly publication which provides comprehensive coverage of international developments relating to ISO's management system standards, including news of their implementation by diverse organizations around the world)4).

[19] Reference websites: http://www.iso.ch
http://www.bsi.org.uk/iso-tc176-sc2

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1) To be revised as ISO 19011, *Guidelines on quality and/or environmental management systems auditing.*

2) To be published. (Revision of ISO 9000-4:1993)

3) Available from website: http://www.iso.ch

4) Available from ISO Central Secretariat (sales@iso.ch).

ICS 03.120.10

Price based on 23 pages

ATTACHMENT 3

SAC's Internal Quality Plan

Votorantim Cimentos	VCNA Suwannee PROCEDURE	Code	PD00009
		Revision	11
	Title: QUALITY PLAN	Area	QC
		Pages	1 OF 10

1. OBJECTIVE

To outline routine quality control testing protocol in order to ensure all raw materials, in-process materials, and finished products are within required specification limits and tolerances.

2. REFERENCES

2.1 Competence, Awareness, and Training
2.2 Raw Materials and In-Process Materials Specification
2.3 Product Sampling
2.4 ISO 9001 - Requirements 5.4 and 7
2.5 ASTM C-183

3. DEFINITIONS

3.1 Quality Plan – Tasks to ensure that quality objectives are met and level of excellence is achieved. Quality Plan includes sampling details and responsibilities, critical analysis requirements and management review items.

3.2 Quality Objectives - Specific and measurable targets set to measure progress of achieving the objectives within a specified timeframe.

3.3 Nonconformities – An event in which any material identified in the quality plan does not meet required specifications.

3.4 Management Review – Routine meeting to ensure the continuing suitability, adequacy and effectiveness of quality planning and realization as outlined in ISO 9001 section 5.6.

3.5 Standard Deviation - A measure of uniformity or variation expressed as a numerical range equidistant from the average. In a normal distribution of test results 68 percent of the results will fall within one standard deviation of the average, 95 percent within two standard deviations of the average, and 99.7 percent within three standard deviations of the average.

3.6 Product Specifications – Target and tolerances based on customer specification requirements (see AASHTO/ASTM/DOT Type I/II and Hardie Cement).

3.7 Total Customer Satisfaction Meetings – Routine meetings between plant and sales personnel to review, discuss, and update on issues concerning product quality, market, and customer satisfaction.

4. STANDARD ITEMS DESCRIPTION

4.1 Quality control technician responsible for carrying out tasks and/or analysis must receive the required training to successfully complete the specified task (see Competence, Awareness, and Training).

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4.2 The Quality Plan and scope will be defined by the Plant, Production, Quality Control, and Purchasing Managers. The plan shall be designed to meet plant, customer, and standard specification requirements.

4.3 The department supervisors identified in the Sampling Process Plan (Table 1) must ensure proper training was provided and procedures were followed correctly.

4.4 Validation of Process: The raw materials have signs at the field, where the status of each material is provided. They are identified as "approved" (green) if within the specification; "in test" (yellow) if the material is under analysis or "Do not use" in red if the material is not approved. For material in process and final product, the validation is automatic. If there is no warning from Quality control to production or shipping: that means the product is approved.

4.5 Traceability: All the material has identification and the traceability is by date of production or receiving.

4.6 In the event that a non-conforming material is identified or a customer complaint is received, a corrective action needs to be carried out. The root cause needs to be investigated and documented and a corrective action plan needs to be developed and implemented to prevent any non-conformity from re-occurring.

4.7 In the event that a foreseeable potential non-conformity could occur, a preventive action plan needs to be developed and implemented to prevent potential non-conformity from occurring.

4.8 Daily composite finish mill cement samples are obtained by combining equal amounts of cement from each hourly finish mill sample for a given period (typically one production day). This daily composite sample is tested by the chemical and physical labs and the remaining portion of the sample is stored up to 3 months.

4.9 RESPONSIBILITIES

Plant Manager
a) Assist with determining the objectives and requirements of the product;
b) Ensure completion of routine management of all critical items;
c) Review product quality and performance;
d) Initiate and participate in preventive and corrective actions defined in the Management Meeting.

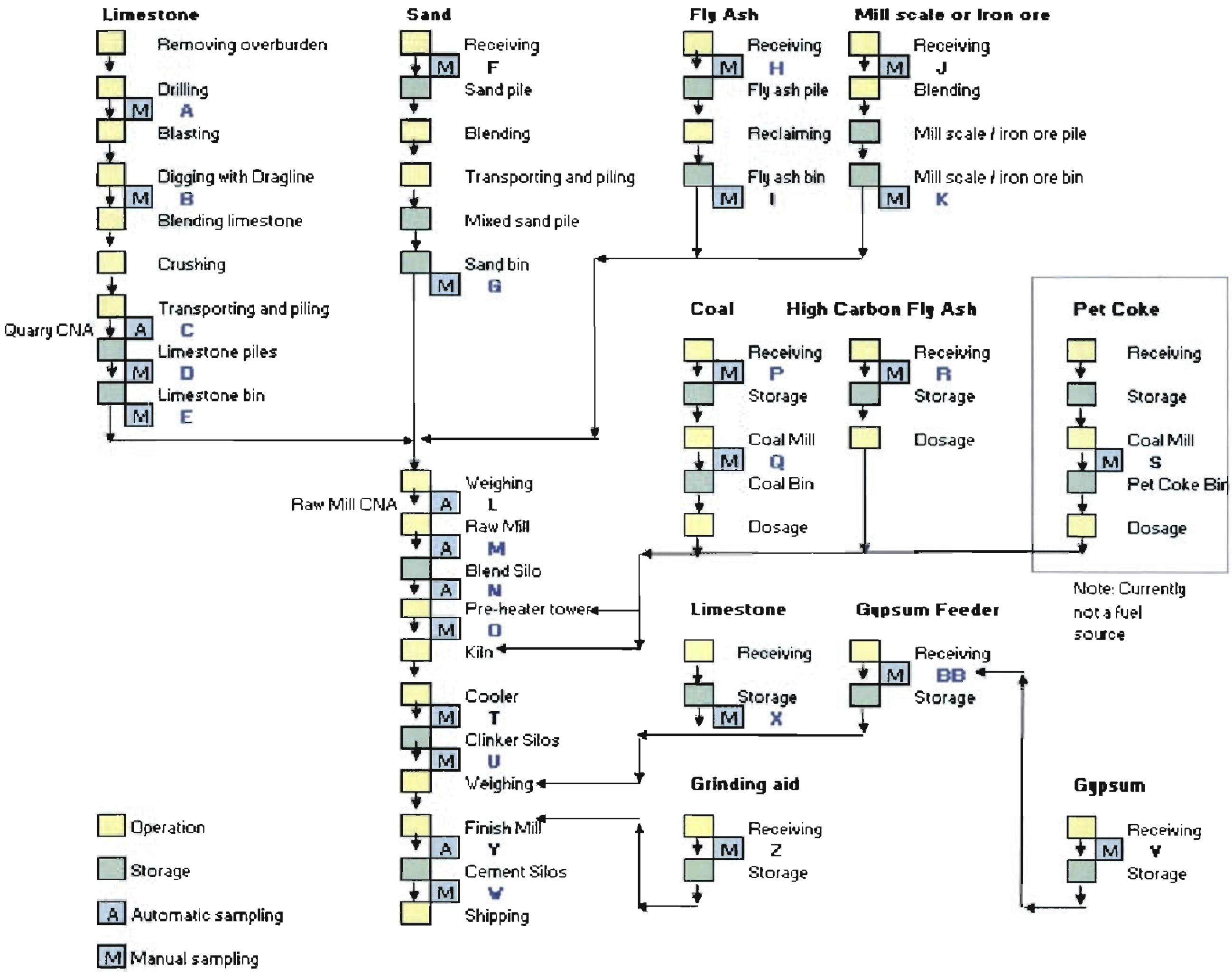
Production Manager
a) Assist with determining the objectives and requirements of the product;
b) Ensure completion of routine management of all critical items;
c) Initiate and participate in preventive and corrective actions defined in the Management Meeting.

Quality Control Manager
a) Determine the required verification, validation, monitoring, inspection and test activities specific to the product and the criteria for product acceptance;
b) Define and accomplish the necessary procedures in order to guarantee assured quality in raw materials and products;
c) Provide necessary equipment and training to perform the analysis;
d) Qualify supplies with Purchasing Department;
e) Ensure completion of all critical items.
f) Initiate and participate in preventive and corrective actions defined in the Management Meeting.

5. APPENDIX

5.1 APPENDIX 01 – Process Sampling

Quality Control - Process Sampling



5.2 APPENDIX 02 - Quality Plan

SAMPLING POINT	MATERIAL	SAMPLING				ANALYSIS			FREQUENCY (min)	CRITICAL ANALYSIS	MANAGEMEN REVIEW (When, Wha Who)
		PLACE	AMOUNT (min)	RESPONSIBLE	**WORK INSTRUCTION**	RESPONSIBLE	TYPE	**WORK INSTRUCTION**			
A	**Limestone from drilling**	Quarry	5 samples of 2 lb each	Quarry Spv	-	X Ray Lab	Chemical composition	PO00043	According to drilling plan	LSF, SO_3	Right after having the results. Plac results in Quarry Map, define move for dragline a plan blending Prod Mng, Quarry Mng Spv and QC Mng.
B	**Underwater rock**	Piles in the Quarry	5 samples of 2 lb each	Quarry Spv with Lab technician	-	X Ray Lab	Chemical composition	PO00043	Twice a month	LSF, SO_3	Bi-weekly. Pl blendings. Pr Mng, Quarry Mng / Spv an QC Mng.
							Moisture	PO00014		-	
C	**Blended limestone**	Quarry CNA	all material on belt	-	-	X Ray Lab	Chemical composition	-	Each 2 min when material on the belt	LSF, SO_3	Daily. LSF av and sd, SO_3 avg. Quarry Mng / Spv an QC Mng.
							Moisture	-		-	
D	**Limestone**	Piles in the raw materials building	4 lb	X Ray Lab	PO00015	X Ray Lab	Chemical composition	PO00043	Each 2 h (only if CNA not available)	SO_3	Daily. SO_3 evolution. Environm Mn Quarry Mng Spv and QC Mng.
							Moisture	PO00014	Each 12 h	-	
E	**Limestone**	Limestone Feeder	4 lb	X Ray Lab	PO00011	X Ray Lab	Chemical composition	PO00043	once per shift	LSF, SO_3	Weekly. Loo for contaminatio or discrepancie Prod Mng an QC Mng.
							Moisture	PO00014			
			1 lb	Chemical Lab	PO00182	Chemical Lab	Hg analysis	External	Daily comps for 30 days, quarterly	Hg	Quarterly. H variation. En Manager.
F	**Sand**	Raw materials building	4 lb	Chemical Lab	PO00015	Chemical Lab	Chemical composition	PO00043	Twice a month	SiO_2	Weekly. Chec for meeting specification and SO_3 control. Pro Mng, Quarry Mng / Spv an QC Mng.
							Moisture	PO00014		Moisture	
							LOI	PO00012		-	
							Free silica	PO00162		Free silica	
G	**Mixed or Pure sand**	Sand Feeder	4 lb	Chemical Lab	PO00011	Chemical Lab	Chemical composition	PO00043	Twice a month	SiO_2	Weekly. Loo for contaminatio or discrepancie Prod Mng an QC Mng.
							Moisture	PO00014			

			1 lb	Chemical Lab	PO00182	Chemical Lab	Hg analysis	External	Daily comps for 30 days, quarterly	Hg	Quarterly. Hg variation. En Manager.
H	**Fly ash**	Truck	2 lb	Chemical Lab	PO00015	Chemical Lab	Chemical composition	PO00043	Once a week	Al_2O_3, Na_2O, K_2O	Weekly. Chec for meeting specification and variation Prod Mng an QC Mng.
							Moisture	PO00014		-	
							LOI	PO00012		-	
							Fixed C	PO00157		Fixed C	
I	**Fly ash**	Fly ash Feeder	2 lb	Chemical Lab	PO00011	Chemical Lab	Chemical composition and carbon content	PO00043	Twice a month	Al_2O_3, alkali, carbon	Weekly. Lool for contaminatior or discrepancies Prod Mng an QC Mng.
							Moisture	PO00014			
			1 lb	Chemical Lab	PO00182	Chemical Lab	Hg analysis	External	Daily comps for 30 days, quarterly	Hg	Quarterly. Hg variation. En Manager.
J	**Mill scale or iron ore**	Raw materials building	6 lb	Chemical Lab	PO00015	Chemical Lab	Chemical composition	PO00043	Once a week	Fe_2O_3	Weekly. Chec for meeting specification and variation Prod Mng an QC Mng.
							Moisture	PO00014		Moisture	
							LOI	PO00012		-	
							Oil content	PO00157		Oil content	
K	**Mill scale or iron ore**	Iron ore feeder	6 lb	Chemical Lab	PO00011	Chemical Lab	Chemical composition	PO00043	Twice a month	Fe_2O_3	Weekly. Lool for contaminatior or discrepancies Prod Mng an QC Mng.
							Carbon content	PO00157		Carbon content	
							Moisture	PO00014			
			1 lb	Chemical Lab	PO00182		Hg analysis	External	Daily comps for 30 days, quarterly	Hg	Quarterly. Hg variation. En Manager.
L	**Raw materials mixed**	Raw mill CNA	all material on belt	-	PO00072	X Ray Lab	Chemical composition	-	Each 1 min	LSF, SR, AR, SO_3	Daily. Module and SO_3 variation. Pro Mng and QC Mng.
M	**Raw meal**	Raw meal sampler	2 lb (50 lb for loose density)	X Ray Lab	PO00011	X Ray Lab	Chemical composition	PO00043	Each 2 h	LSF, SR, AR, SO_3, alk equiv	Daily, Module SO_3 and fineness avg and sd. Env Mng. Prod Mr and QC Mng
							Moisture	PO00014	Once a day	-	
							Fineness R#170	PO00010	Each 4 h	R#170	
						QC Lab	Loose Density	-	Annually	Loose Density	Annually, Silo inventory measuremen Quality Contr and Productic Manager
N	**Kiln feed**	Kiln feed sampler	2 lb	X Ray Lab	PO00011	X Ray Lab	Chemical composition	PO00043	Each 2 h	LSF, SO_3	Daily. LSF av and sd, SO_3 avg. Env Mng Prod Mng an
						Chemical Lab	LOI	PO00012	Daily	-	

							Free silica	PO00162	Once a month (on monthly comp)	Free silica	QC Mng.
						X Ray Lab	Fineness R#170	PO00010	Each 4 h	R#170	
			1/2 lb	Chemical Lab	PO00182	Chemical Lab	Hg analysis	External	Daily comps for 30 days, quarterly	Hg	Quarterly. H variation. En Manager.
O	**Kiln feed**	Stage #1	1 lb	PA	PO00029	X Ray Lab	Chemical composition	PO00043	Twice a shift	SO_3	Daily. SO_3 an unburned carbon variation. En Mng, Prod Mr and QC Mng
							LOI	PO00012		Decarbon-ation	
						Chemical Lab	Unburned Carbon	PO00154	Monday through Friday	Unburned fuel	
P	**Raw Coal (as received)**	Coal storage (grizzly) /truck sample	2 lb	Chemical Lab	PO00015	Chemical Lab	Moisture	PO00014	Once a week	-	Weekly. Variation for items. Prod Mng and QC Mng.
							Sulfur	PO00020		S	
							Ash content	PO00020		Ash	
							Volatiles	PO00020		volatile	
							Calorific Value	PO00020		BTU/lb	
Q	**Milled coal**	After the coal mill	1/2 lb	X Ray Lab	PO00011	X Ray Lab	Moisture	PO00014	Each 4 h	Moisture	Weekly. Variation for items. Prod Mng and QC Mng.
							Fineness	PO00010		R#200	
						Chemical Lab	Sulfur	PO00020	Daily	-	
							Calorific Value	PO00020	Once a week	BTU/lb	
							Volatiles	PO00020		volatile	
							Ash content	PO00020	3 times a week	%	
			1/2 lb	Chemical Lab	PO00182		Hg analysis	External	Daily comps for 30 days, quarterly	Hg	Quarterly. H variation. En Manager.
R	**High Carbon Fly Ash**	Silo sample box	Make a composite with all individual bags left by	Chemical Lab	PO00015	Chemical Lab	Moisture	PO00014	daily	-	Daily. LOI an Carbon variation. Pro Mng and QC Mng.
							Chemical composition	PO00043	daily	Al_2O_3, alkali, SO_3	

			truck drivers				Calorific Value	PO00020	Once a week	BTU/lb	
							LOI	PO00012	Daily	LOI	
							Fixed C	PO00157	Daily	Carbon	
			1/4 lb	Chemical Lab	PO00182		Hg analysis	External	Daily comps for 30 days, quarterly	Hg	Quarterly. Hg variation. Em Manager.
S	**Pet coke**	Pet coke storage	1 lb	Chemical Lab	PO00015	Chemical Lab	Moisture	PO00014	Once a week (if used)	-	Weekly. Variation for a items. Prod Mng and QC Mng.
							Sulfur	PO00020		S	
							Ash content	PO00020		Ash	
							Chemical composition	PO00020		volatile	
							Calorific Value	PO00020		BTU/lb	
T.	**Clinker**	Cooler exit	2 lb	X Ray Lab	PO00011	X Ray Lab	Chemical composition	PO00043	Each 2 h	C_3S, FCaO, LSF, SR, AR, SO_3, Coating tendency, liquid phase	Daily. Result versus target average and standard deviation. Pro Mng and QC Mng.
							Liter-weight	PO00174	Each 4 h	LW	
						Chemical Lab	Microscopy	PO00158	Twice a week	Alite and belite sizes	
						X Ray Lab	Wet free lime	PO00001	When XRD Free lime higher than 5%	FCaO	
U	**Clinker**	Feeders M11, M12, M13 and M14	2 lb (50 lb for loose density)	X Ray Lab	PO00011	X Ray Lab	Chemical composition	PO00043	As requested	C_3S, FCaO	Twice a mont C_3S and FCaO in each belt. C Mng.
						QC Lab	Loose Density	-	Annually	Loose Density	Annually, Silo inventory measuremen Quality Contr and Productio Manager
V	**Gypsum**	Gypsum storage	4 lb	Chemical Lab	PO00015	Chemical Lab	Moisture	PO00170	Once a week	-	Weekly. Variation for a items. Prod Mng and QC Mng.
							Hydration water	PO00014	Upon source changes	-	
							LOI	PO00012	Once a week	LOI	
							SO_3	PO00043		SO_3	
BB	**Gypsum Feeder**	Gypsum Feeder	4 lb	Chemical Lab	PO00015	Chemical Lab	Moisture	PO00170	Twice a month	-	Twice a mont Variation for a items. Prod Mng and QC Mng.
							LOI	PO00012		LOI	
							SO_3	PO00043		SO_3	

Z	**Grinding aid**	Grinding aid dosage system	2 lb	Chemical Lab	PO00183	Chemical Lab	Specific gravity	-	As received or at least once a month	Specific gravity	Monthly. Variation. Pro Mng.
X	**Limestone**	Limestone Feeder for the Finish Mill	4 lb	Chemical Lab	PO00011	Chemical Lab	Moisture	PO00014	Twice per week	Moisture	Weekly. Averages an variation. Pro Mng and QC Mng.
							Chemical composition	PO00043		-	
							CO2	-		$CaCO_3$	
							LOI	PO00012		-	
Y	**Cement**	Cement sampler	2 lb	X Ray Lab	PO00011	X Ray Lab	Chemical composition	PO00043	Each 2 h	SO_3, C_3S, C_3A, alkali, FCaO	Daily. Result versus targe and average Prod Mng an QC Mng.
							Fineness	PO00010	Each 4 h	R#325	
							Blaine	PO00051	Each 2 h	Blaine	
							LOI (AASHTO only)	PO00012	Each 2 h	LOI	
		Daily composites (partial days will be composited)	20 lb (50 lb for loose density)	X Ray Lab	PO0178	Chemical Lab	Chemical composition	PO00043	Daily	SO_3, C_3S, C_3A, alkali, FCaO	Daily. Result versus target and variation Prod Mng an QC Mng.
							LOI	PO00012	Daily	LOI	

							IR	PO000176	One IR for every five (5) FM daily composites for AASHTO. Once a month for Hardie.	-	
							CO_2	-	Daily for ASHTO	Limestone added	
						Physical Lab	Strengths	PO0007	Daily	1 and 28 days	
							Autoclave expansion	PO0003	Weekly for AASHTO. Monthly for Hardie. (may include all in single autoclave run)	Expansion	
							Air content	PO00083	Weekly for AASHTO. Monthly for Hardie	-	
							Initial Setting Time (Vicat)	PO00019	Weekly for AASHTO. Daily for Hardie.	Initial setting time	
							Final Setting Time (Vicat)	PO00015	Weekly for AASHTO. Monthly for Hardie.	-	
							Fineness	PO00013	Daily	R#325	
							Blaine	PO00064	Daily	Blaine	
							Heat of Hydration	External	Twice a year for AASHTO. Once a year for Hardie.	-	
						Chemical Lab	Color	PO00156	Daily	-	

						Physical Lab	Density	PO00164	Twice a year for each cement type	-	
							Early Stiffening of Cement Paste (False Set)	PO00008	Weekly for AASHTO. Monthly for Hardie	Pene-tration Ratio	
							Normal consistency	PO00023	Weekly for AASHTO. Daily for Hardie.	-	
							Particle Size Distribution	PO00077	Monthly per cement type	Amount between 3 and 30 micron. Curve distribution	
						X Ray Lab	Pack set	PO00163	Daily for AASHTO. Monthly for Hardie	Pack set index.	
						QC Lab	Loose Density	-	Annually	Loose Density	Annually, Sil inventory measuremen Quality Contr and Productic Manager
W	**Cement**	Shipping	10 lb	Load-out	PO00011	Chemical Lab	Chemical composition	PO00043	Each silo once a week.	C_3S, SO_3, C_3A, alkali, FCaO	Weekly. Averages an variation. Pro Mng and QC Mng.
							LOI	PO00012		LOI	
						Physical Lab	Strengths (7 and 28 days)	PO00007	AASHTO only, 10 samples a month (minimum of 2 per week) + 1 duplicate.	7 and 28 days	
							Fineness	PO00018	Each silo once a week.	R#325	
							Blaine	PO00004		Blaine	

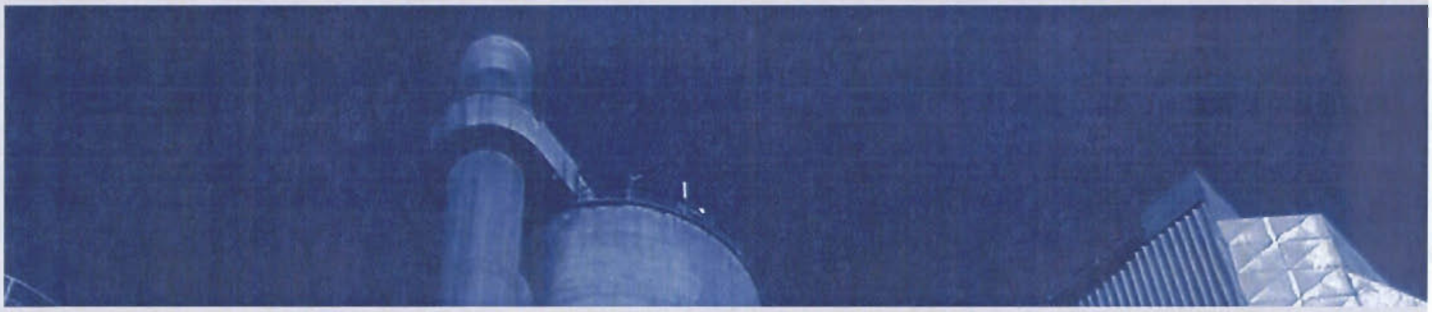
ATTACHMENT 4

Environmental Data of the German Cement Industries 2007

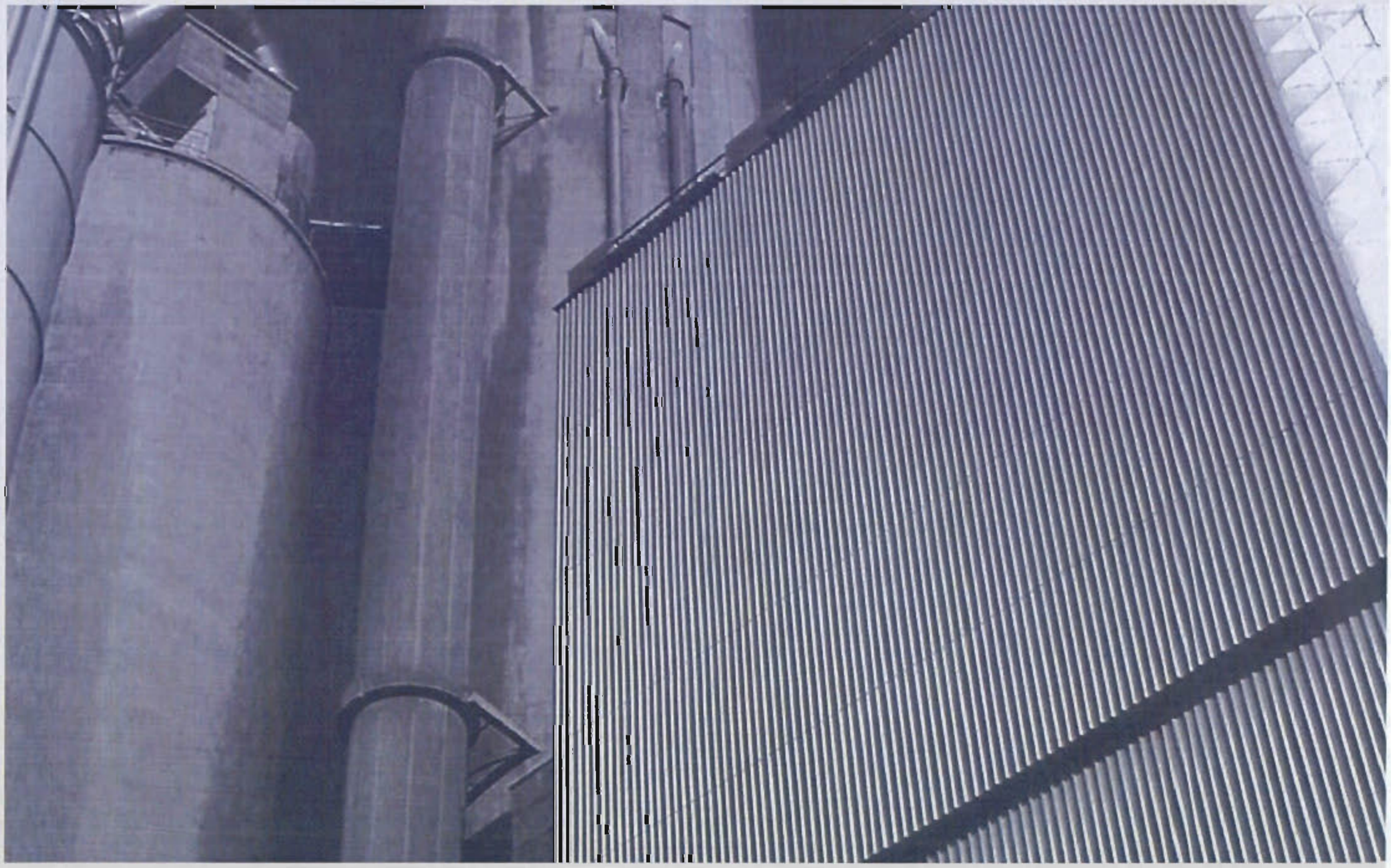
vdz.
Deutsche Zementindustrie

Environmental Data of the German Cement Industrie 2007

2007



Verein Deutscher Zementwerke e.V.
Forschungsinstitut der Zementindustrie



Contents

Foreword

In September 2000 the German Cement Works Association presented the “Environmental Data of the German Cement Industry” for the first time.

The present ninth edition updates the data and continues the report. Extent and contents remain largely unchanged. Again all clinker producing works in Germany took part in the survey on which these figures are based. As a consequence, a complete documentation of both the results of continuous emission monitoring and of individual measurements of trace elements and organic exhaust gas constituents can be presented for the year 2007.

Düsseldorf, in September 2008

Verein Deutscher Zementwerke e. V.

1 Cement manufacture

Cement is a construction material that sets automatically as a consequence of chemical reactions with water and subsequently retains its strength and soundness both when exposed to air and submerged in water.

Cement consists of finely ground Portland cement clinker and calcium sulphate (natural gypsum, anhydrite or gypsum from flue gas desulphurisation). In addition, cement may contain other main constituents, such as granulated blast furnace slag, natural pozzolana (e.g. trass), fly ash, burnt oil shale or limestone. Fig. 1-1 depicts the manufacturing process schematically.

What is known as Portland cement clinker is made from a raw material mix mainly consisting of calcium oxide (CaO), silicon dioxide (SiO_2), aluminium oxide (alumina (Al_2O_3)), and iron oxide (Fe_2O_3). These chemical constituents are supplied by limestone, chalk and clay or their natural blend, lime marl. Limestone and chalk are composed of calcium carbonate ($CaCO_3$). The major constituents of clay, which is a natural product of weathering processes, are fine-grained mica-like minerals and smaller quantities of quartz and feldspar, which constitute residues of the starting material. Clay minerals and feldspar are compounds of aluminium oxide and silicon dioxide (aluminosilicates) with alkalis, such as sodium and potassium. The iron oxide required for melt formation is either contained in the clay minerals in the form of ferrous hydroxide or it is added in the form of iron ore. For the cement to conform to the quality requirements stipulated, a precisely defined raw material composition must be complied with. Only a small margin of deviation can be tolerated.

The raw material mix is heated up to a temperature of approximately 1,450 °C in a rotary kiln until it starts sintering. This results in the starting materials forming new compounds known as clinker phases.

These are certain calcium silicates and calcium aluminates which confer on the cement its characteristic features of setting in the presence of water.

The clinker burnt in the rotary kiln is subsequently ground to cement in finish mills with calcium sulphate and, if necessary, with further main constituents being added. The calcium sulphate serves to adjust the setting behaviour of the cement in order to obtain optimum workability of the product during concrete production.

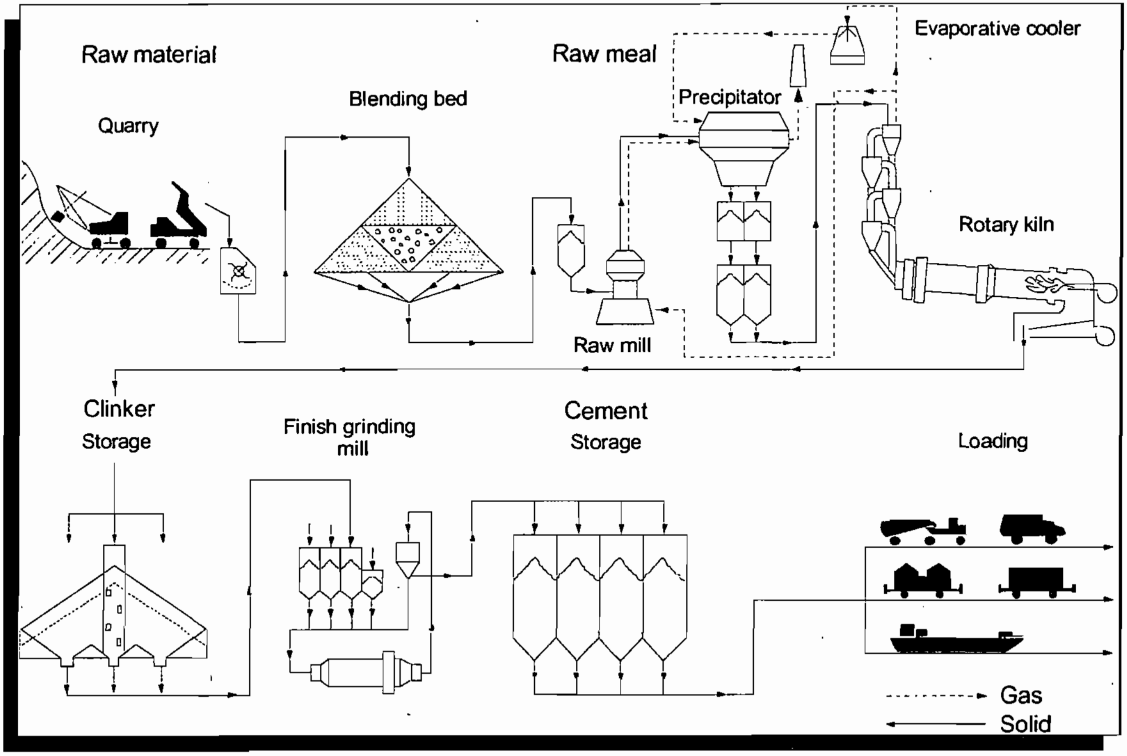


Fig. 1-1: Schematic presentation of the cement manufacturing process from quarry to dispatch

Apart from cement clinker, substances of silicate, aluminate or calcareous nature represent the further main constituents. They contribute to the setting of the cement or have favourable effects on the physical properties of the concrete.

2 Production and structural data

Cement is a homogeneous bulk commodity that, given the high cost of transport, is almost exclusively delivered to local markets. Production facilities of the German cement industry are spread evenly all over the Federal Republic of Germany and located in the immediate vicinity of the respective limestone deposits. In 2007, 22 companies with their 56 works produced about 33.4 million t of cement in Germany (Fig. 2-1).

Tables 2-1 and 2-2 give an overview of the clinker output in Germany and the cement made from it. The ready-mixed concrete industry (53% of cement output) and the manufacturers of concrete elements (25% of cement output) are among the principal buyers of cement. 8% of the cement is dispatched as bagged cement.

In Germany most of the cement clinker is nowadays produced in rotary kilns with cyclone preheaters applying the dry process. Kilns equipped with grate preheaters account for a significantly lower share of output (Table 2-3).

Fig. 2-1: Cement works in the Federal Republic of Germany in the year 2007

	Unit	2005	2006	2007
Clinker output	1,000 t	24.379	24.921	26.992
Cement sales (incl, clinker export)	1,000 t	32.364	34.714	34.076
of which: domestic sales	1,000 t	25.615	27.428	26.064
export incl, clinker	1,000 t	6.749	7.286	8.012
Cement import	1,000 t	1.427	1.492	1.144

Table 2-1: Output, sales and import [1, 2]

Cement type	Group	Unit	2005	2006	2007
Portland cement	CEM I	1,000 t	13.226	11.189	8.932
Portland-slag cement	CEM II	1,000 t	3.701	5.170	5.229
Portland-pozzolana cement		1,000 t	34	32	30
Portland-fly ash cement		1,000 t	5	0	0
Portland-burnt shale cement		1,000 t			
Portland-limestone cement		1,000 t	3.878	3.946	3.837
Portland-composite cement		1,000 t	437	1.480	2.203
Blastfurnace cement	CEM III	1,000 t	3.621	4.764	4.883
Other cements		1,000 t	193	263	308
Total		1,000 t	25.095	26.843	25.422

Table 2.2: Domestic sales classified by cement types [1]

		As at: 01. Jan 2006			As at: 01. Jan 2007			As at: 01. Jan 2008		
		Number	Capacity		Number	Capacity		Number	Capacity	
			t/d	%		t/d	%		t/d	%
Kilns with cyclone preheaters		42	103,650	91.0	41	100,550	90.8	41	101,000	92.1
Kilns with grate preheaters		11	8,970	7.9	11	8,970	8.1	9	7,500	6.8
Shaft kilns		8	1,200	1.1	8	1,200	1.1	8	1,200	1.1
Total		61	113,820	100	60	110,720	100	58	109,700	100
Average kiln capacity in t/d	Rotary kilns		2,124			2,106			2,170	
	Shaft kilns		150			150			150	

Table 2-3: Number and capacity of kilns with operating permits in the Federal Republic of Germany in the years from 2005 to 2007 [2].

3 Input materials

3.1 Raw materials

Limestone or chalk and clay or their natural blend – lime marl – constitute the most important raw materials for the production of Portland cement clinker. Depending on the raw material situation at the location of a cement works, it may be necessary to add pure limestone, iron ore, sand or other corrective substances to the raw material mix in order to compensate for the lack of certain chemical constituents.

Apart from natural raw materials, also alternative raw materials can be utilised, such as lime sludge, used foundry sand and fly ash. They contain silicon dioxide, aluminium oxide, iron oxide and/or calcium oxide as main constituents as well and are combined with the raw materials in quantities apt to ensure compliance with the clinker composition specified. The preconditions to be met by the material composition of an alternative raw material primarily depend on the raw material situation prevailing at a cement works, i.e. the composition of the limestone and marl deposits, respectively.

Table 3-1 lists the raw materials utilised in the year 2007. They can be classified into different groups, according to their chemical composition. Most of them are utilised as raw material components in the clinker burning process. Blastfurnace slag, a small proportion of the limestone, oil shale (burnt) and trass are used as main constituents of cement.

Group	Raw material	Input quantity 1,000 t/a
Ca	Limestone / marl / chalk	40,207
	Others, such as:	118
	- lime sludge from drinking water and sewage treatment	
	- hydrated lime	
	- foam concrete granulates	
	- calcium fluoride	
Si	Sand	1,399
	Used foundry sand	164
Si-Al	Clay	1,114
	Bentonite / kaolinite	48
	Residues from coal pre-treatment	
Fe	Iron ore	158
	Other input materials from the iron and steel industries, such as:	128
	- roasted pyrite	
	- contaminated ore	
	- iron oxide/fly ash blends	
	- dusts from steel plants	
	- mill scale	
Si-Al-Ca	Granulated blastfurnace slag	6,602
	Fly ash	387
	Oil shale	233
	Trass	28
	Others, such as:	91
	- paper residuals	
	- ashes from incineration processes	
	- mineral residuals, e. g. soil contaminated by oil	
S	Natural gypsum	625
	Natural anhydrite	547
	Gypsum from flue gas desulpherisation	389
Al	Input materials from the metal industry, such as:	62
	- residues from reprocessing salt slag	
	- aluminium hydroxide	

The cement industry is making efforts to increase the share in the cement of constituents other than clinker. This allows to modify the quality of the product purposefully, to improve the economic efficiency of the manufacturing process, to conserve natural resources, and to utilise materials generated by other processes in a useful manner, as stipulated by the German Waste Management and Recycling Act.

The materials, having industrial importance as potential substitutes for cement clinker in the cement in Germany, are chiefly (granulated) blastfurnace slag and also limestone. Blastfurnace slag is a spin-off of pig iron production and is used in the manufacture of Portland-slag and blastfurnace cements.

Natural gypsum and/or anhydrite cover about 70% of the demand for sulphate agents, which serve to adjust the working properties of the cements. Gypsum from flue gas desulphurisation accounts for the remaining share.

3.2 Fuels

Cement clinker burning uses up most of the fuel energy consumed in cement manufacture. To a lesser extent thermal energy is also used for drying raw materials and other major cement constituents, such as granulated blastfurnace slag. Since the mid-70ies, the traditional fuels of the cement industry have been coal and lignite and, on a smaller scale, also heavy fuel oil. A significant portion of coal has been replaced by petcoke since the 90ies. Petcoke is a coal-like fraction of mineral oil generated in crude oil processing. In addition to that, light and heavy fuel oil and gas are used for kiln start-up and drying processes. Table 3-2 lists all the energy sources exploited in the German cement industry.

Fuel	2005 million GJ/a	2006 million GJ/a	2007 million GJ/a
Coal	8.7	11.4	13.9
Lignite	29.1	27.6	25.1
Petcoke	4.2	4.3	5.6
Heavy fuel oil	2.2	1.9	2.1
Fuel oil EL	0.2	0.2	0.2
Natural gas and other gases	0.5	0.3	0.1
Other fossil fuels	0.5	0.3	0.3
Total fossil fuels	45.4	46.0	47.3
Total alternative fuels	43.3	46.1	52.2
Total thermal energy consumption	88.7	92.1	99.5

Table 3-2: Fuel energy consumption classified by en-

Apart from fossil fuels, the use of alternative fuels in the clinker burning process is gaining in importance nowadays. Alternative fuels accounted for about 50% of the total fuel energy consumption of the German cement industry in 2007. Table 3-3 lists the alternative fuels utilised and their average calorific values.

Alternative fuel	1,000 t/a	MJ/kg
Tyres	289	26
Waste oil	85	26
Fractions of industrial and commercial waste:	-	-
- Pulp, paper and cardboard	236	7
- Plastics	452	23
- Packaging	0	0
- Wastes from the textile industries	0	0
- Others	907	20
Meat and bone meal and animal fat	293	18
Mixed fractions of municipal waste	186	15
Scrap wood	13	13
Solvents	100	23
Fuller earth	0	0
Sewage sludge	254	4
Others, such as: - oil mud - organic distillation residues	90	7

Table 3-3: Consumption and average calorific value of alternative fuels in 2007 [3]

4 Energy

The production of one tonne of cement consumed an average of 2,915 MJ fuel energy and 99.7 kWh electrical energy in 2007 (Tables 4-1 and 4-2). Fuel energy is primarily required for clinker burning, while electrical energy is chiefly used for raw material pre-treatment (about 35%), for burning and cooling the clinker (about 22%) and for cement grinding (about 38%).

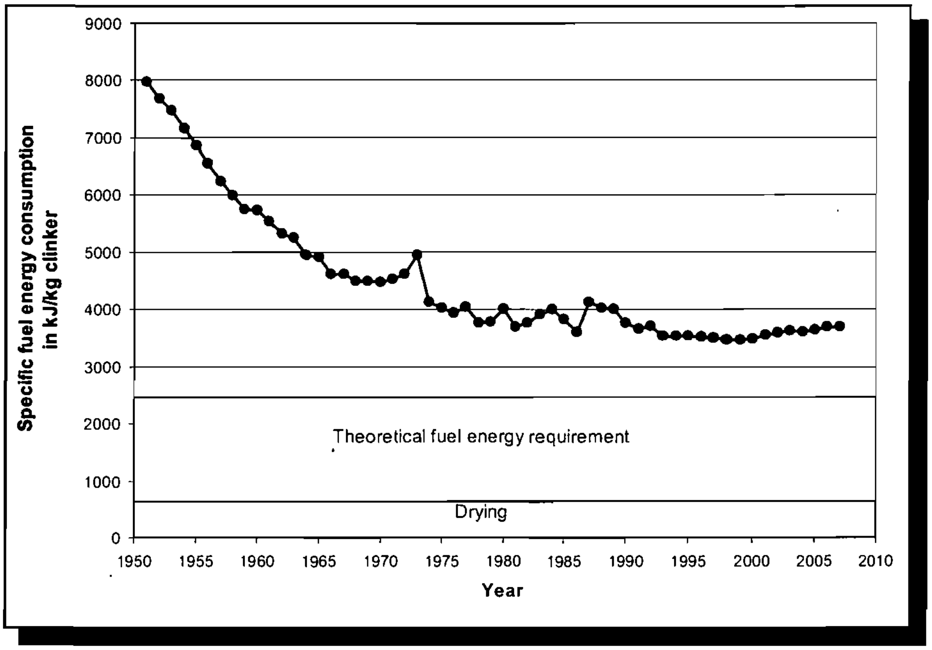


Fig. 4-1: Development of the specific fuel energy consumption (New Federal States included since 1987) [2]. Note: Fuel energy is relative to clinker in this chart.

Specific thermal energy consumption in the cement industry has declined significantly over the past 50 years. This is mainly attributable to improvements in plant and process technology. After 1990, the modernisation of the cement works in the New Federal States was one of the factors contributing to a further decrease in specific fuel energy consumption.

Since some years the clinker specific fuel energy consumption is stabilized at 3,500 to 3,700 kJ/kg clinker. Taking the utilization of the heat in the kiln exhaust gases for the drying processes (raw material, pulverized coal, blastfurnace slag) into account the overall efficiency of rotary kiln plants is more than 70%. This demonstrates the high level of energy efficiency of the clinker burning process [4].

Year	Fuel energy consumption	
	absolute in million GJ/a	specific in kJ/kg cement
2005	88,7	2785
2006	92,1	2674
2007	99,5	2915

Table 4-1: Absolute and specific fuel energy consump-

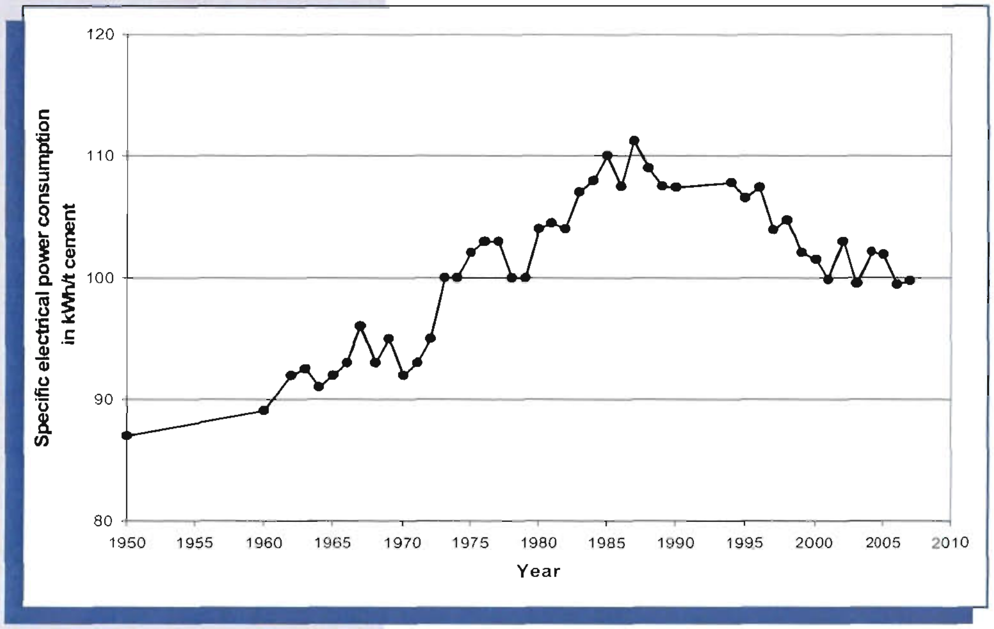


Fig. 4-2: Development of the specific electrical power consumption (New Federal States included since 1987) [2]

More demanding specifications for product quality and measures aimed at improving environmental protection were the major causes for the upward tendency in electrical power consumption over the past decades (Fig. 4-2). Among other things, improvements in grinding technique have contributed to a stabilisation of the specific electrical energy consumption most recently.

Year	Electrical power consumption	
	absolute in million MWh/a	specific in kWh/t cement
2005	3,24	101,9
2006	3,42	99,4
2007	3,40	99,7

Table 4-2: Absolute and specific electrical power consumption [2]

5 Emissions

The erection and operation of cement works are subject to the provisions of the Federal Ambient Pollution Protection Act. Depending on the type of fuel utilised, different specifications for the emission concentrations to be complied with are laid down. If standard fuels are used exclusively, the regulations of the Clean Air Act (TA Luft) are decisive. If a proportion of the standard fuels is replaced by waste used as alternative fuels, the provisions of the German regulation on waste incineration (17th BImSchV) apply additionally. Proceeding from this legal basis, the competent authorities can order both measurements for special reasons and first-time and recurrent measurements to be carried out by accredited measuring bodies only.

Object of measurement	Standard, guideline
Total dust	DIN EN 13284-1
Heavy metals	DIN EN 13211, 14385
- Sampling	VDI 3868, Sheet 1
- Analysis	VDI 2268, Sheets 1 - 4
Sulphur dioxides	DIN EN 14791
Nitrogene oxides	VDI 2456
Carbon monoxide	DIN EN 15058
Gaseous inorganic chlorine compounds	DIN EN 1911, Parts 1 - 3
Gaseous inorganic fluorine compounds	VDI 2470, Sheet 1
Dioxins, furans	
- Sampling	DIN EN 1948, Part 1
- Analysis	DIN EN 1948, Parts 2 - 3
Polycyclic aromatic hydrocarbons	
- Sampling	DIN EN 1948, Part 1
- Analysis	VDI 3873, Sheet 1
Organically bound carbon	DIN EN 12619, 13526
Benzene, toluene, ethylbenzene, xylene	DIN EN 13649

Table 5-1: Emission measuring methods

Emissions from cement works can be determined both by continuous and discontinuous measuring methods, which are described in corresponding VDI guidelines and DIN standards (Table 5-1). Continuous measurement is primarily used for dust, NO_x and SO_2, while the remaining parameters relevant pursuant to ambient pollution legislation are usually determined discontinuously by individual measurements.

The measurement results [3] presented in this chapter are based on the emission measurements at the rotary kiln plants of the German cement industry required by law. The emissions measured continuously (dust, NO_x, SO_2) were converted to annual averages. In the case of emissions measured discontinuously, the values are derived from the respective individual measurements. All measured values relate to 1 m^3 of dry gas under standard conditions with an oxygen content of 10%.

In some of the Figures the ranges for detection limits are marked in grey to facilitate assessment. Detection limits depend on sampling, sample preparation and analysis methods and are thus not identical for all measurements. The ranges indicated in the charts were determined, among other things, applying the performance characteristics given in the pertinent technical standards. Although significantly lower detection limits are cited in measurement reports in some cases, these generally refer to the analytical part of the measuring method only.

In the last few years, the European Union has increasingly set the course in environmental policy. For example, Commission decision 2000/479/EC instituting an European Pollutant Emission Register (EPER) came into force on July 28, 2001. It is to comprise the emission data on 37 air pollutants and 26 water pollutants emitted by about 20,000 industrial plants in the European Union. The data will be compiled specifically for each plant and published on the internet regularly, with the plant name being quoted. This compilation also covers all European cement plants having an output of more than 500 t clinker per day. The first reports by member states on the reference year 2001 had to be submitted to the Commission by June 2003. In Germany, these reports have been established on the basis of the emission declarations filed for 2000. In 2007 the EPER system was substituted by the even more complex PRTR system (PRTR: Pollutant Release and Transfer Register).

The figures supplied for the register refer to quantities emitted, i.e. the quantity of a certain substance that an industrial plant emits annually (kg/year). In order to record significant sources only, emissions below certain threshold values need not be indicated. Accordingly, the emissions of only 19 of the 37 air pollutants are considered relevant in the case of cement works (Table 5-2).

In the following, the concentration of a pollutant in the clean gas of rotary kiln systems is supplemented by the associated emission quantity, which is presented in an additional Figure. It is calculated on the basis of the clean gas volume flow emitted per year (m^3/year) and the pollutant concentration it contains (g/m^3). If the pollutant is detectable in the clean gas, it is possible to supply definite figures, the accuracy of which can be described by the measuring uncertainty, for example. If, however, this is not the case (e.g. values not secured or measurements below the detection limit), only a theoretical upper limit for the emissions released can be indicated. It is calculated on the basis of the assumption that the pollutant concentration in the clean gas reaches the detection limit. The quantity actually emitted, however, is lower. In the Figures, the range of possible values is represented by a broken line.

Evaluation of the measurement results shows that emissions from rotary kiln plants in the cement industry undershoot the thresholds for mandatory reporting pursuant to EPER, in some cases even significantly so.

Pollutant	Threshold value kg/year
Carbon monoxide (CO)	500,000
Carbon dioxide (CO_2)	100,000,000
Non-methane volatile organic compounds (NMVOC)	100,000
Nitrogene oxides (NO_x)	100,000
Sulphur dioxide (SO_2)	150,000
Arsenic	20
Cadmium	10
Chromium	100
Copper	100
Mercury	10
Nickel	50
Lead	200
Zinc	200
Dioxins and furans (PCDD/F)	0.001
Benzene	1,000
Polycyclic aromatic hydrocarbons (PAH)	50
Chlorine and inorganic chlorine compounds (HCl)	10,000
Fluorine and inorganic fluorine compounds (HF)	5,000
Fine dust (PM_{10})	50,000

Table 5-2: Threshold values for mandatory reporting on 19 of the 37 air pollutants covered by the European Pollutant Emission Register (sector-specific list for the industrial plants of the cement industry [5])

5.1 Greenhouse gases / carbon dioxide (CO_2)

During the clinker burning process climatically relevant gases are emitted. CO_2 accounts for the main share of these gases. Other climatically relevant gases, such as dinitrogen monoxide (N_2O) or methane (CH_4), are emitted in very small quantities only.

CO_2 emissions are both raw material-related and energy-related. Raw material-related emissions are produced during limestone decarbonation ($CaCO_3$) and account for about 60% of total CO_2 emissions. Energy-related emissions are generated both directly through fuel combustion and indirectly through the use of electrical power. Table 5-3 lists the proportions of CO_2 emissions accordingly.

In the year 1995, the German cement industry committed itself to make its contribution to global warming prevention and lower its specific fuel energy consumption by 20% between 1987 and 2005. This commitment has been updated into a negotiated agreement and, since November 9, 2000, has provided for a 28% reduction in energy-related specific CO_2 emissions from 1990 to 2008/2012.

Specific CO_2 emissions					
Year	Thermal energy-related 1)	Electrical energy-related	Raw-material-related	Total	Unit
2005	0,132	0,068	0,406	0,606	t CO_2 / t cement
2006	0,123	0,067	0,383	0,573	t CO_2 / t cement
2007	0,128	0,067	0,419	0,614	t CO_2 / t cement

Table 5-3: CO_2 emissions by the cement industry [2]

1) only regular fuels

On January 1, 2005 a trading system for CO_2 emissions was introduced in the EU. Direct CO_2 emissions from the combustion of all fuels (without biogenous compounds) and decarbonation of limestone are part of this trading system. In contrast the negotiated agreement of the cement industry also contains emissions deriving from the electrical energy consumption. CO_2 emissions from the combustion of alternative fuels are not taken into account, because they substitute fossil fuels and thereby reduce CO_2 emissions elsewhere. Since the emissions trading scheme further on refers only to the clinker burning process, but the agreement to the whole cement production, different emission values occur in the corresponding reporting systems.

5.2 Dust

To manufacture 1 t of Portland cement, about 1.5 to 1.7 t raw materials, 0.1 t coal and 1 t clinker (minus other main constituents and sulphate agents) must be ground to dust fineness during production. In this process, the steps of raw material preparatory processing, fuel preparation, clinker burning and cement grinding constitute major emission sources for particulate components. While particulate emissions of up to 3,000 mg/m^3 were measured at the stack of cement rotary kiln plants as recently as in the 50ies, these can be limited to 20 mg/m^3 today.

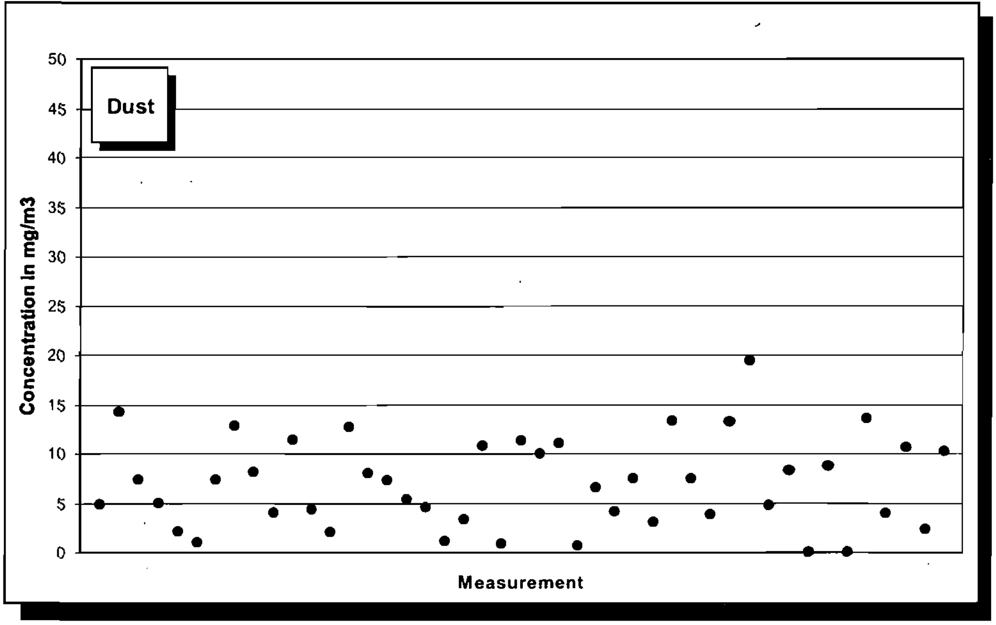


Fig. 5-1: Average (year 2007) dust concentrations in the clean gas of 45 rotary kilns

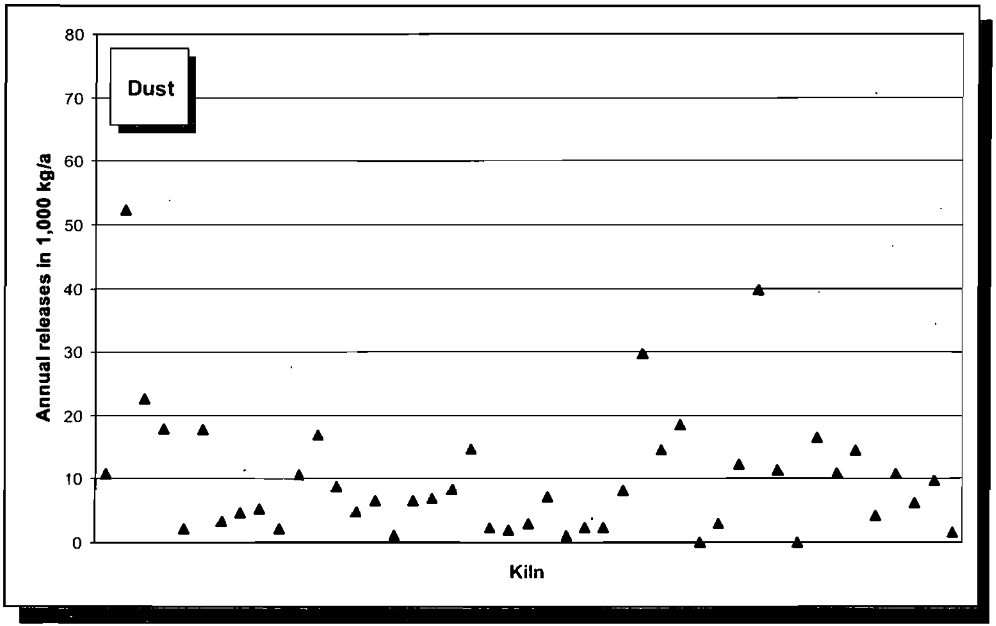


Fig. 5-2: Dust emissions (annual releases in 2007) of 45 rotary kilns

5.3 Nitrogen oxides (NO_x)

The clinker burning process is a high-temperature process resulting in the formation of nitrogen oxides (NO_x). Nitrogen monoxide (NO) accounts for about 95%, and nitrogen dioxide (NO_2) for about 5% of this compound present in the exhaust gas of rotary kiln plants. As most of the NO is converted to NO_2 in the atmosphere, emissions are given as NO_2 per m^3 exhaust gas.

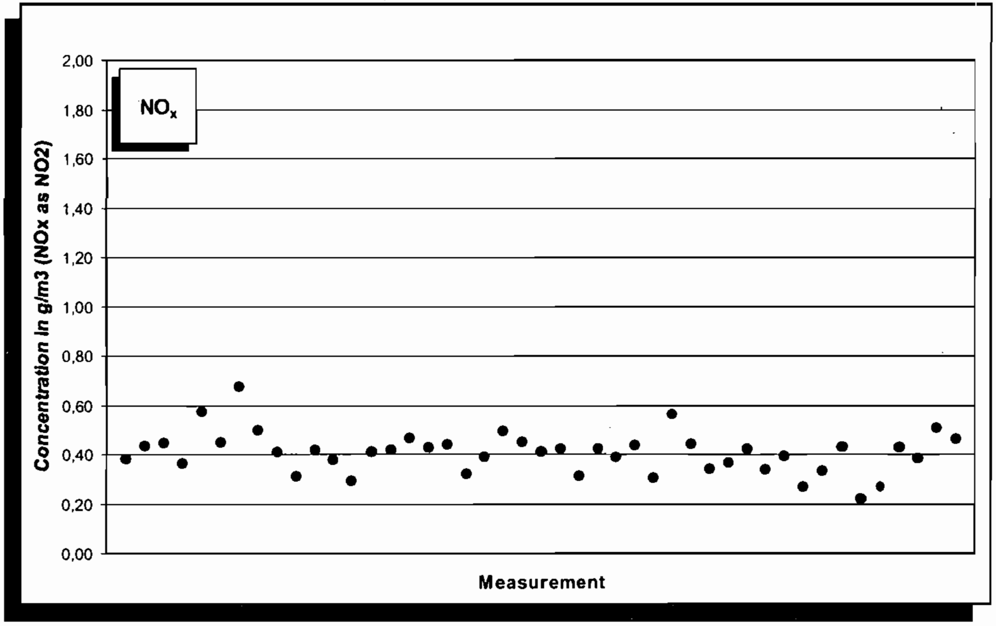


Fig. 5-3: Average NO_x concentrations (year 2007) in the clean gas of 45 rotary kilns. Note: In 2007, the emissions of several kilns exceeded the emission values for cement plants specified by the Clean Air Act now. The operating permits for these works are based on higher NO_x limits. Some of these plants have been or will be retrofitted with NO_x reduction devices.

Without reduction measures, process-related NO_x contents in the exhaust gas of rotary kiln plants would considerably exceed the current specifications of the Clean Air Act of 0.50 g/m^3. Reduction measures are aimed at smoothing and optimising plant operation. Furthermore, considerable efforts were made to achieve compliance with the demanding NO_x values in different ways. In 2007, eight plants were equipped with staged combustion, and the SNCR technique was applied at about 35 plants.

High process temperatures are required to convert the raw material mix to Portland cement clinker. Kiln charge temperatures in the sintering zone of rotary kilns range at around 1,450 °C. To reach these flame temperatures of about 2,000 °C are necessary.

For reasons of clinker quality the burning process takes place under oxidising conditions under which the partial oxidation of the molecular nitrogen in the combustion air resulting in the formation of nitrogen monoxide dominates. This reaction is also called thermal NO formation.

At the lower temperatures prevailing in a secondary firing unit, however, thermal NO formation is negligible: here the nitrogen bound in the fuel can result in the formation of what is known as fuel-related NO.

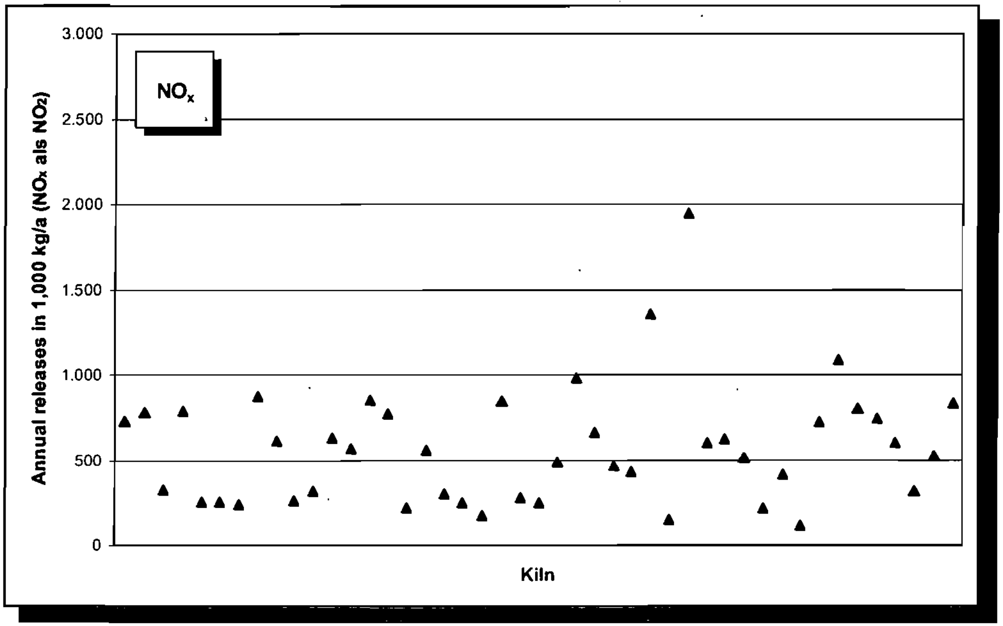


Fig. 5-4: NO$_x$ emissions (annual releases in 2007) of 45 rotary kilns

5.4 Sulphur dioxide (SO_2)

Sulphur is fed into the clinker burning process via raw materials and fuels. Depending on their respective deposits, the raw materials may contain sulphur bound as sulphide or sulphate. Higher SO_2 emissions by rotary kiln systems of the cement industry might be attributable to the sulphides contained in the raw material, which become oxidised to form SO_2 at the temperatures between 370 °C and 420 °C prevailing during the kiln feed preheating process. Most of the sulphides are pyrite or marcasite contained in the raw materials. Given the sulphide concentrations found in German raw material deposits, SO_2 emission concentrations can total up to 1.2 g/m^3 depending on the site location.

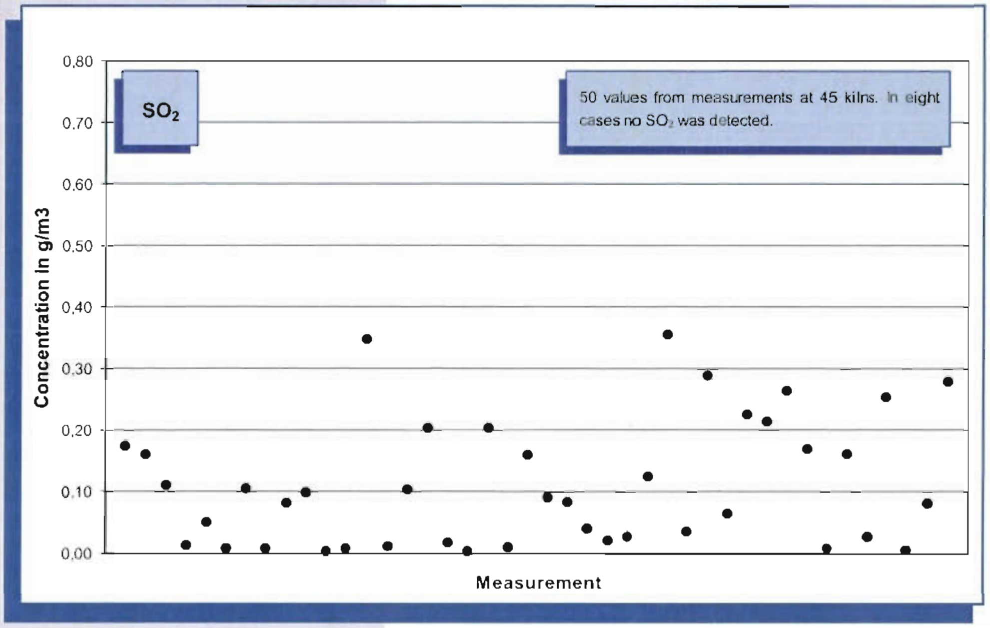


Fig. 5-5: Average SO_2 concentrations (year 2007) in the clean gas of 45 rotary kilns.

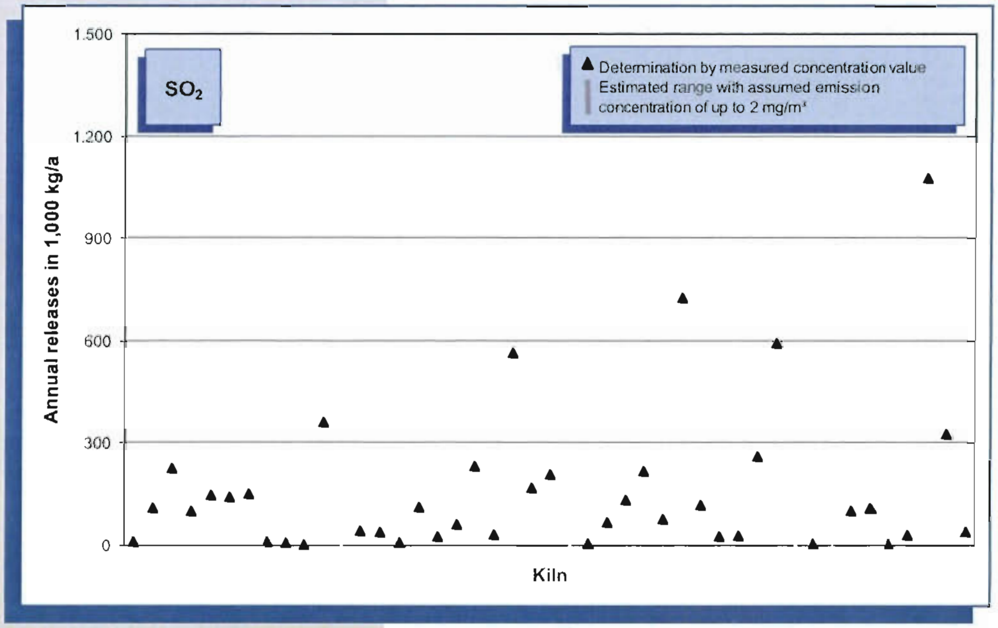


Fig. 5-6: SO_2 emissions (annual releases in 2007) of 45 rotary kilns.

If the values measured are below the detection limit, the releases can only be estimated. In these cases, the

The cement industry has made great efforts to reduce SO_2 emissions. For example, lime hydrate is utilised at 15 kiln systems to lower SO_2 emissions.

The sulphur input with the fuels is completely converted to SO_2 during combustion in the rotary kiln. In the area of the preheater and the kiln, this SO_2 reacts to form alkali sulphates, which are bound in the clinker.

5.5 Carbon monoxide (CO) and total carbon (Σ C)

The exhaust gas concentrations of CO and organically bound carbon are a yardstick for the burn-out rate of the fuels utilised in energy conversion plants, such as power stations. By contrast, the clinker burning process is a material conversion process that must always be operated with excess air for reasons of clinker quality. In concert with long residence times in the high-temperature range, this leads to complete fuel burn-up.

The occurring emissions of carbon monoxide and total carbon do not result from combustion, but from the thermal decomposition of organic compounds of the raw material in the preheater.

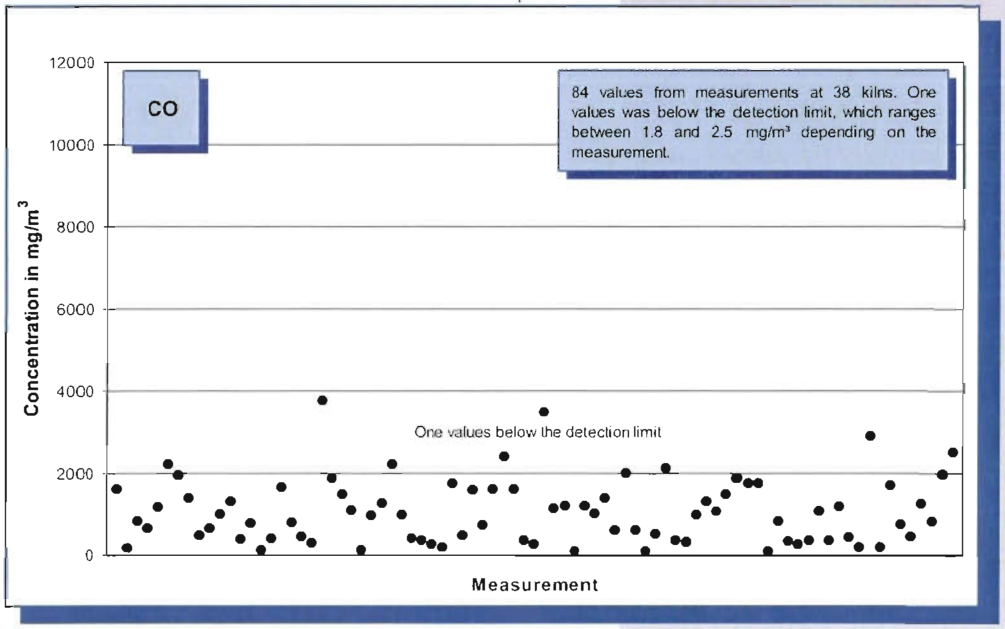


Fig. 5-7: CO concentration values (year 2007) measured in the clean gas of 38 rotary kilns.

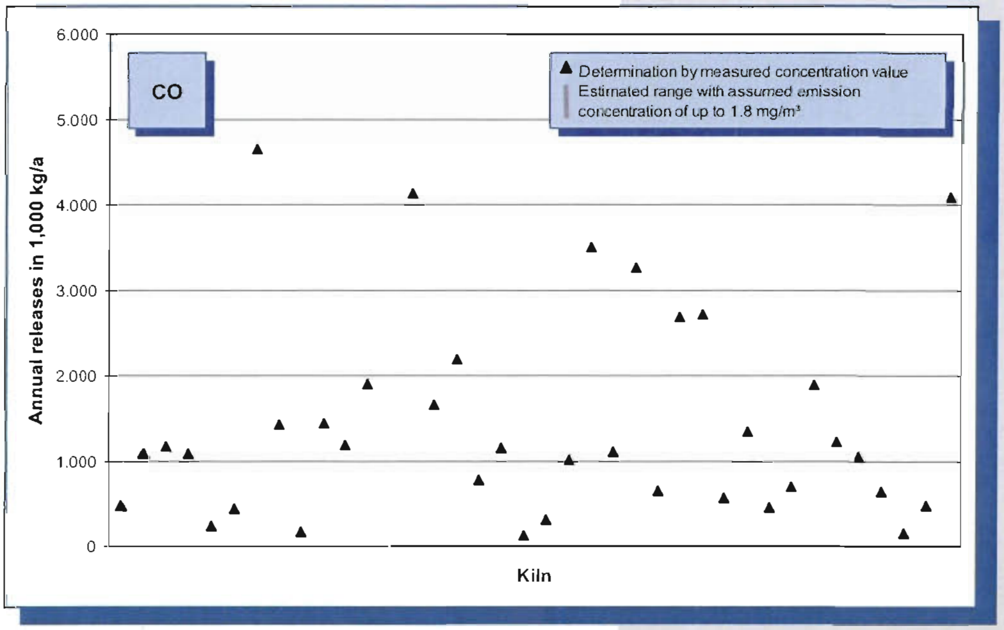
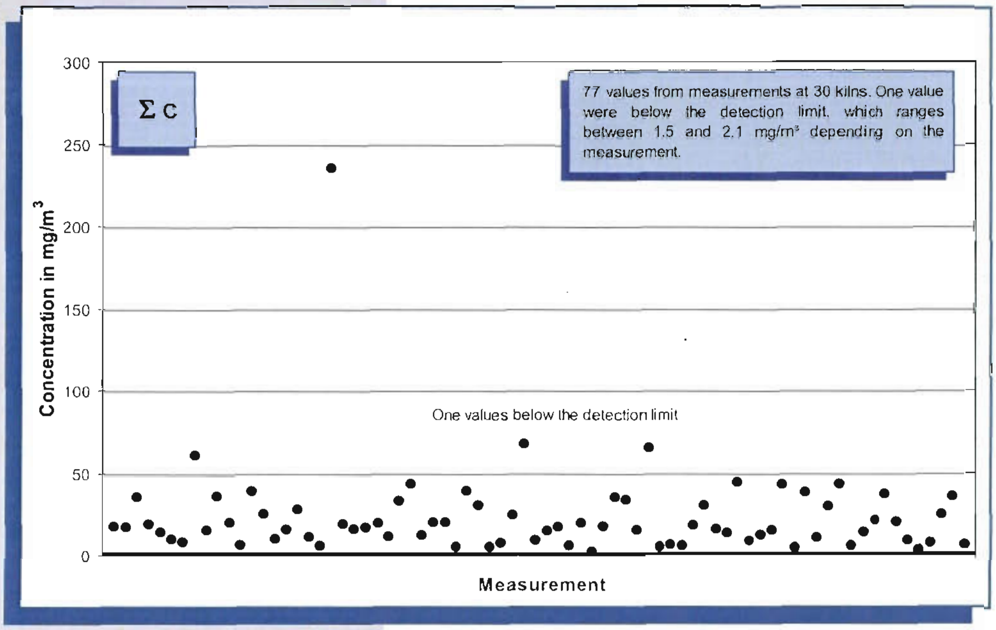


Fig. 5-8: CO emissions (annual releases in 2007) of 38 rotary kilns.

If the values measured are below the detection limit, the releases can only be estimated. In these cases, the range of possible emissions is represented by a bro-

The emissions of CO and organically bound carbon during the clinker burning process are caused by the small quantities of organic constituents input via the natural raw materials (remnants of organisms and plants incorporated in the rock in the course of geological history). These are converted during kiln feed preheating and become oxidised to form CO and CO_2. In this process, small portions of organic trace gases (total organic carbon) are formed as well. In case of the clinker burning process, the content of CO and organic trace gases in the clean gas therefore does not permit any conclusions on combustion conditions.



77 values from measurements at 30 kilns. One value were below the detection limit, which ranges between 1.5 and 2.1 mg/m³ depending on the measurement.

Fig. 5-9: Total organic carbon concentration values (year 2007) measured in the clean gas of 30 rotary kilns.

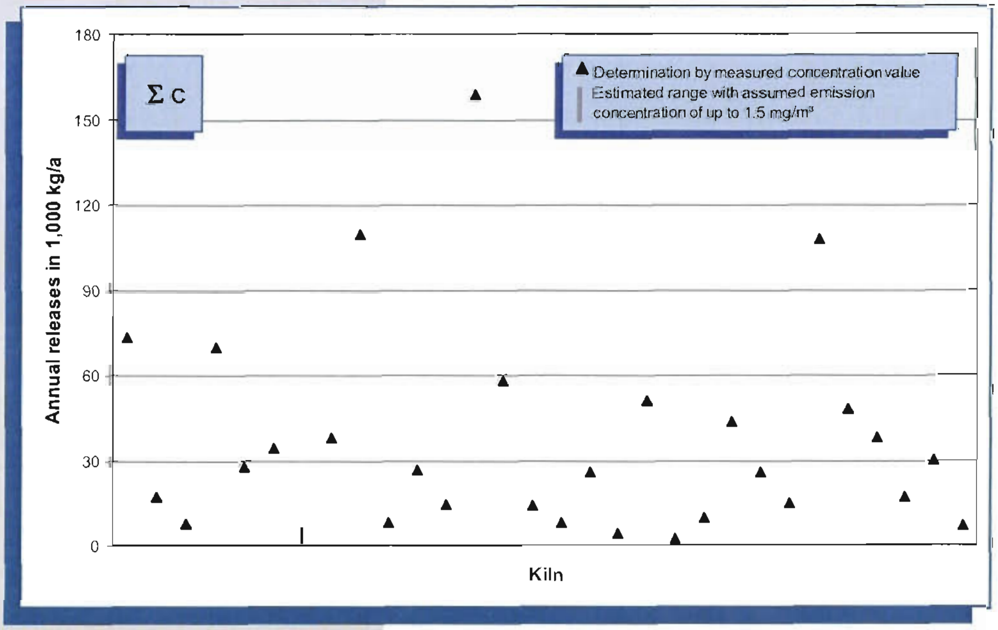


Fig. 5-10: Total organic carbon emissions (annual releases in 2007) of 30 rotary kilns.

If the values measured are below the detection limit, the releases can only be estimated. In these cases, the

5.6 Dioxins and furans (PCDD/F)

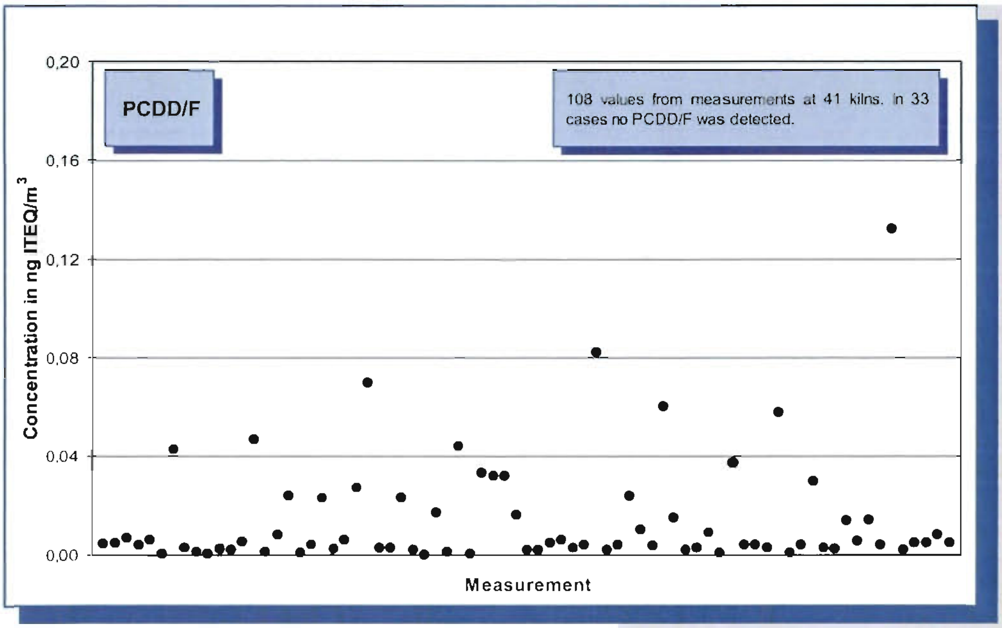


Fig. 5-11: Dioxin and furan (PCDD/F) concentration values (year 2007) measured in the clean gas of 41 rotary kilns. In 33 cases no PCDD/F was detected [1]. Note: No detection limit can be deduced from the standard. To evaluate the measurement results, interlaboratory variation of the method (comparison between different laboratories) can be referred to. Pursuant to DIN EN 1948 it amounts to ±0.05 ng ITEQ/m^3. (ITEQ: international toxicity equivalent)

Rotary kilns of the cement industry and classic incineration plants mainly differ in terms of the combustion conditions prevailing during clinker burning. Kiln feed and rotary kiln exhaust gases are conveyed in counter-flow and mixed thoroughly. Thus, temperature distribution and residence time in rotary kilns afford particularly favourable conditions for organic compounds, introduced either via fuels or derived from them, to be completely destroyed. For that reason, only very low concentrations of polychlorinated dibenzo-p-dioxins and dibenzofurans (in short: dioxins and furans) can be found in the exhaust gas from cement rotary kilns. Investigations have shown that their emissions are independent of the type of input materials used and cannot be influenced by process technology measures.

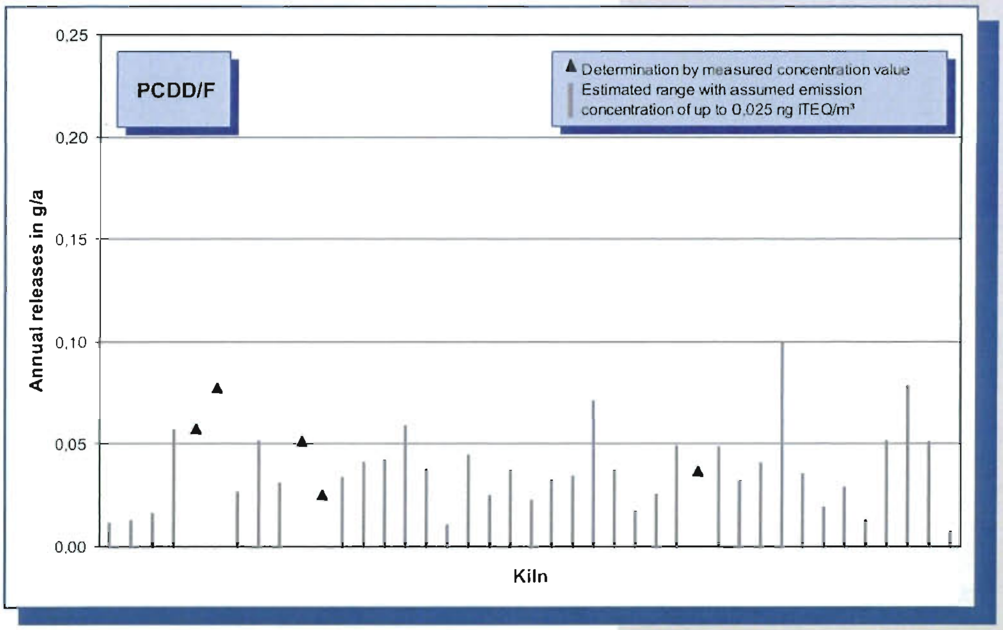


Fig. 5-12: Dioxin and furan emissions (annual releases in 2007) of 41 rotary kilns.

If the values measured are within the range of the external deviation of the method, the releases can only

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[1] In one case an increased PCDD/F value was measured due to a technical modification during the measurement. It was an unique outlier that could be attributed to the trial conditions which were not con-

5.7 Polychlorinated biphenyl (PCB)

The emission behaviour of PCB is comparable to that of dioxins and furans. PCB may be introduced into the process via alternative raw materials and fuels. The rotary kiln systems of the cement industry guarantee a virtually complete destruction of these trace components.

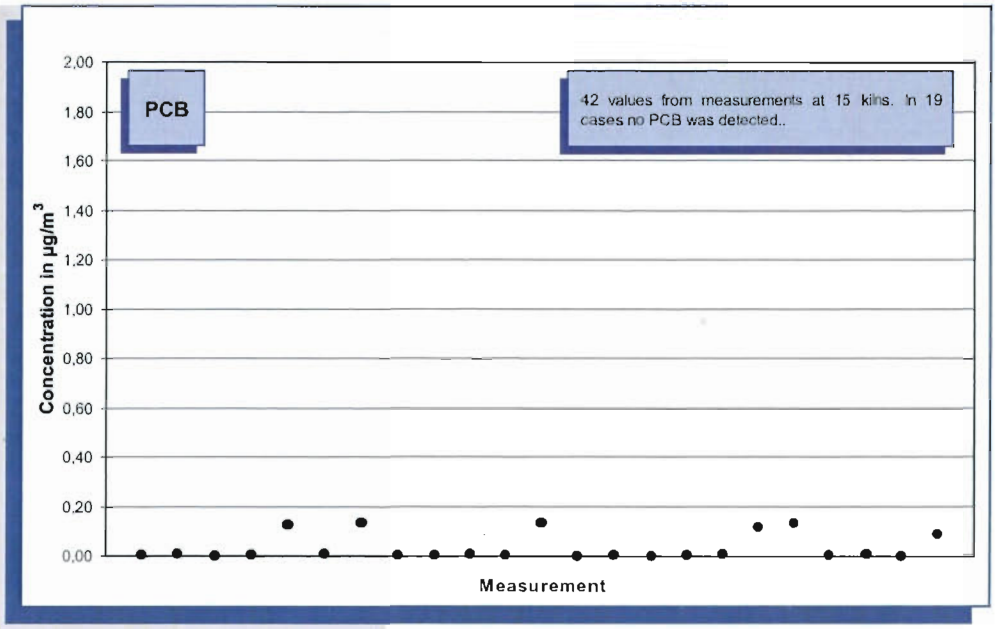


Fig. 5-13: Polychlorinated biphenyl (PCB according to DIN 51527) concentration values (year 2007) measured in the clean gas of 15 rotary kilns. In 19 cases no PCB was detected. Note: there is no standardised test specification indicating the performance characteristics of the measuring method used for measuring PCB in the clean gas of rotary kilns. For that reason, no detection limit is given here. below 0.02 µg/m³ the methods currently used do not provide secured emission concentrations.

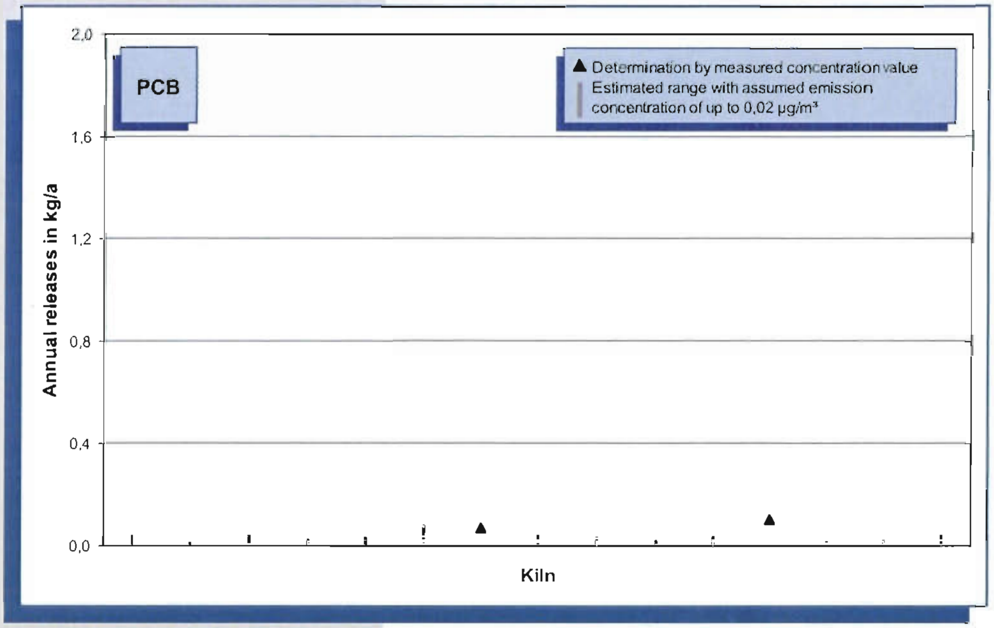


Fig. 5-14: PCB emissions (annual releases in 2007) of 15 rotary kilns.

If the measurements are not secured, the releases can

5.8 Polycyclic aromatic hydrocarbons (PAH)

PAHs (according to EPA 610) in the exhaust gas of rotary kilns usually appear at a distribution dominated by naphthalene, which accounts for a share of more than 90% by mass. The rotary kiln systems of the cement industry guarantee a virtually complete destruction of the PAHs input via fuels. Emissions are caused by organic constituents in the raw material.

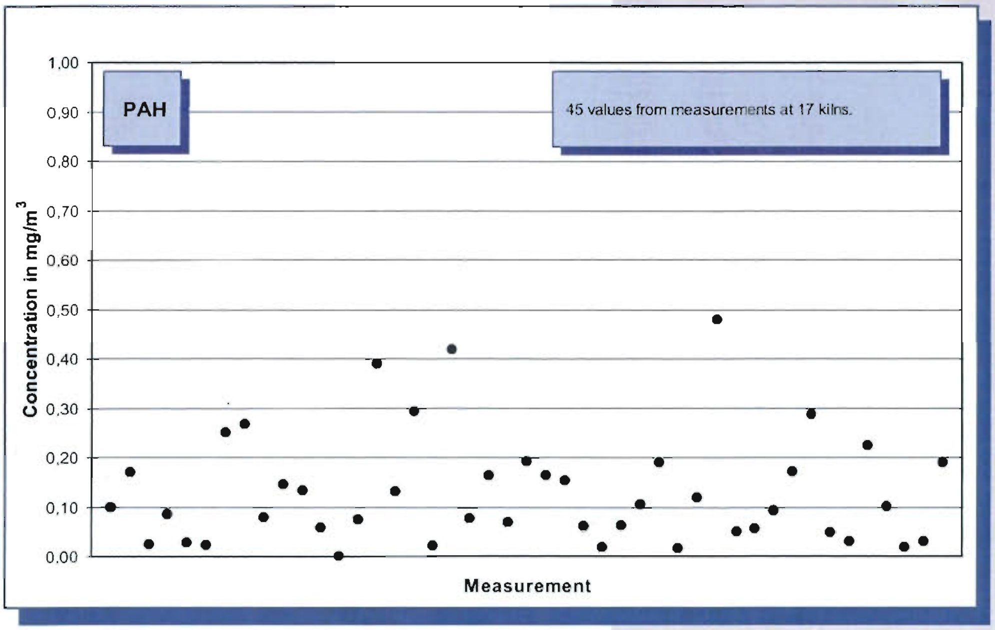


Fig. 5-15: Polycyclic aromatic hydrocarbon (PAH according to EPA 610) concentration values (year 2007) measured in the clean gas of 17 rotary kilns.

No detection limit can be deduced from the standard. Below 0.01 mg/m^3 the measuring methods currently used do not provide secured emission concentrations.

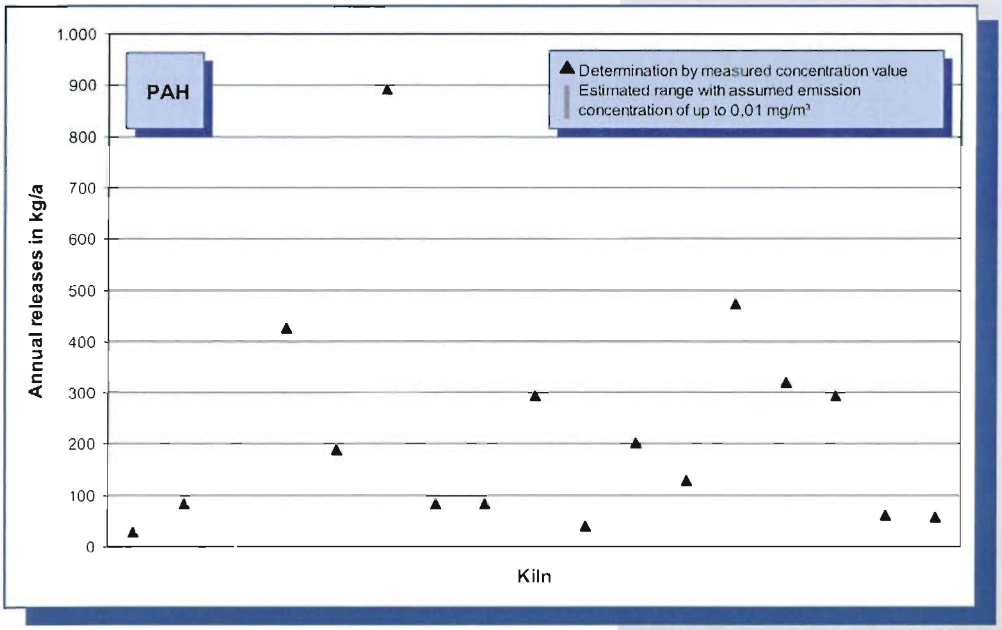


Fig. 5-16: PAH emissions (annual releases in 2007) of 17 rotary kilns.

If the measurements are not secured, the releases can only be estimated. In these cases, the range of possible emissions is represented by a broken line, the

5.9 Benzene, toluene, ethylbenzene, xylene (BTEX)

As a rule the above compounds are present in the exhaust gas of rotary kilns in a characteristic ratio. BTEX is formed during the thermal decomposition of organic raw material constituents in the preheater. They account for about 10% of total carbon emissions.

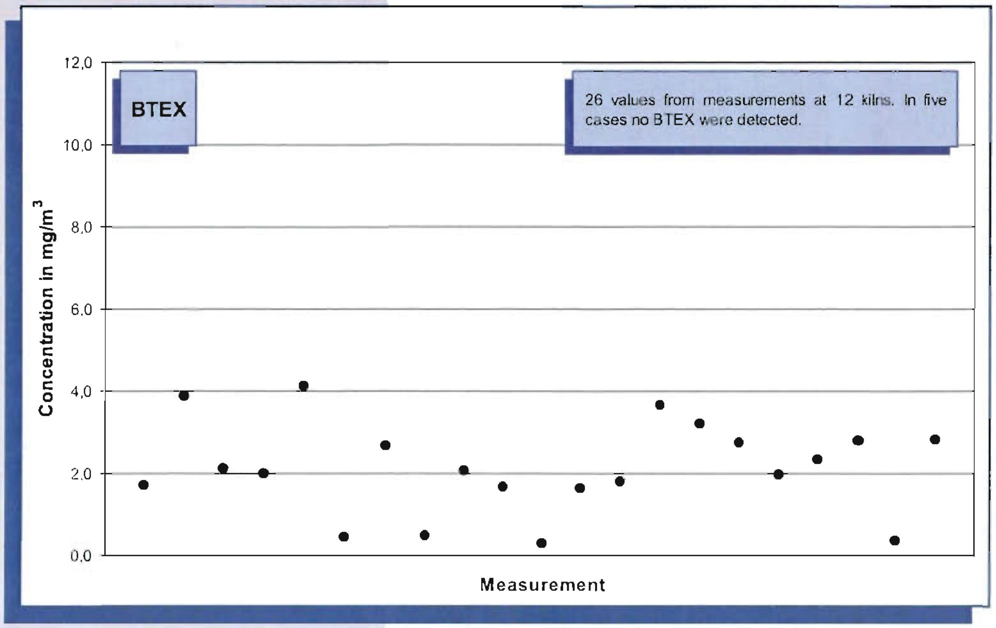


Fig. 5-17: BTEX concentration values (year 2007) measured in the clean gas of 12 rotary kilns. In five cases no BTEX were detected.
No detection limit can be deduced from the standard. Below 0.013 mg/m^3 the measuring methods currently used do not provide secured emission concentrations.

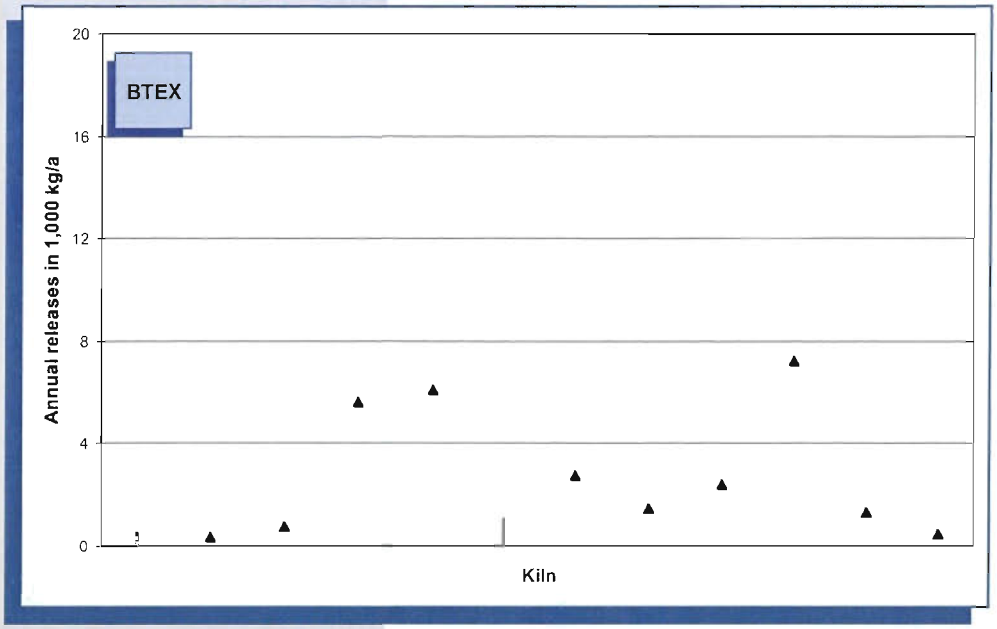


Fig. 5-18: BTEX emissions (annual releases in 2007) of 12 rotary kilns.

5.10 Benzene

Benzene is produced during the thermal decomposition of organic raw material constituents in the preheater. As a rule, it accounts for more than half of the BTEX emissions.

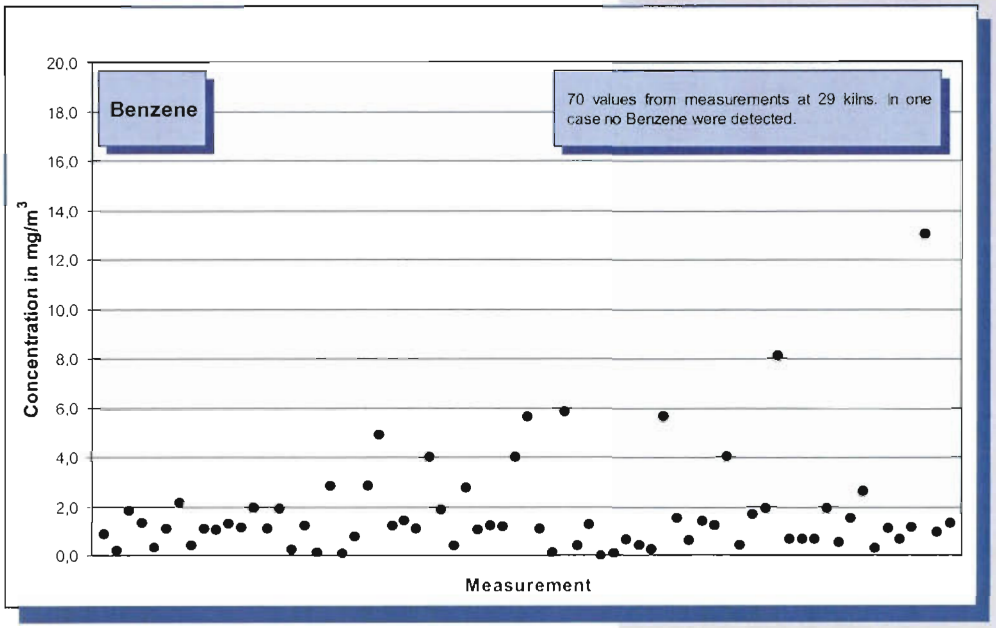


Fig. 5-19: Benzene concentration values (year 2007) measured in the clean gas of 29 rotary kilns. In one case no Benzene were detected.
No detection limit can be deduced from the standard. Below 0.013 mg/m^3 the measuring methods currently used do not provide secured emission concentrations.

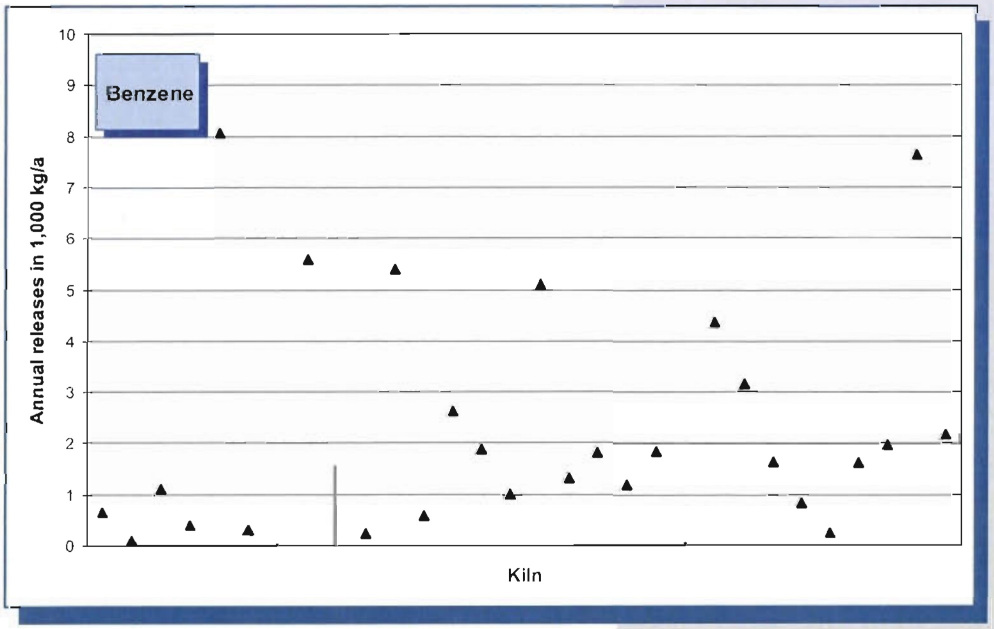


Fig. 5-20: Benzene emissions (annual releases in 2007) of 29 rotary kilns.

5.11 Gaseous inorganic chlorine compounds (HCl)

Chlorides are minor additional constituents contained in the raw materials and fuels of the clinker burning process. They are released when the fuels are burnt or the kiln feed is heated and primarily react with the alkalis from the kiln feed to form alkali chlorides. These compounds, which are initially vaporous, condense on the kiln feed or the kiln dust, respectively, at temperatures between 700 °C and 900 °C, subsequently re-enter the rotary kiln system and evaporate again. This cycle in the area between the rotary kiln and the preheater can result in coating formation. A bypass at the kiln inlet allows to effectively reduce alkali chloride cycles and to thus diminish operational malfunctions.

During the clinker burning process gaseous inorganic chlorine compounds are either not emitted at all or only in very small quantities. Owing to the alkaline kiln gas atmosphere, the formation of hydrogen chloride (HCl) in the exhaust gas can be virtually ruled out. Gaseous inorganic chlorides detected in the exhaust gas of rotary kiln systems are generally attributable to ultra-fine grain size fractions of alkali chlorides in the clean gas dust. They can pass through measuring gas filters, thus

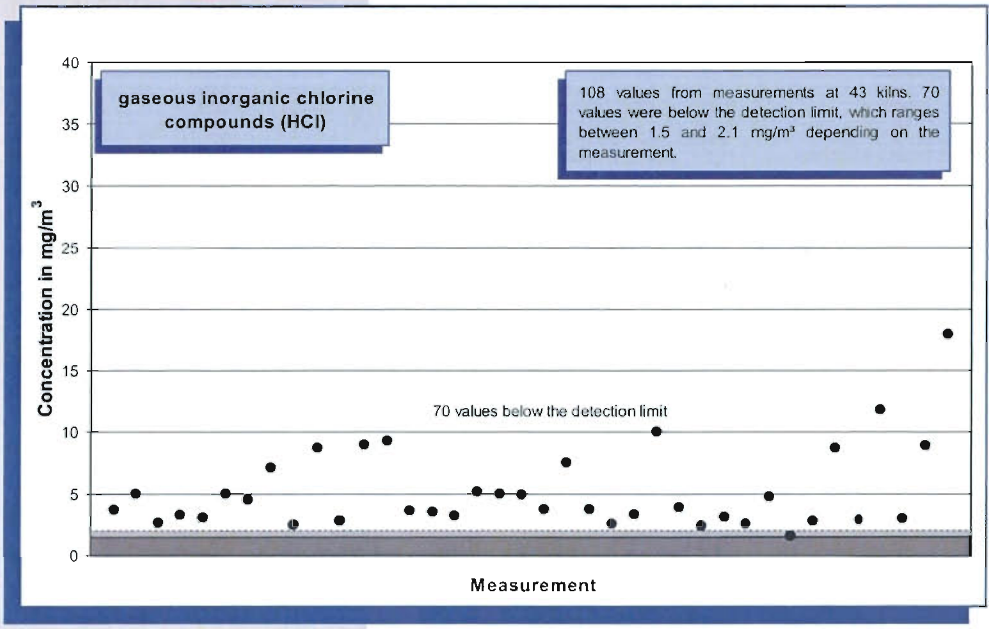


Fig. 5-21: Gaseous inorganic chlorine compound concentration values (year 2007) measured in the clean gas of 43 rotary kilns and given as HCl.

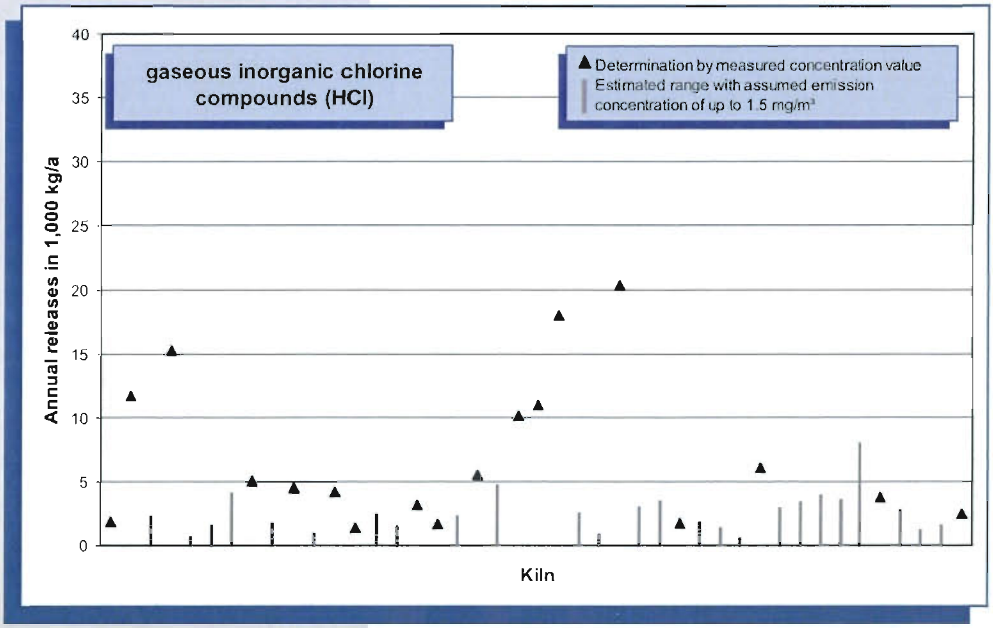
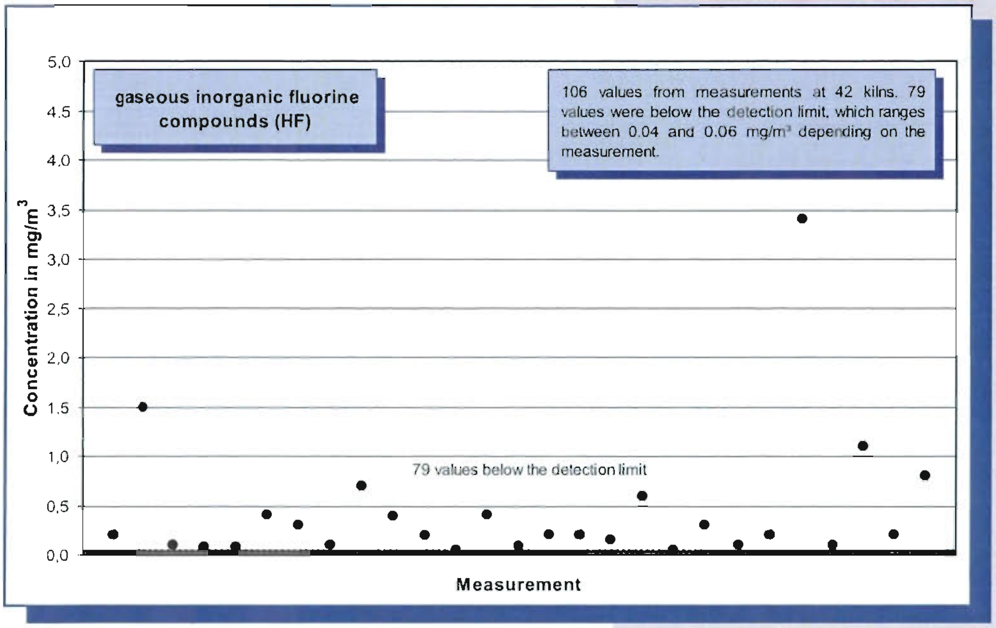


Fig. 5-22: HCl emissions (annual releases in 2007) of 43 rotary kilns.
If the values measured are below the detection limit, the releases can only be estimated. In these cases, the range of possible emissions is represented by a bro-

5.12 Gaseous inorganic fluorine compounds (HF)

Of the fluorine present in rotary kilns, 90 to 95% is bound in the clinker and the remainder is bound with dust in the form of calcium fluoride stable under the conditions of the burning process. Owing to the great calcium excess, the emission of gaseous fluorine compounds and of hydrogen fluoride in particular, is virtually excluded. Ultra-fine dust fractions that pass hrough the measuring gas filter may simulate low contents of gaseous fluorine compounds in rotary kiln systems of the cement industry.



106 values from measurements at 42 kilns. 79 values were below the detection limit, which ranges between 0.04 and 0.06 mg/m³ depending on the measurement.

Fig. 5-23: Gaseous inorganic fluorine compound concentration values (year 2007) measured in the clean gas of 42 rotary kilns and given as HF.

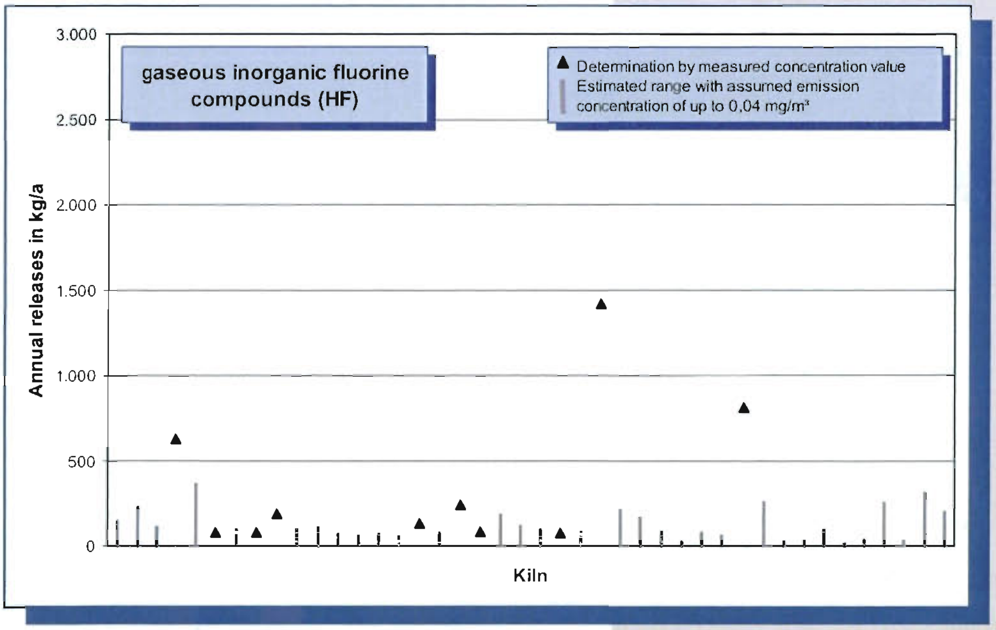


Fig. 5-24: HF emissions (annual releases in 2007) of 42 rotary kilns.

If the values measured are below the detection limit, the releases can only be estimated. In these cases, the

5.13 Trace elements

The emission behaviour of the individual elements in the clinker burning process is determined by the input scenario, the behaviour in the plant and the precipitation efficiency of the dust collection device. The trace elements introduced into the burning process via the raw materials and fuels may evaporate completely or partially in the hot zones of the preheater and/or rotary kiln depending on their volatility, react with the constituents present in the gas phase and condense on the kiln feed in the cooler sections of the kiln system. Depending on the volatility and the operating conditions, this may result in the formation of cycles that are either restricted to the kiln and the preheater or include the combined drying and grinding plant as well.

Trace elements from the fuels initially enter the combustion gases, but are emitted to an extremely small extent only owing to the retention capacity of the kiln and the preheater. Table 5-4 gives representative transfer coefficients for rotary kiln systems equipped with cyclone preheaters. These coefficients serve to calculate the proportion of trace elements from fuels emitted with the clean gas.

By contrast, the emission factors listed in the Table are higher than the corresponding transfer coefficients. Apart from fuel-related emissions, they also take into account raw material-related emissions, which usually predominate by a significant margin. The bandwidths indicated for the emission factors result from inventory investigations. No values are given for mercury since measurement results primarily depend on the respective operating conditions.

Component	EF in %	TC in %
Cadmium	< 0.01 to < 0.2	0.003
Thallium	< 0.01 to < 1	0.02
Antimony	< 0.01 to < 0.05	0.0005
Arsenic	< 0.01 to 0.02	0.0005
Lead	< 0.01 to < 0.2	0.002
Chromium	< 0.01 to < 0.05	0.0005
Cobalt	< 0.01 to < 0.05	0.0005
Copper	< 0.01 to < 0.05	0.0005
Manganese	< 0.001 to < 0.01	0.0005
Nickel	< 0.01 to < 0.05	0.0005
Vanadium	< 0.01 to < 0.05	0.0005

Table 5-4: Emission factors (EF, emitted portion of the total input) and transfer coefficients (TC, emitted portion of the fuel input) for rotary kiln systems with cyclone pre-heater

Under the conditions prevailing in the clinker burning process, non-volatile elements (e.g. arsenic, vanadium, nickel) are completely bound in the clinker. Elements such as lead and cadmium preferably react with the excess chlorides and sulphates in the section between the rotary kiln and the preheater, forming low-volatile compounds. Owing to the large surface area available, these compounds condense on the kiln feed particles at temperatures between 700 °C and 900 °C. In this way, the low-volatile elements accumulated in the kiln-preheater-system are precipitated again in the cyclone preheater, remaining almost completely in the clinker.

Thallium and its compounds condense in the upper zone of the cyclone preheater at temperatures between 450 °C and 500 °C. As a consequence, a cycle can be formed between preheater, raw material drying and exhaust gas purification.

Mercury and its compounds are not precipitated in the kiln and the preheater. They condense on the exhaust gas route due to the cooling of the gas and are partially adsorbed by the raw material particles. This portion is precipitated in the kiln exhaust gas filter.

Owing to trace element behaviour during the clinker burning process and the high precipitation efficiency of the dust collection devices, trace element emission concentrations are on a low overall level. For example, the average values measured in 2006 of the trace elements listed in the German regulation on waste incineration (17th BImSchV) were above the detection limit in merely about 20% of all cases.

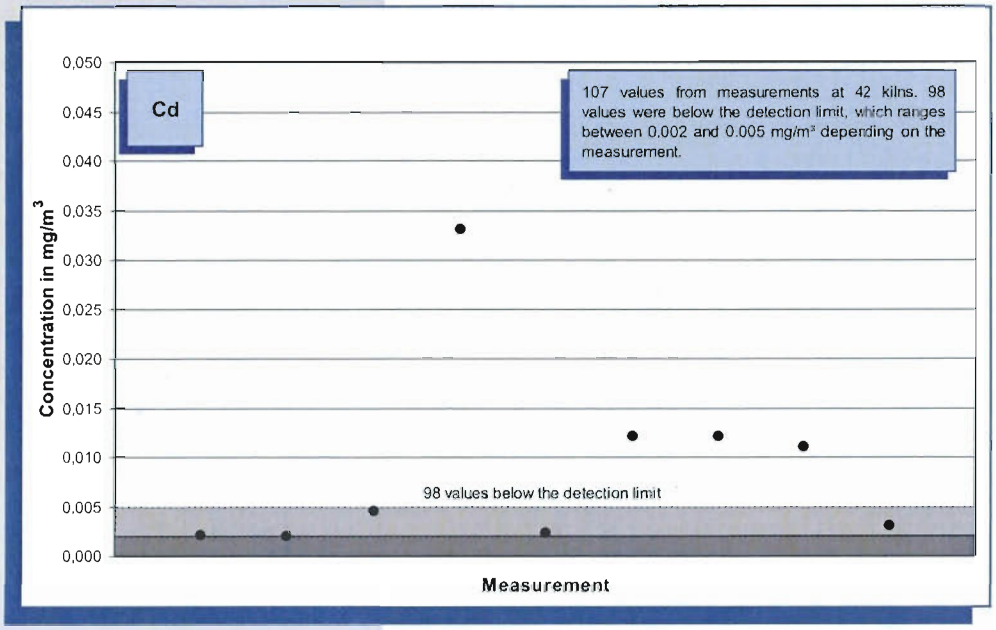


Fig. 5-25: Cadmium concentration values (year 2007) measured in the clean gas of 42 rotary kilns.

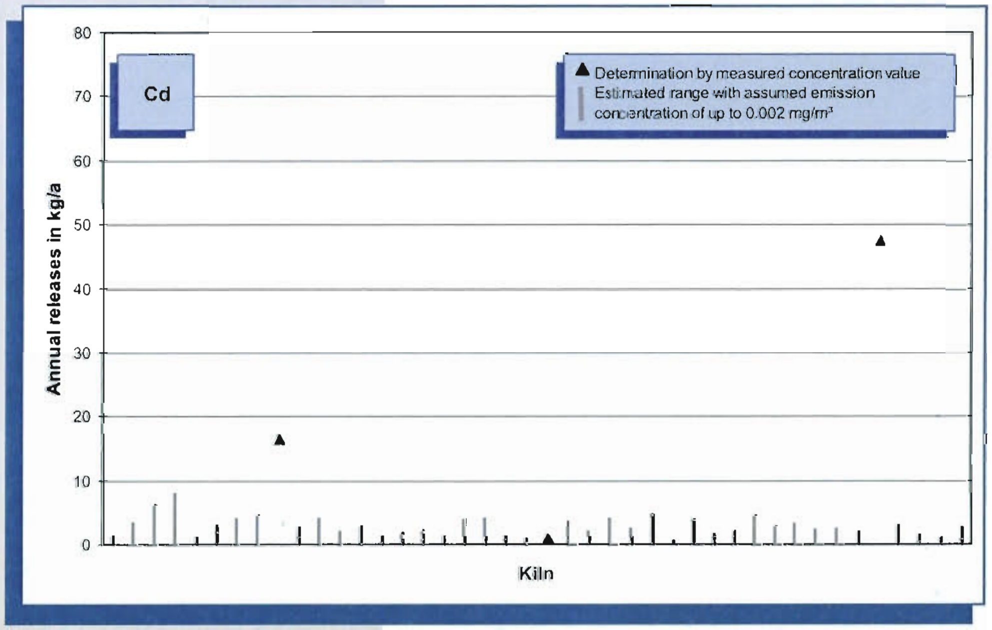
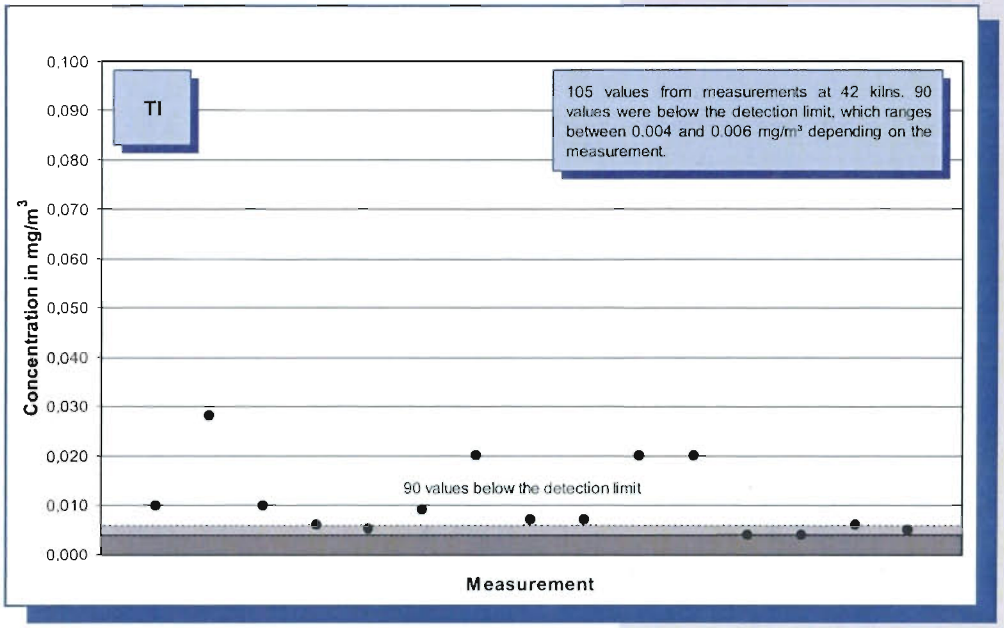


Fig. 5-26: Cadmium emissions (annual releases in 2007) of 42 rotary kilns.

If the values measured are below the detection limit, the releases can only be estimated. In these cases, the range of possible emissions is represented by a bro-



105 values from measurements at 42 kilns. 90 values were below the detection limit, which ranges between 0.004 and 0.006 mg/m³ depending on the measurement.

Fig. 5-27: Thallium concentration values (year 2007) measured in the clean gas of 42 rotary kilns.

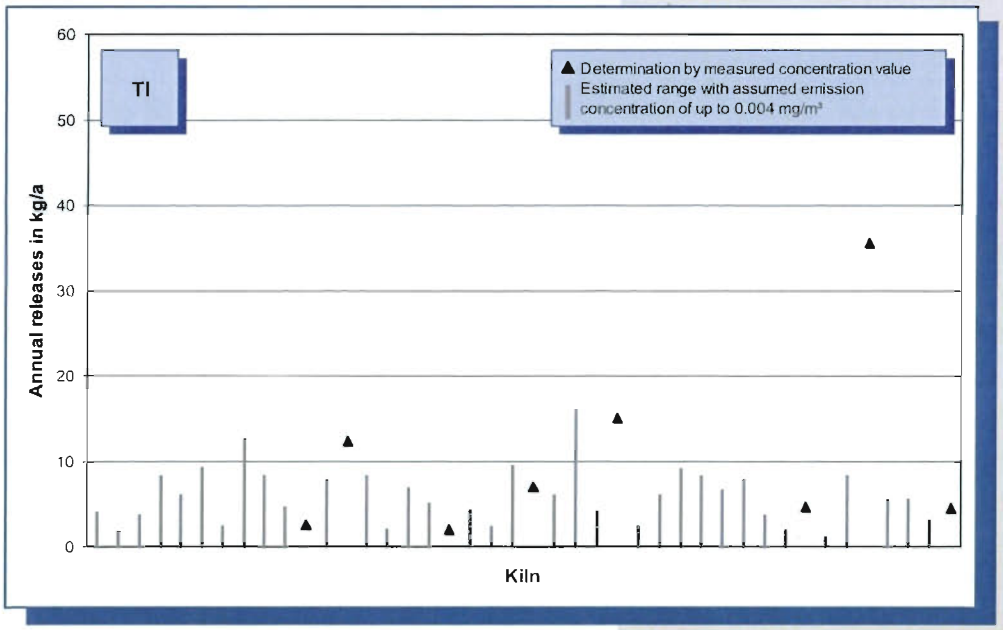


Fig. 5-28: Thallium emissions (annual releases in 2007) of 42 rotary kilns.

If the values measured are below the detection limit, the releases can only be estimated. In these cases, the range of possible emissions is represented by a bro-

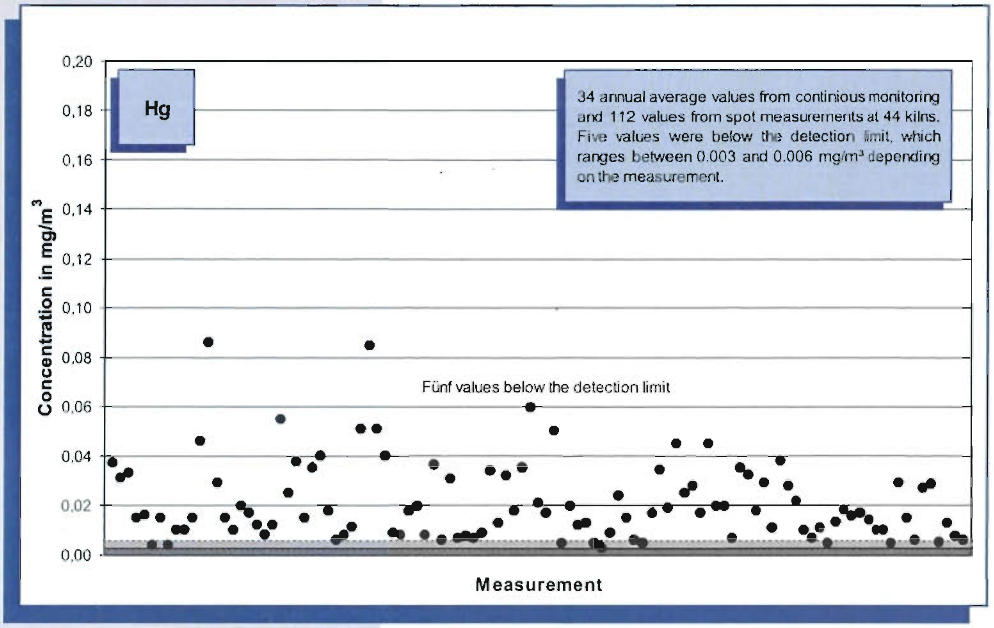


Fig. 5-29: Mercury concentration values (year 2007) measured in the clean gas of 44 rotary kilns.

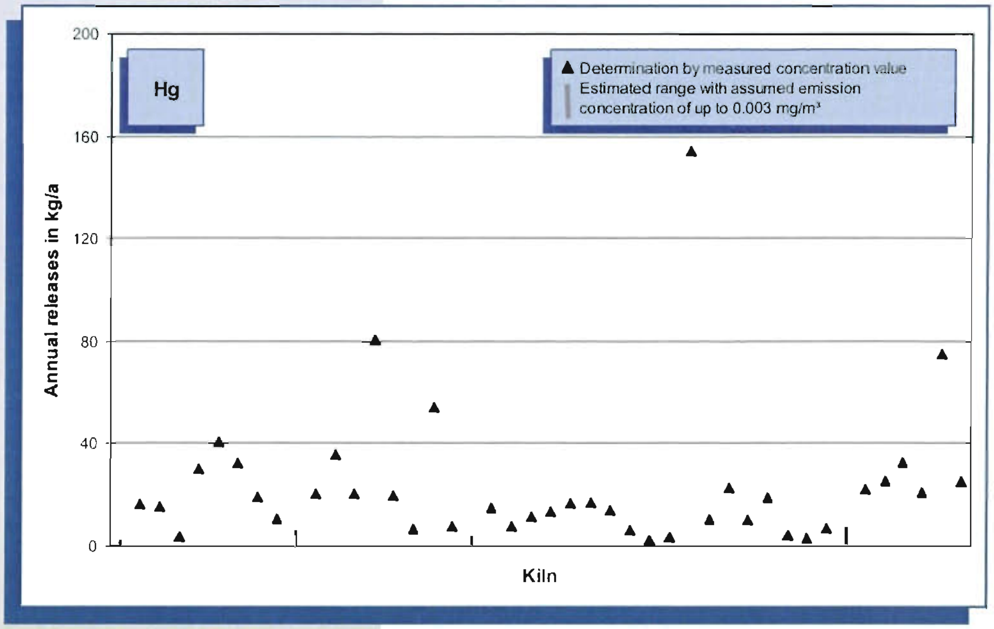


Fig. 5-30: Mercury emissions (annual releases in 2007) of 44 rotary kilns.

If the values measured are below the detection limit, the releases can only be estimated. In these cases, the range of possible emissions is represented by a bro-

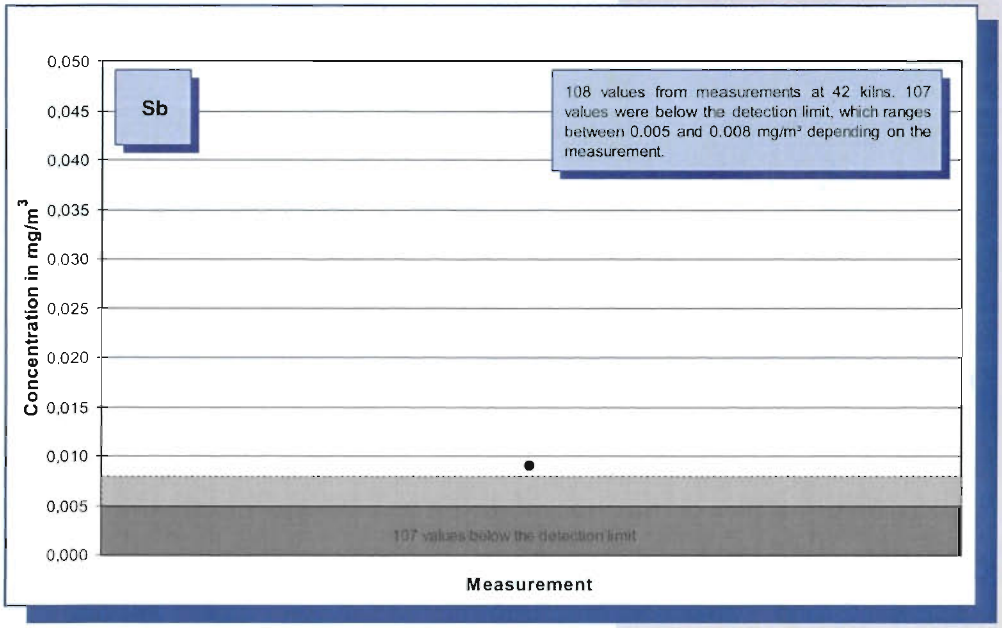


Fig. 5-31: Antimony concentration values (year 2007) measured in the clean gas of 42 rotary kilns.

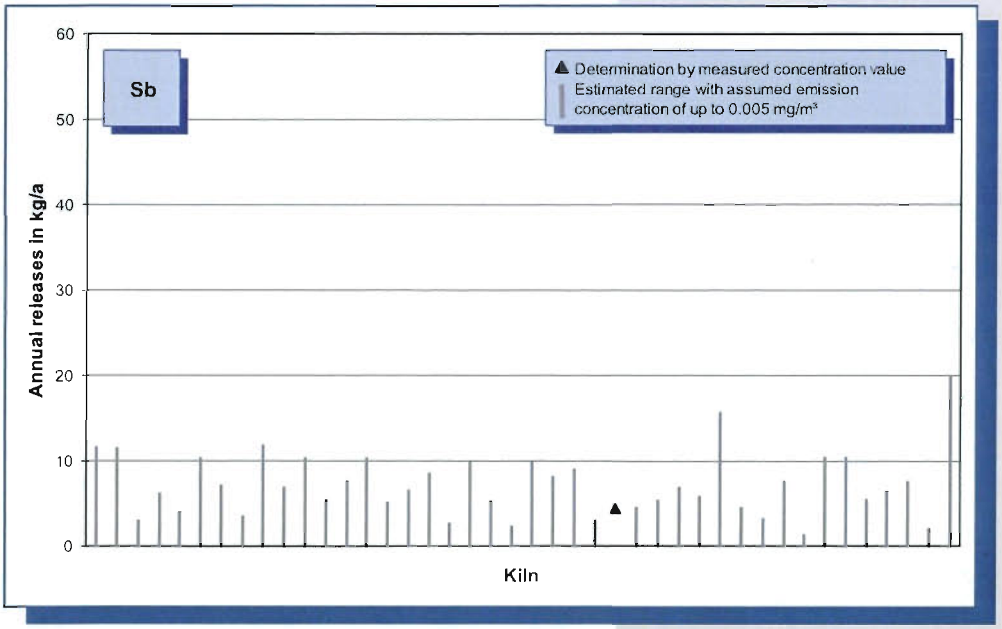


Fig. 5-32: Antimony emissions (annual releases in 2007) of 42 rotary kilns.

If the values measured are below the detection limit, the releases can only be estimated. In these cases, the range of possible emissions is represented by a bro-

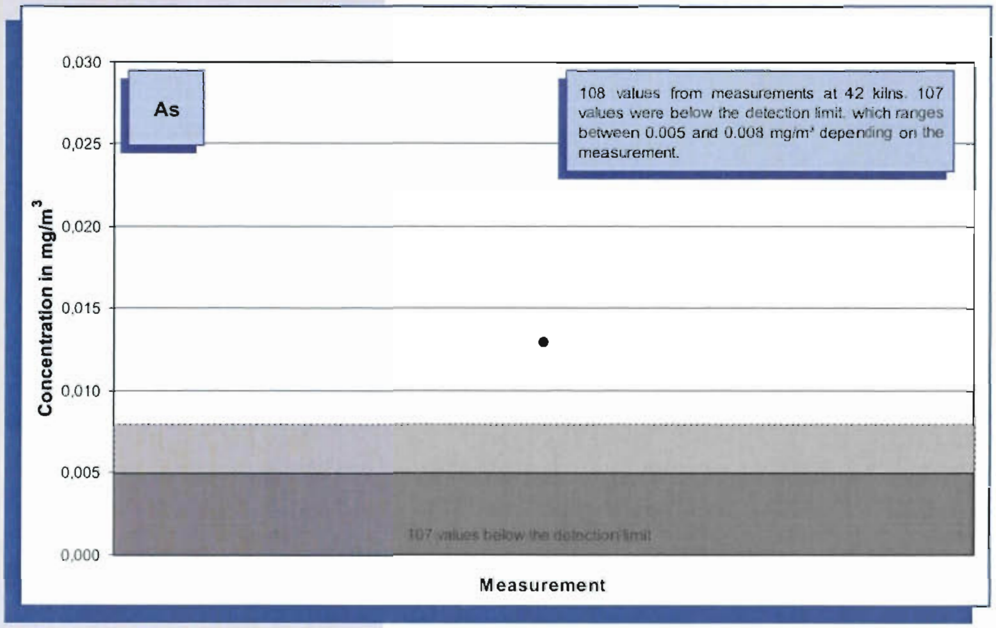


Fig. 5-33: Arsenic concentration values (year 2007) measured in the clean gas of 42 rotary kilns.

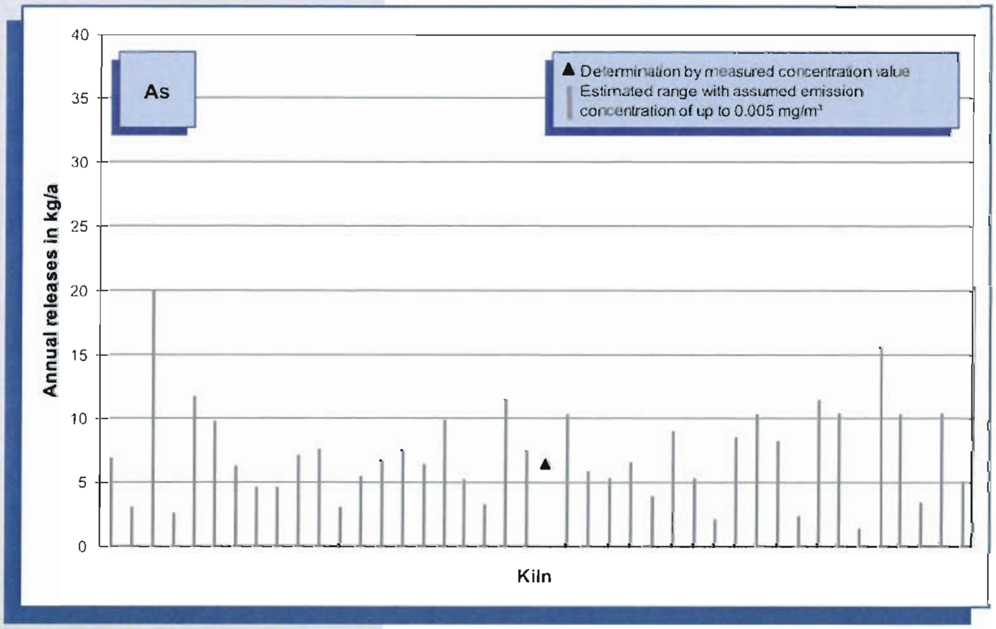


Fig. 5-34: Arsenic emissions (annual releases in 2007) of 42 rotary kilns.

If the values measured are below the detection limit, the releases can only be estimated. In these cases, the range of possible emissions is represented by a bro-

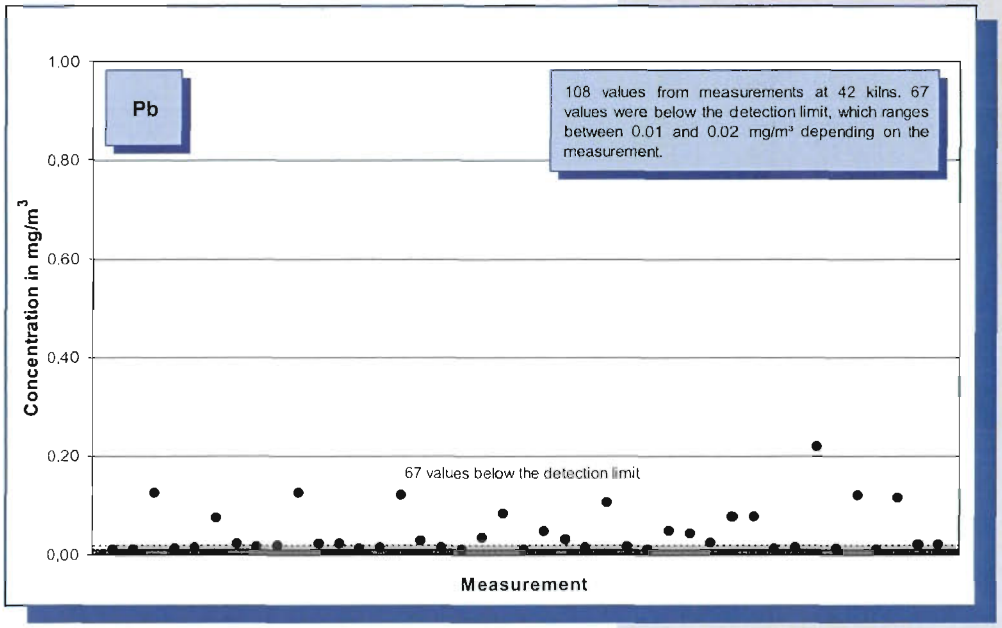


Fig. 5-35: Lead concentration values (year 2007) measured in the clean gas of 42 rotary kilns.

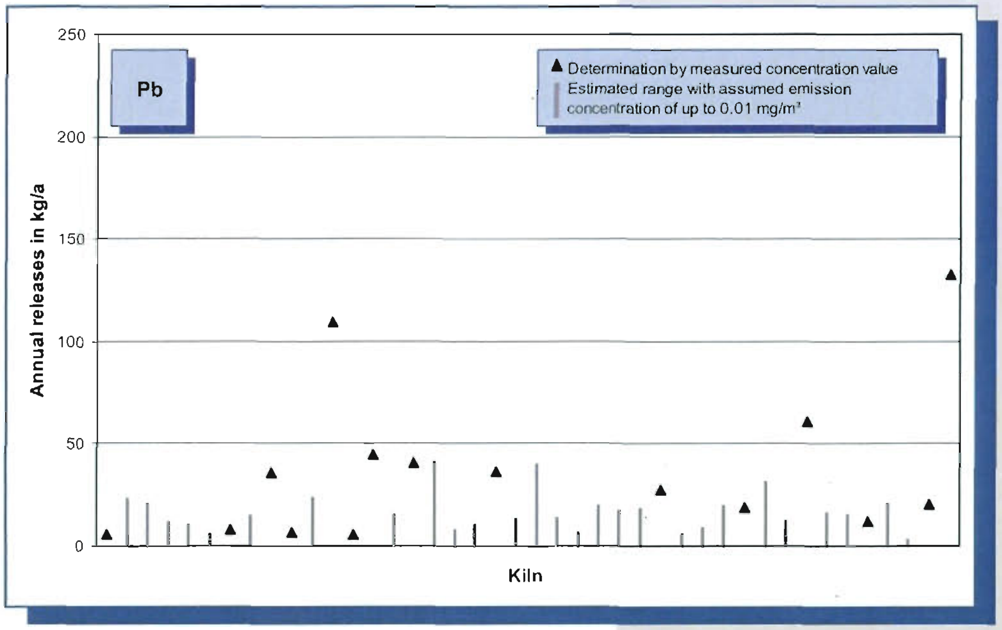


Fig. 5-36: Lead emissions (annual releases in 2007) of 42 rotary kilns.
If the values measured are below the detection limit, the releases can only be estimated. In these cases, the range of possible emissions is represented by a broken

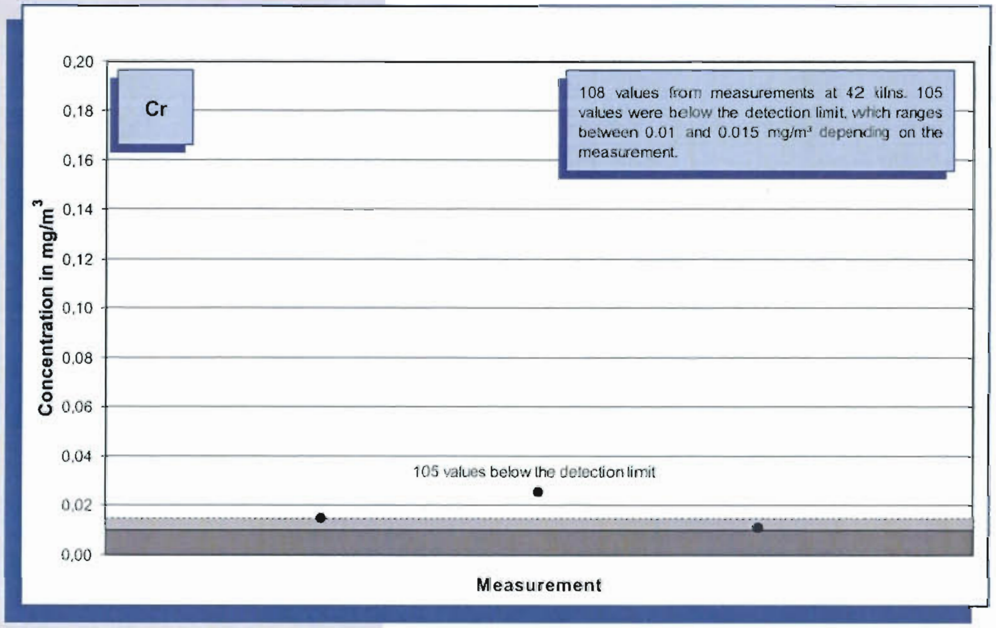


Fig. 5-37: Chromium concentration values (year 2007) measured in the clean gas of 42 rotary kilns.

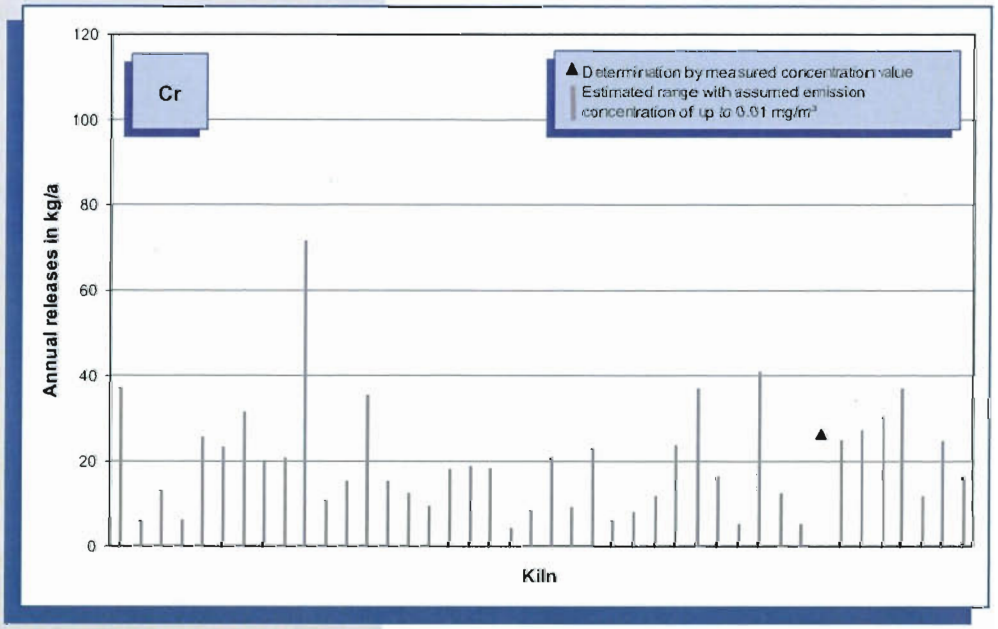
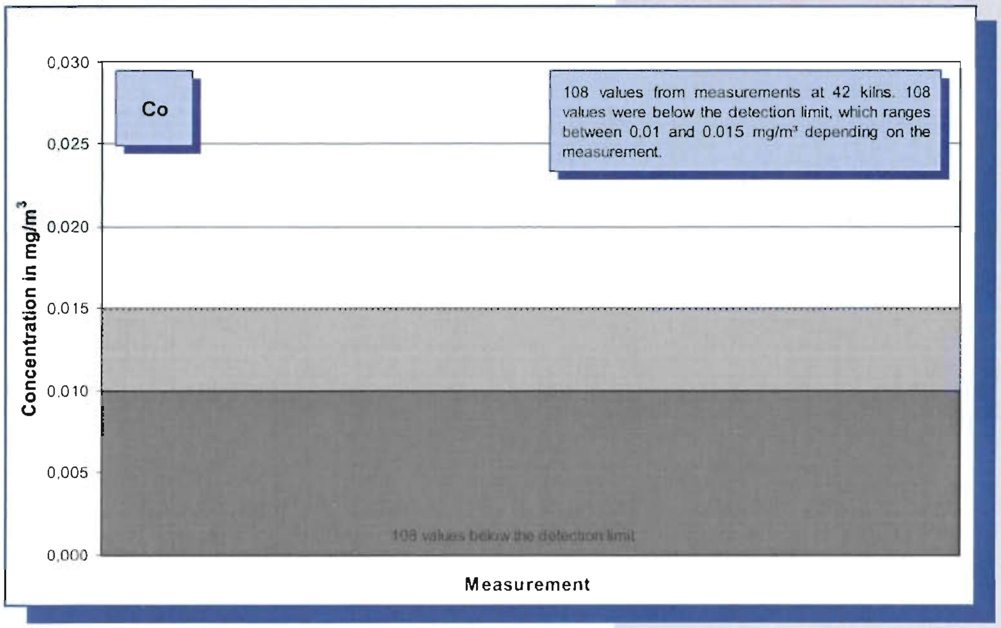


Fig. 5-38: Chromium emissions (annual releases in 2007) of 42 rotary kilns.
If the values measured are below the detection limit, the releases can only be estimated. In these cases, the range of possible emissions is represented by a bro-



108 values from measurements at 42 kilns. 108 values were below the detection limit, which ranges between 0.01 and 0.015 mg/m³ depending on the measurement.

Fig. 5-39: Cobalt concentration values (year 2007) measured in the clean gas of 42 rotary kilns.

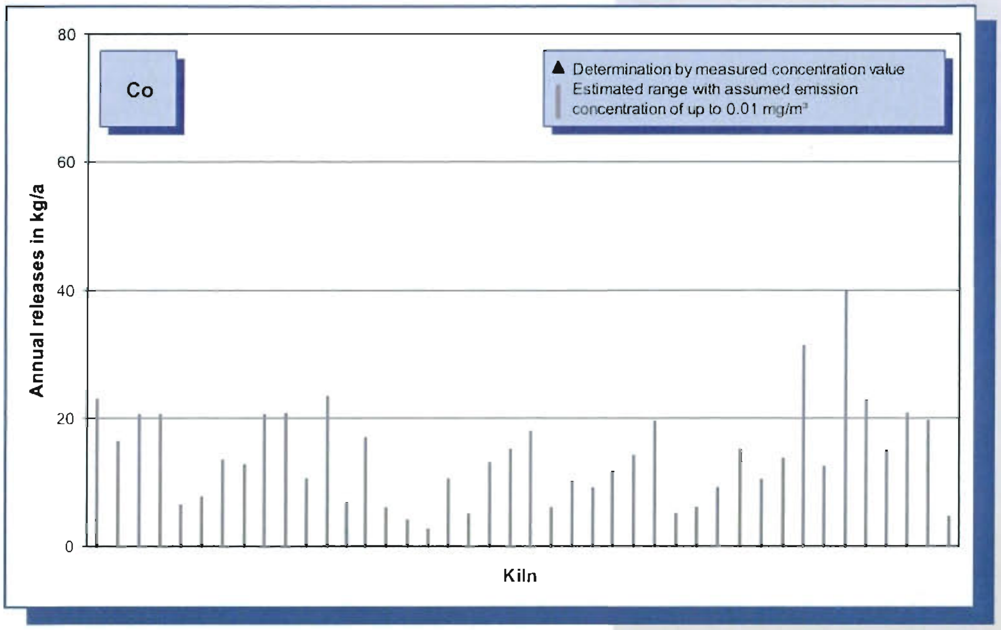


Fig. 5-40: Cobalt emissions (annual releases in 2007) of 42 rotary kilns.

If the values measured are below the detection limit, the releases can only be estimated. In these cases, the range of possible emissions is represented by a bro-

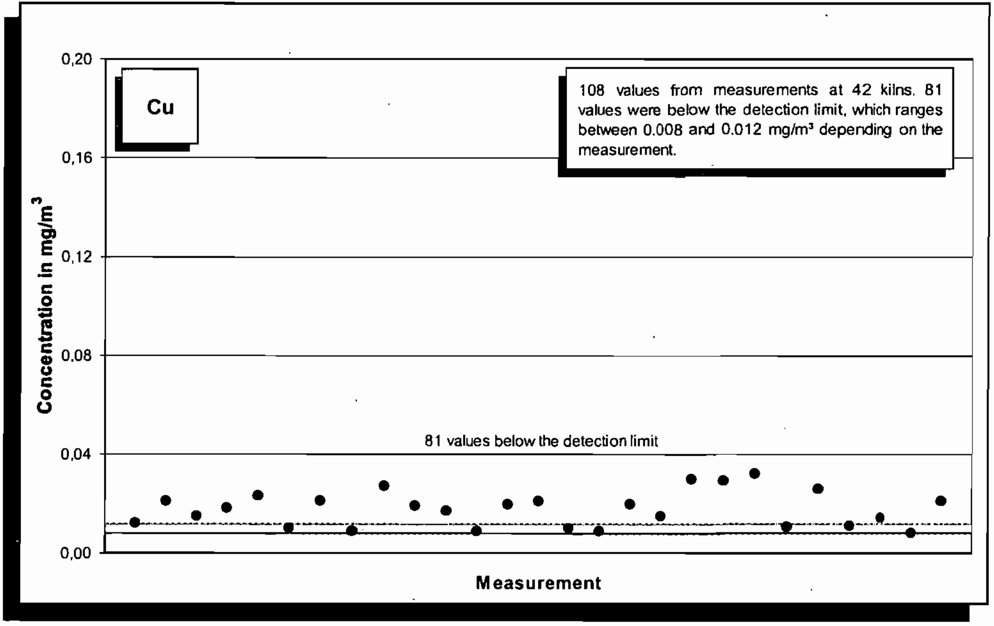


Fig. 5-41: Copper concentration values (year 2007) measured in the clean gas of 42 rotary kilns.

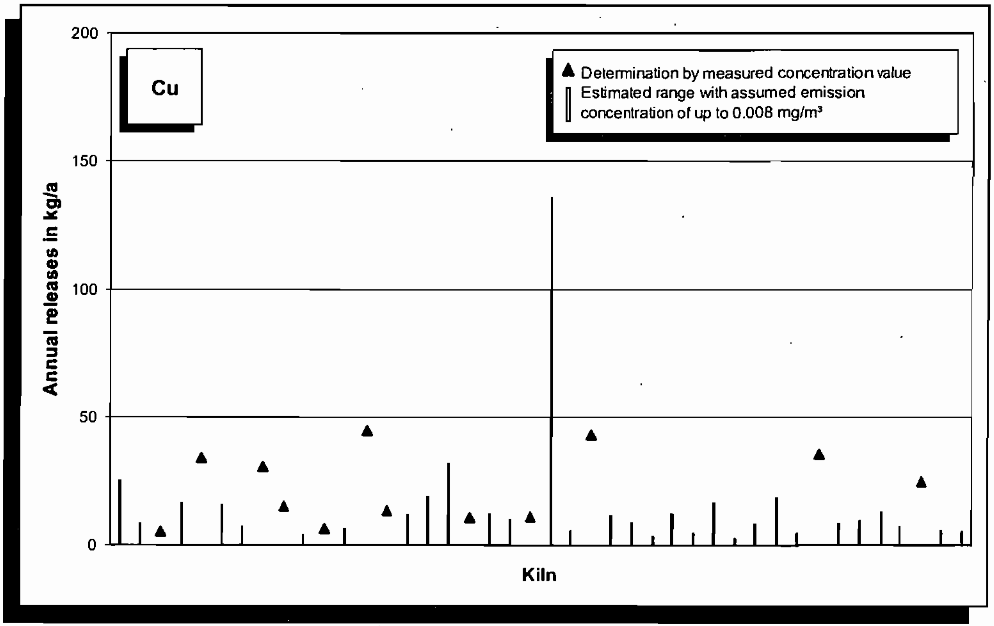


Fig. 5-42: Copper emissions (annual releases in 2007) of 42 rotary kilns.

If the values measured are below the detection limit, the releases can only be estimated. In these cases, the range of possible emissions is represented by a bro-

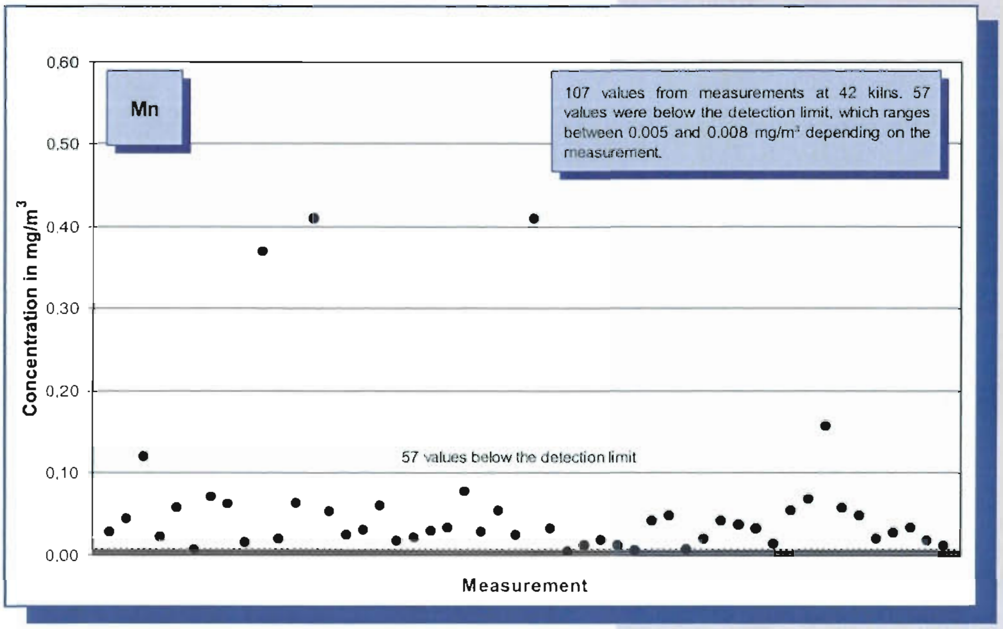


Fig. 5-43: Manganese concentration values (year 2007) measured in the clean gas of 42 rotary kilns.

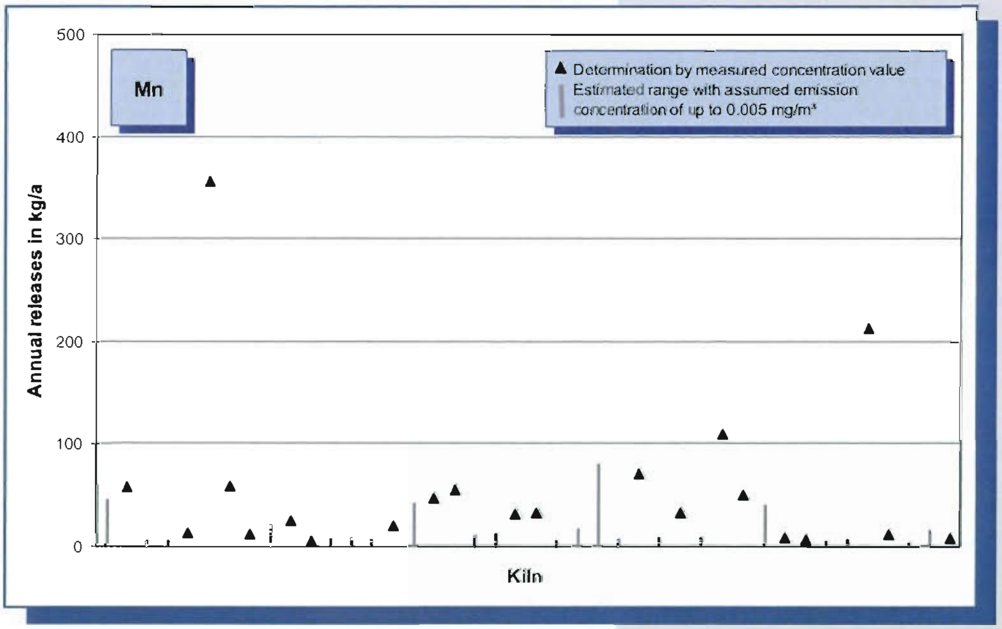
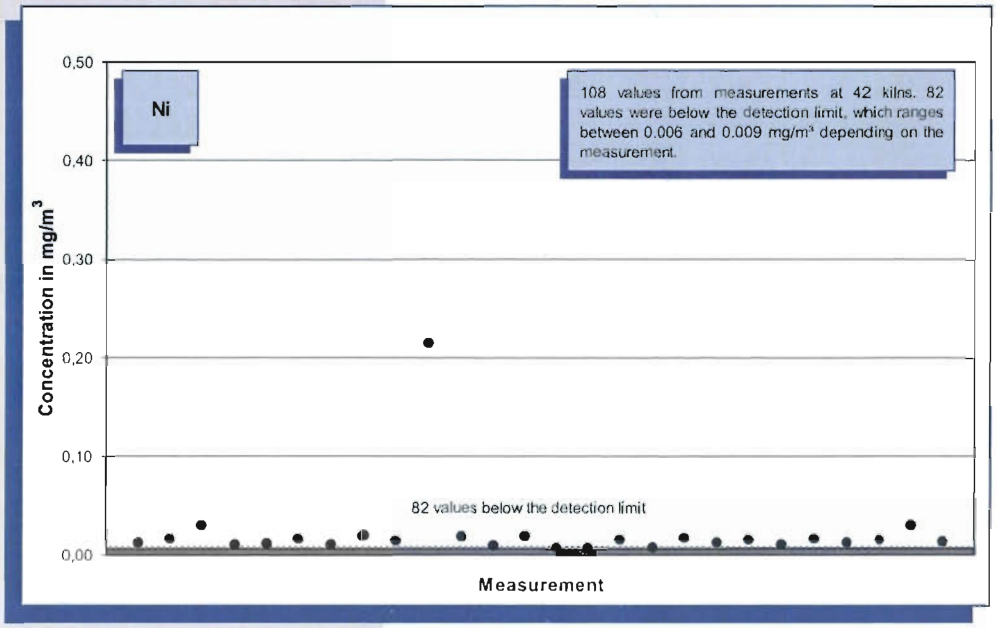


Fig. 5-44: Manganese emissions (annual releases in 2007) of 42 rotary kilns.

If the values measured are below the detection limit, the releases can only be estimated. In these cases, the range of possible emissions is represented by a bro-



108 values from measurements at 42 kilns. 82 values were below the detection limit, which ranges between 0.006 and 0.009 mg/m³ depending on the measurement.

Fig. 5-45: Nickel concentration values (year 2007) measured in the clean gas of 42 rotary kilns.

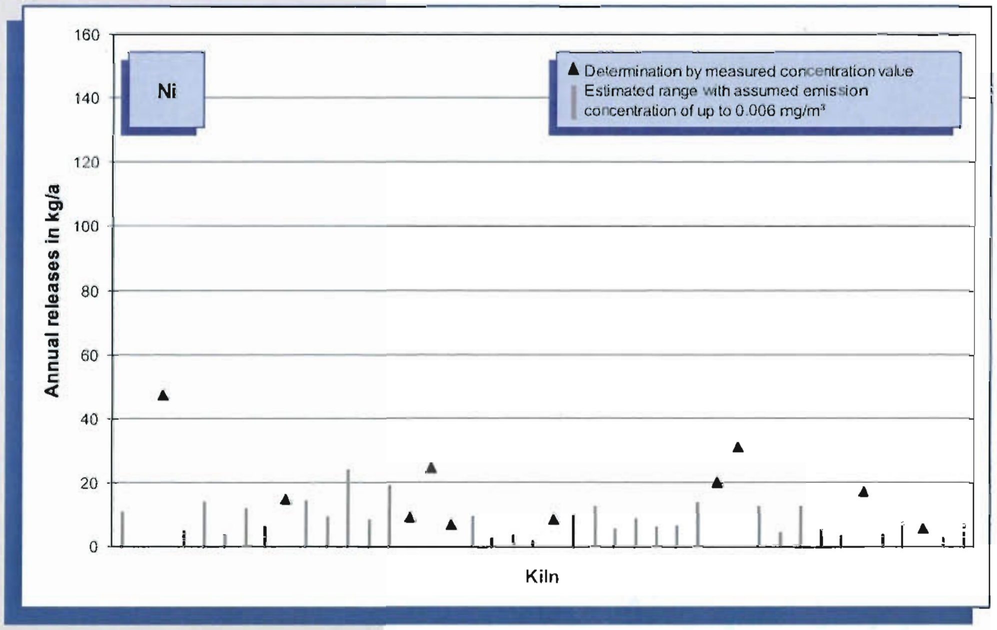


Fig. 5-46: Nickel emissions (annual releases in 2007) of 42 rotary kilns.
If the values measured are below the detection limit, the releases can only be estimated. In these cases, the range of possible emissions is represented by a bro-

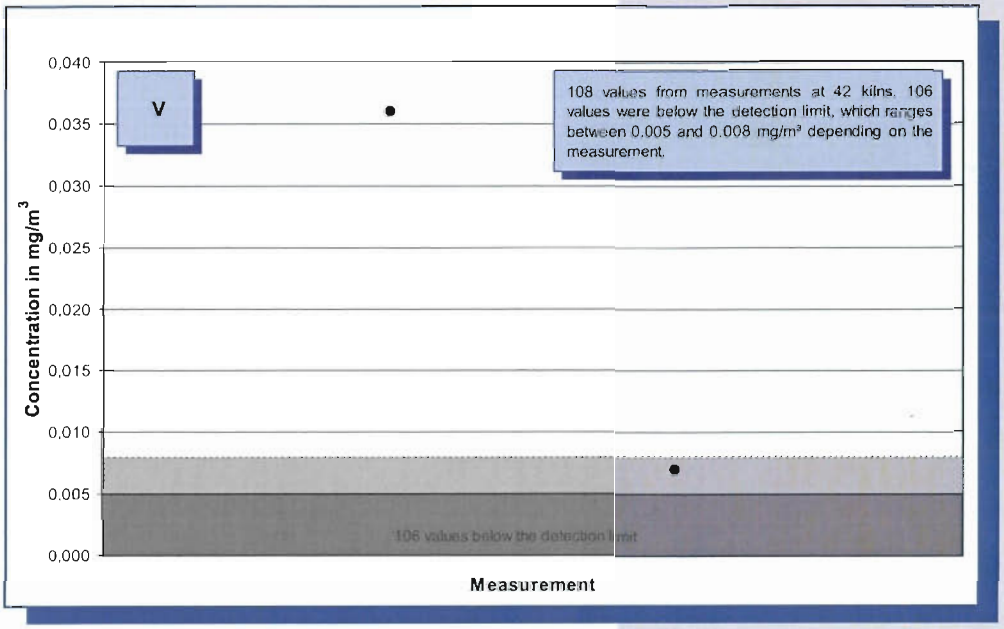


Fig. 5-47: Vanadium concentration values (year 2007) measured in the clean gas of 42 rotary kilns.

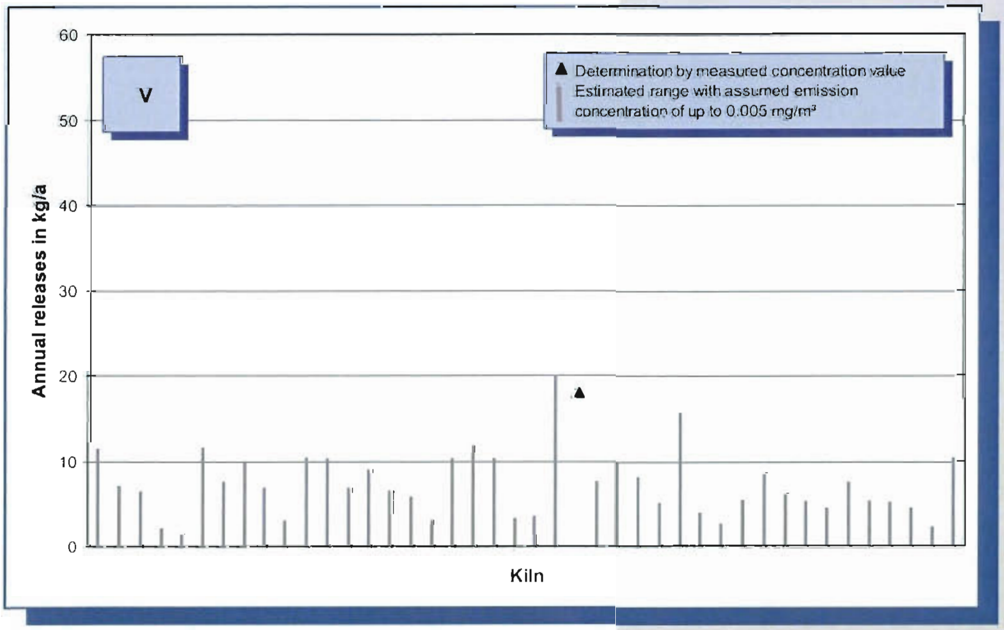
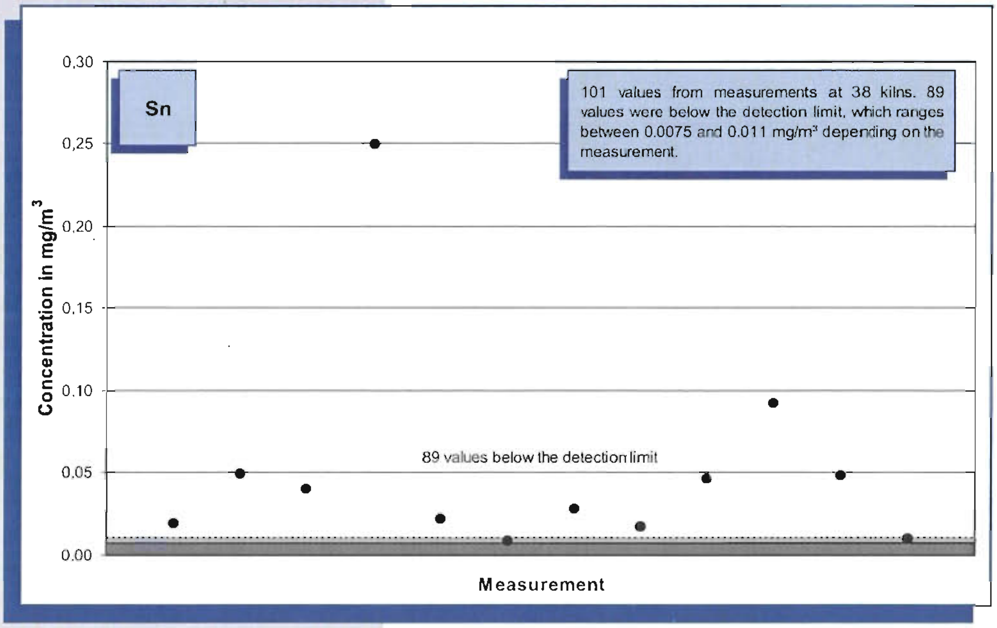


Fig. 5-48: Vanadium emissions (annual releases in 2007) of 42 rotary kilns.

If the values measured are below the detection limit, the releases can only be estimated. In these cases, the range of possible emissions is represented by a bro-



101 values from measurements at 38 kilns. 89 values were below the detection limit, which ranges between 0.0075 and 0.011 mg/m³ depending on the measurement.

Fig. 5-49: Tin concentration values (year 2007) measured in the clean gas of 38 rotary kilns.

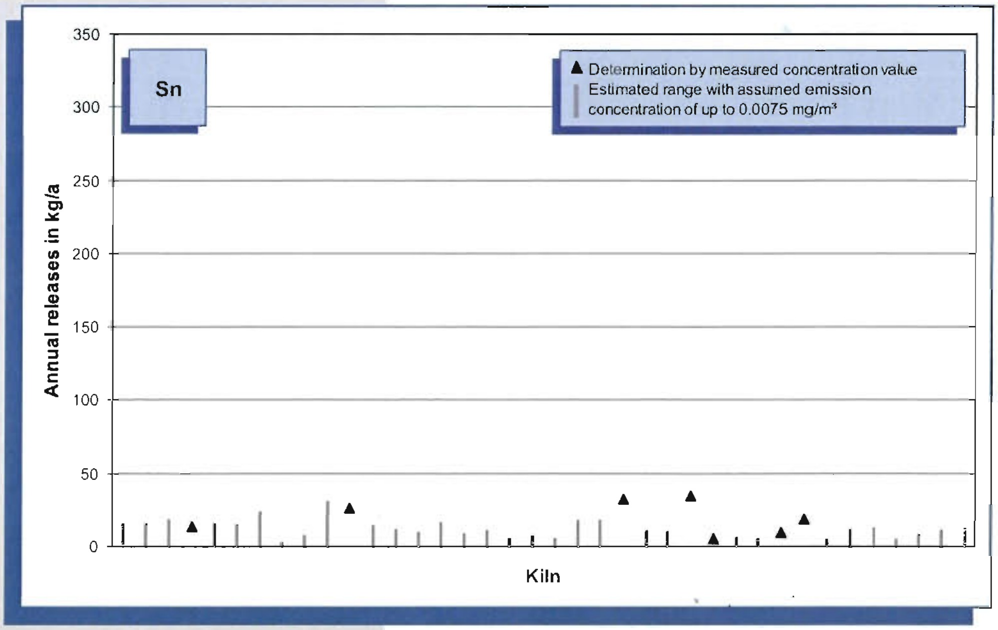


Fig. 5-50: Tin emissions (annual releases in 2007) of 38 rotary kilns.

If the values measured are below the detection limit, the releases can only be estimated. In these cases, the range of possible emissions is represented by a bro-

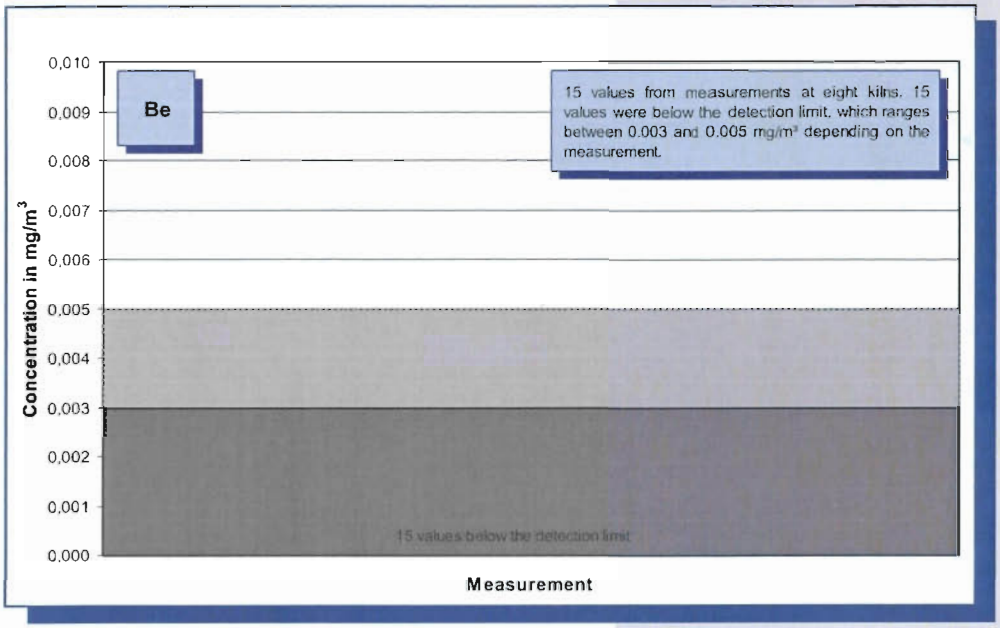


Fig. 5-51: Beryllium concentration values (year 2007) measured in the clean gas of eight rotary kilns.

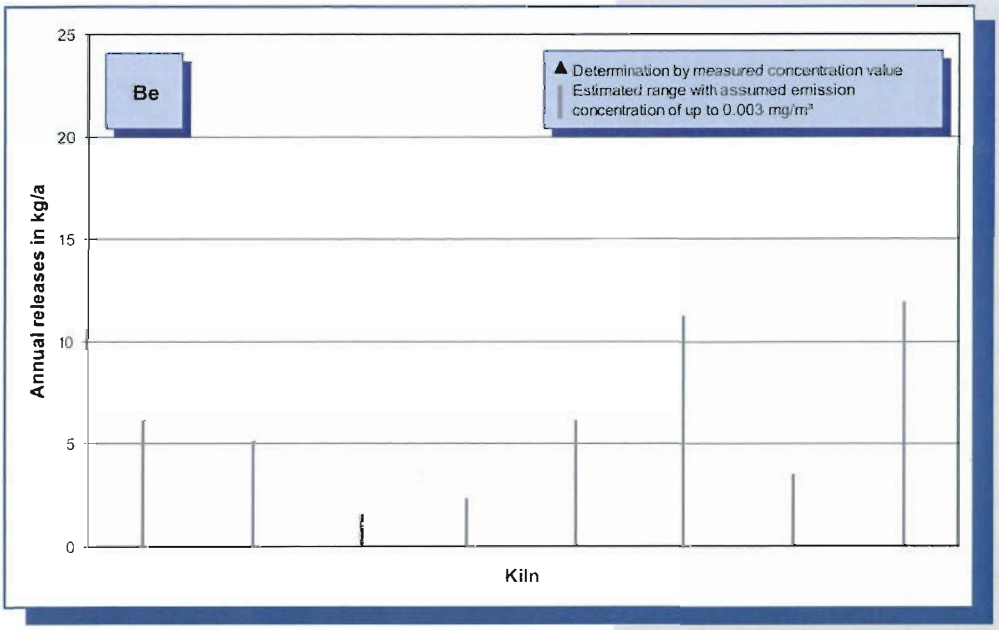
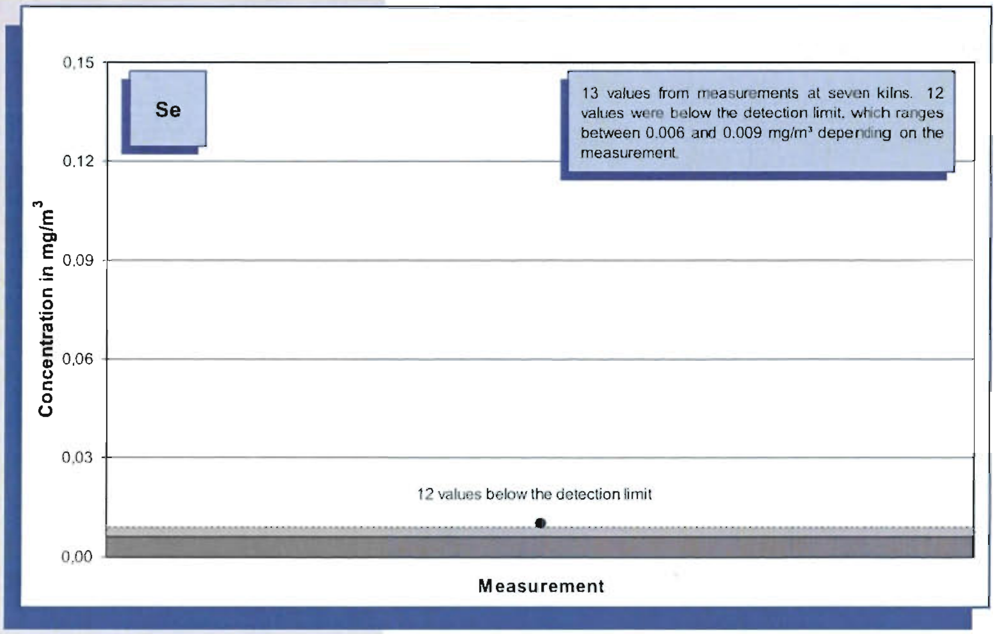


Fig. 5-52: Beryllium emissions (annual releases in 2007) of eight rotary kilns.

If the values measured are below the detection limit, the releases can only be estimated. In these cases, the range of possible emissions is represented by a bro-



13 values from measurements at seven kilns. 12 values were below the detection limit, which ranges between 0.006 and 0.009 mg/m³ depending on the measurement.

12 values below the detection limit

Fig. 5-53: Selenium concentration values (year 2007) measured in the clean gas of seven rotary kilns.

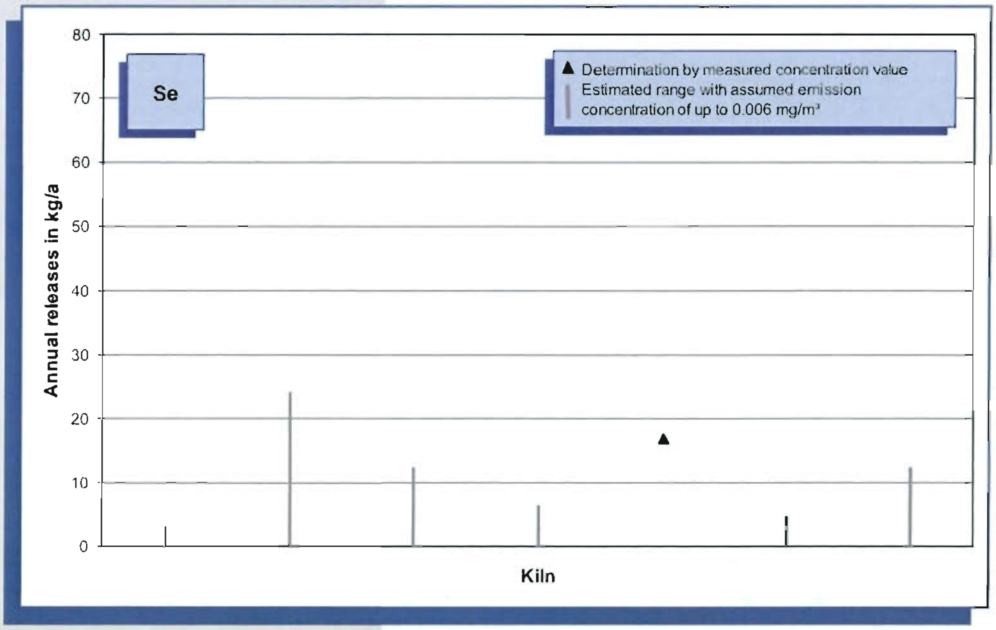


Fig. 5-54: Selenium emissions (annual releases in 2007) of seven rotary kilns.
If the values measured are below the detection limit, the releases can only be estimated. In these cases, the range of possible emissions is represented by a bro-

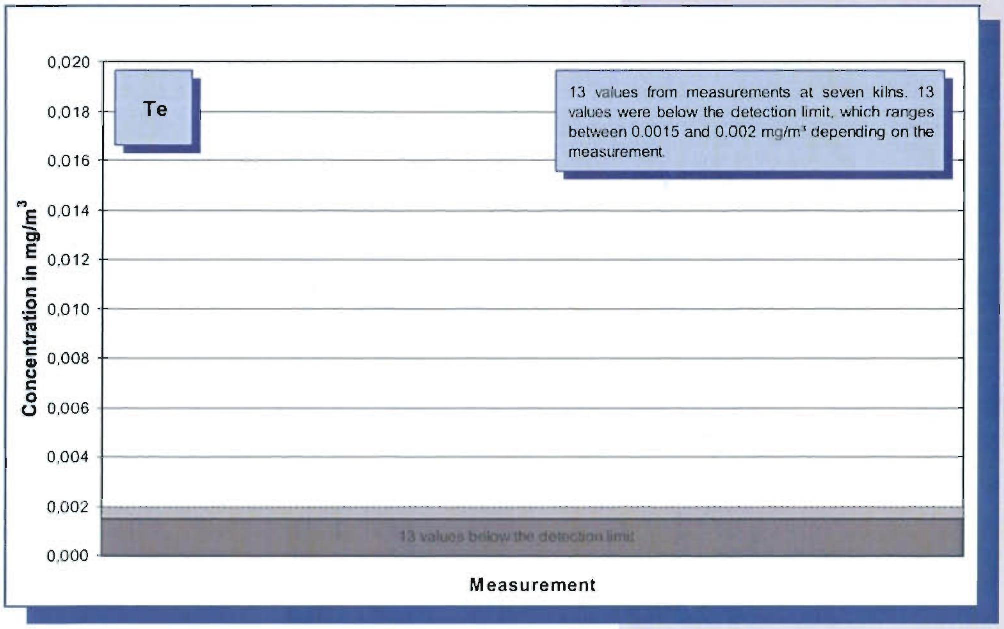


Fig. 5-55: Tellurium concentration values (year 2007) measured in the clean gas of seven rotary kilns.

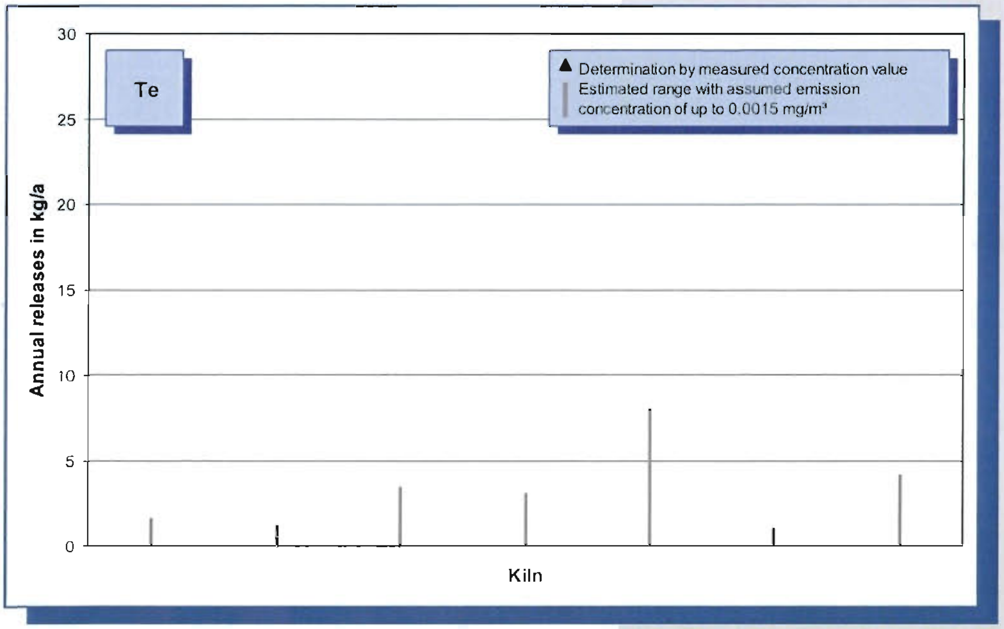


Fig. 5-56: Tellurium emissions (annual releases in 2007) of seven rotary kilns.

If the values measured are below the detection limit, the releases can only be estimated. In these cases, the range of possible emissions is represented by a bro-

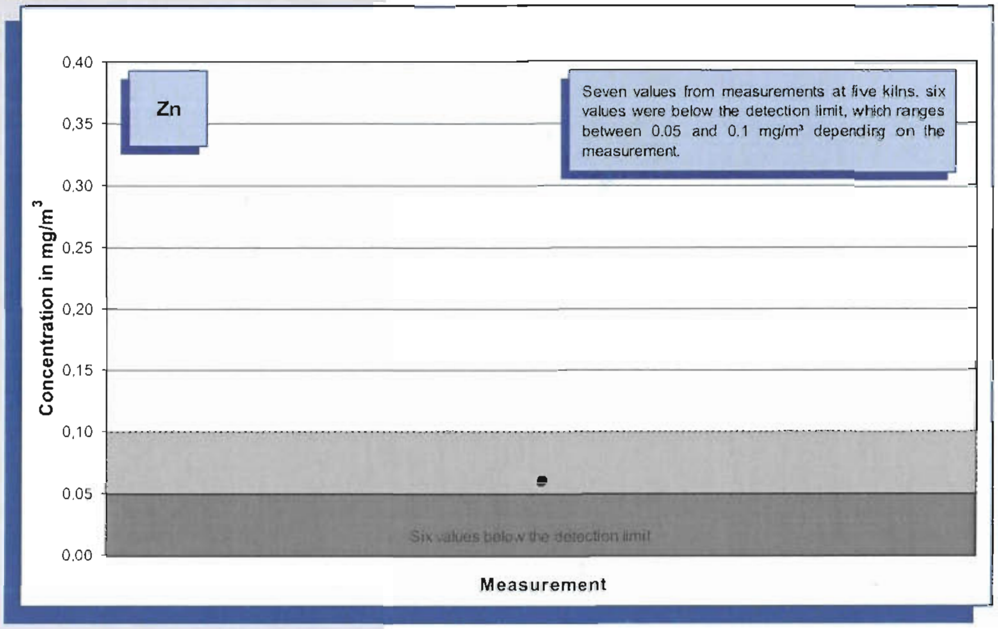


Fig. 5-57: Zinc concentration values (year 2007) measured in the clean gas of five rotary kilns.

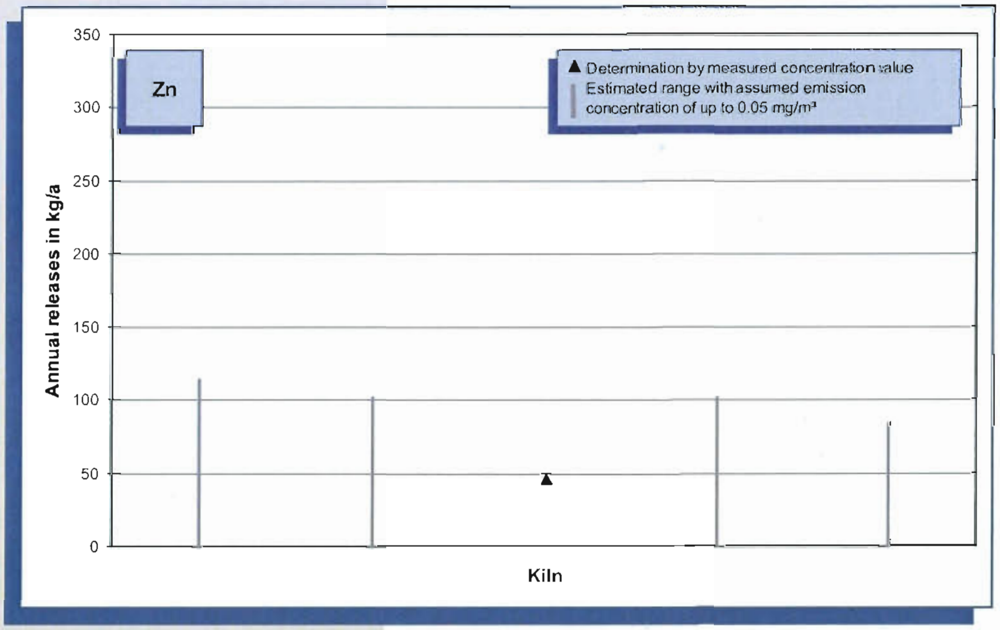


Fig. 5-58: Zinc emissions (annual releases in 2007) of five rotary kilns.
If the values measured are below the detection limit, the releases can only be estimated. In these cases, the range of possible emissions is represented by a bro-

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